Community Engagement through Three-dimensional Mapping: Part 1 – Introduction

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Abstract

Local land conservation has become technologically sophisticated. The availability of geographic information system (GIS) capabilities has enabled land trusts and watershed organizations to benefit from a wellspring of ever-expanding environmental information. Traditionally, online two-dimensional (2D) mapping applications are used to communicate landscape assessments, monitor status and trends, target conservation and restoration actions, and track implementation of projects. However, traditional 2D maps have limitations, particularly in terms of how map users make connections between geographic "space" and the phenomenon of "place" (or how local stakeholders experience the land and resources they value).

Interactive 3D visualization can better connect local stakeholders to place-based stewardship opportunities and challenges. Despite a lingering perception that 3D is beyond the capabilities of local organizations, technological advancements have brought 3D mapping to a much more general audience. Specifically, the increasing availability of Light Detection and Ranging (LiDAR), building footprint, and high-resolution land cover data enables the creation of realistic, interactive landscapes that stakeholders can explore through a variety of interfaces.

This poster is the first in a series aimed at demonstrating how local, interactive web scenes can be used to underscore conservation and restoration issues by visualizing structural elements of Chesapeake landscapes, providing a new approach to connecting stakeholders to "place".

Implications of 3D in Communication

Studies have shown that 3D can have multiple benefits:

- 3D visual displays are considered more intuitive and natural in appearance (Hamilton et al 2001) and are often easier to interpret (Lewis and Sheppard 2006),
- 3D visualization provides a sense of immersion in the environment, wherein the user can better appreciate the sense of scale and better judge impacts of development (Lai et al 2010),
- 3D GIS derived visualizations are particularly suitable for landscapes with many vertical structures (e.g., structures and vegetation) (Lai et al 2010),
- 3D graphics may be more visually appealing than 2D (Fisher et al 1997), and
- Users may perceive 3D landscapes with a higher degree of confidence and credibility (Lewis and Sheppard 2006).

Landscape visualization may be well suited for the following purposes:

- Communicating current environmental conditions,
- Communicating potential future or past conditions,
- Explaining ecosystem changes (natural or before/after interventions),
- Complementing local story lines for management decisions,
- Place-based storytelling -- integration of multiple topics for data-driven storytelling in a particular location.

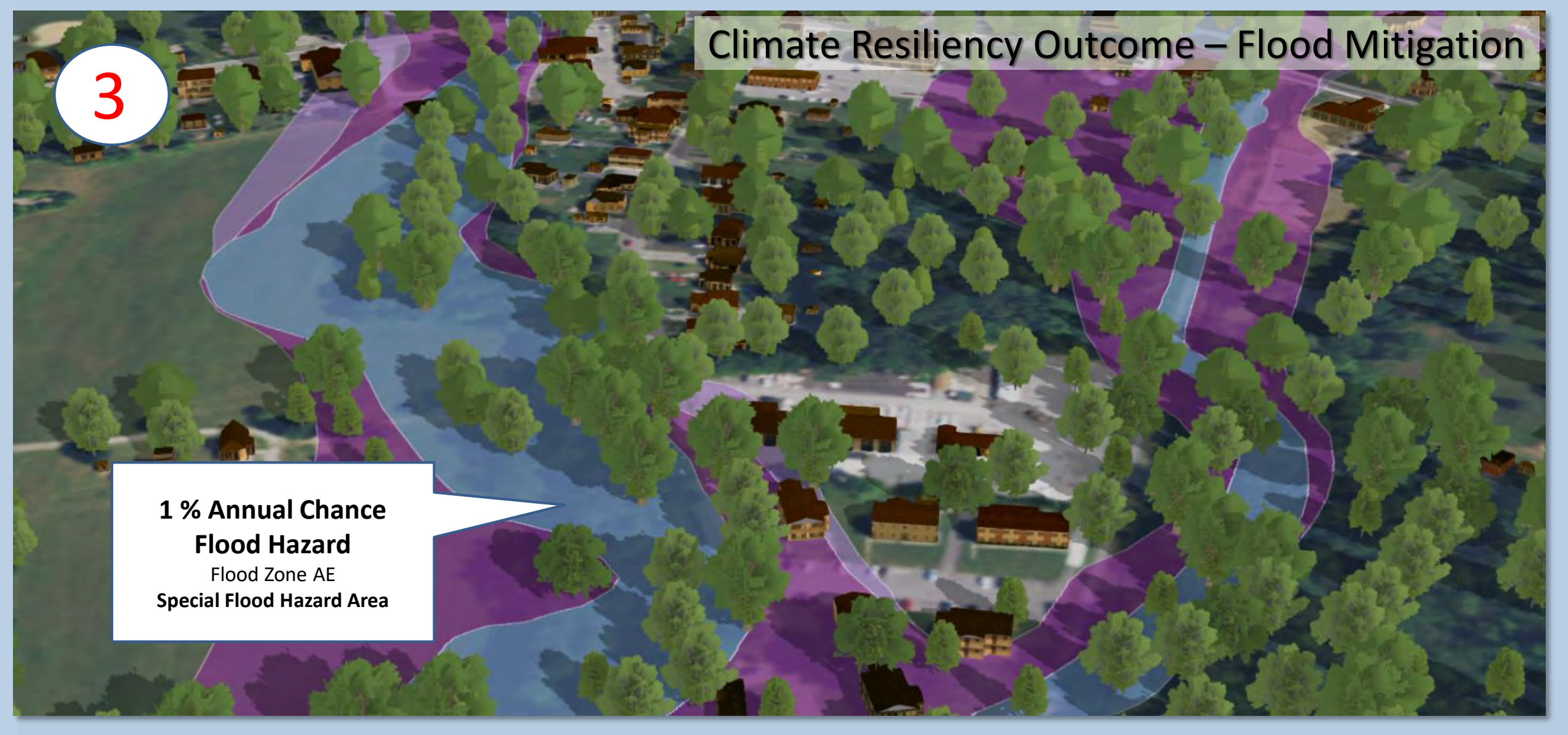


Figure 3. 3D landscape visualization of floodplain in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source of data: Frederick County, Maryland LiDAR and building footprint data.

Data-driven Landscapes

Conceptual diagrams (Figure 1a) have been shown to be an effective tool for science communication. Specifically, they:

- Provide synthesis, visualization, and context to scientific topics,
- Are accessible, informative, and visually interesting, and
- Facilitate communication among scientists, resource managers, and non-scientists (Thomas et al 2004).

However, conceptual diagrams are limited in their ability to convey place-based conditions without substantial investment of time in custom graphic design. They are best suited for applications where messaging is generic across an ecosystem and static images are the preferred form of communication.

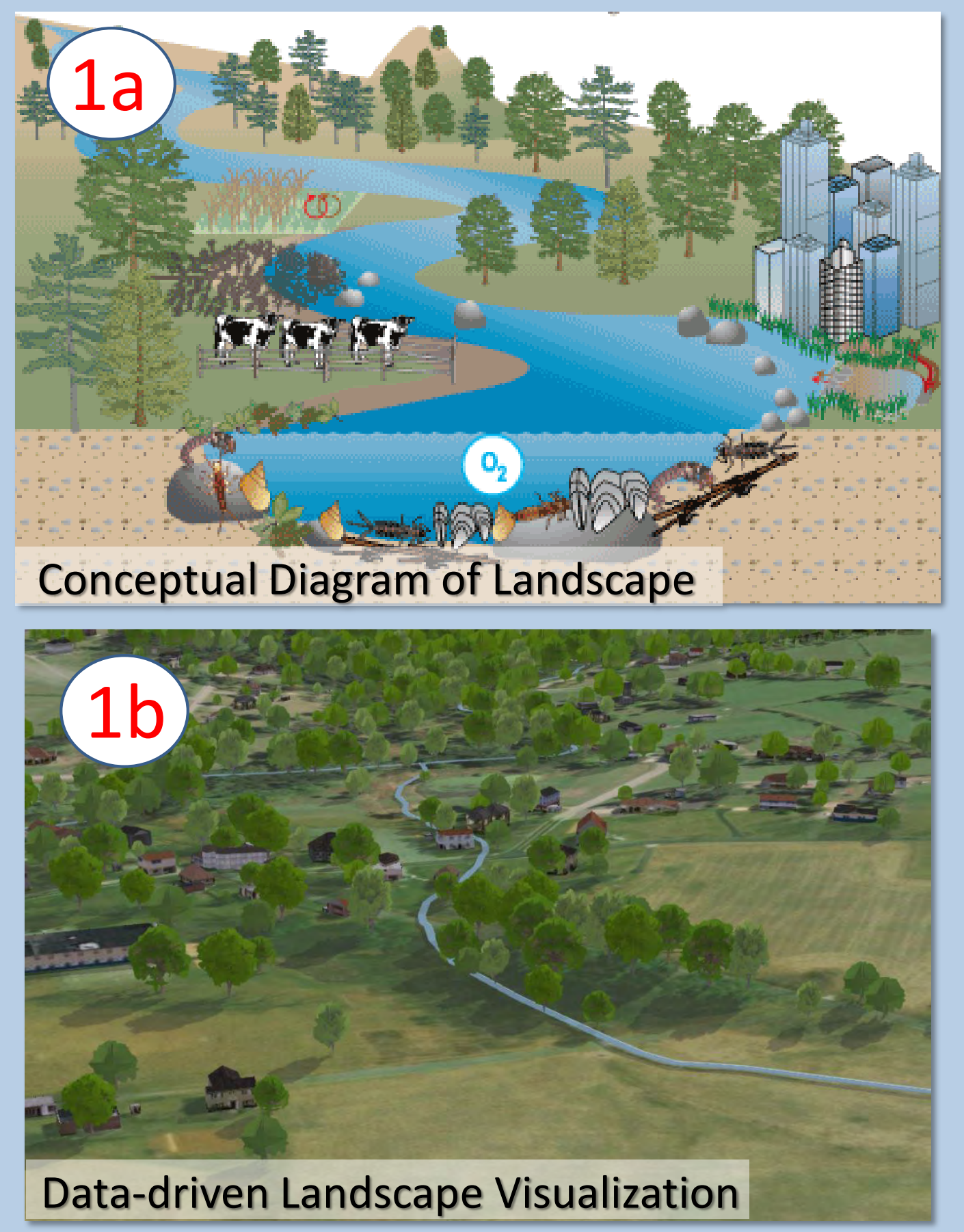


Figure 1. Comparison of conceptual diagram of a landscape/ecosystem (1a) and data-driven landscape (1b) . Source: 1a – Lane et al 2007; 1b – derived from Frederick County, Maryland LiDAR and Building Footprints.

Conversely, data-driven landscape visualizations (Figure 2) derived from elevation data and building footprints can be used to communicate place-based ecosystem characteristics without significant manual intervention. Essentially, once the data is assembled and formatted and symbolization rules are defined, large areas of landscapes can be depicted in 3D representing both existing and potential conditions.

Data-driven landscape visualizations:

- Are rendered based on procedural rules,
- Require LiDAR and building footprint data,
- Can be generated at various levels of detail.

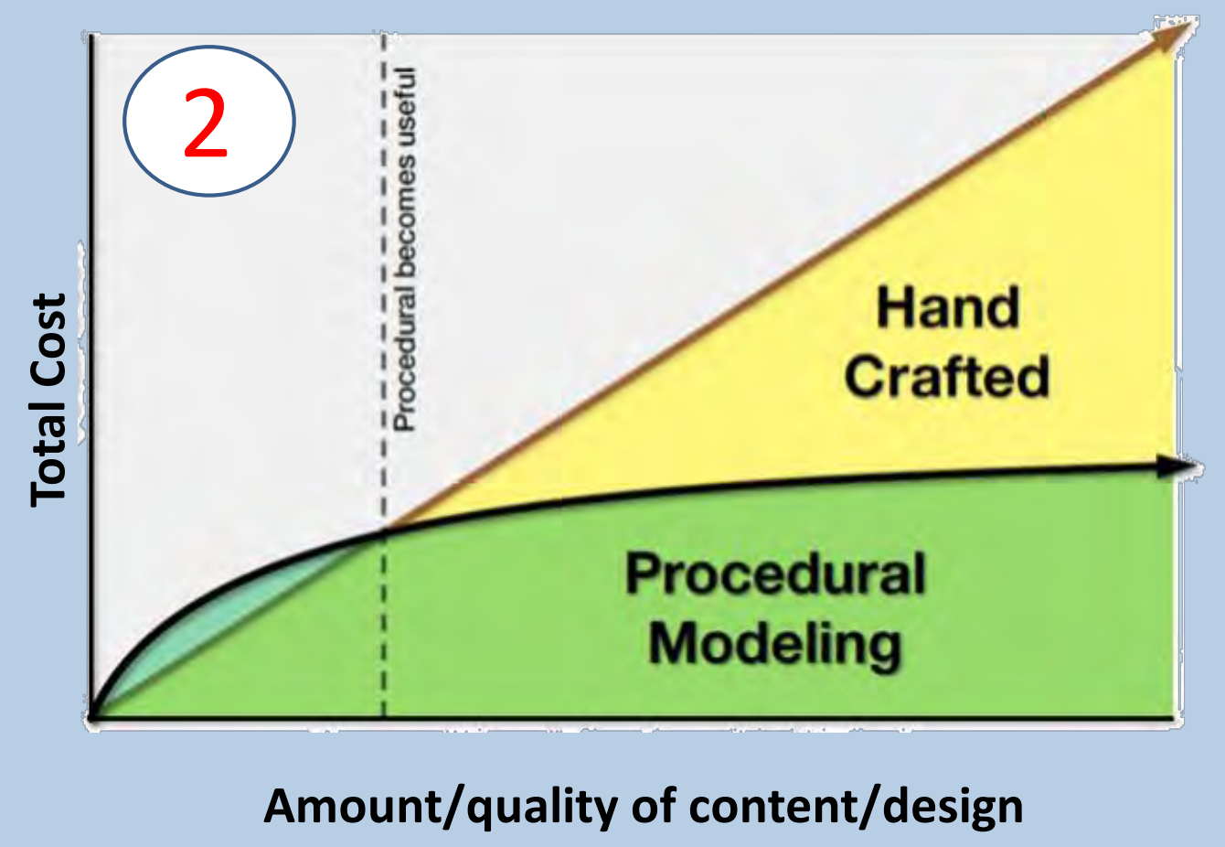


Figure 2. Cost relative to amount of effort in generating manual vs procedural landscapes. Source: Esri 2007.

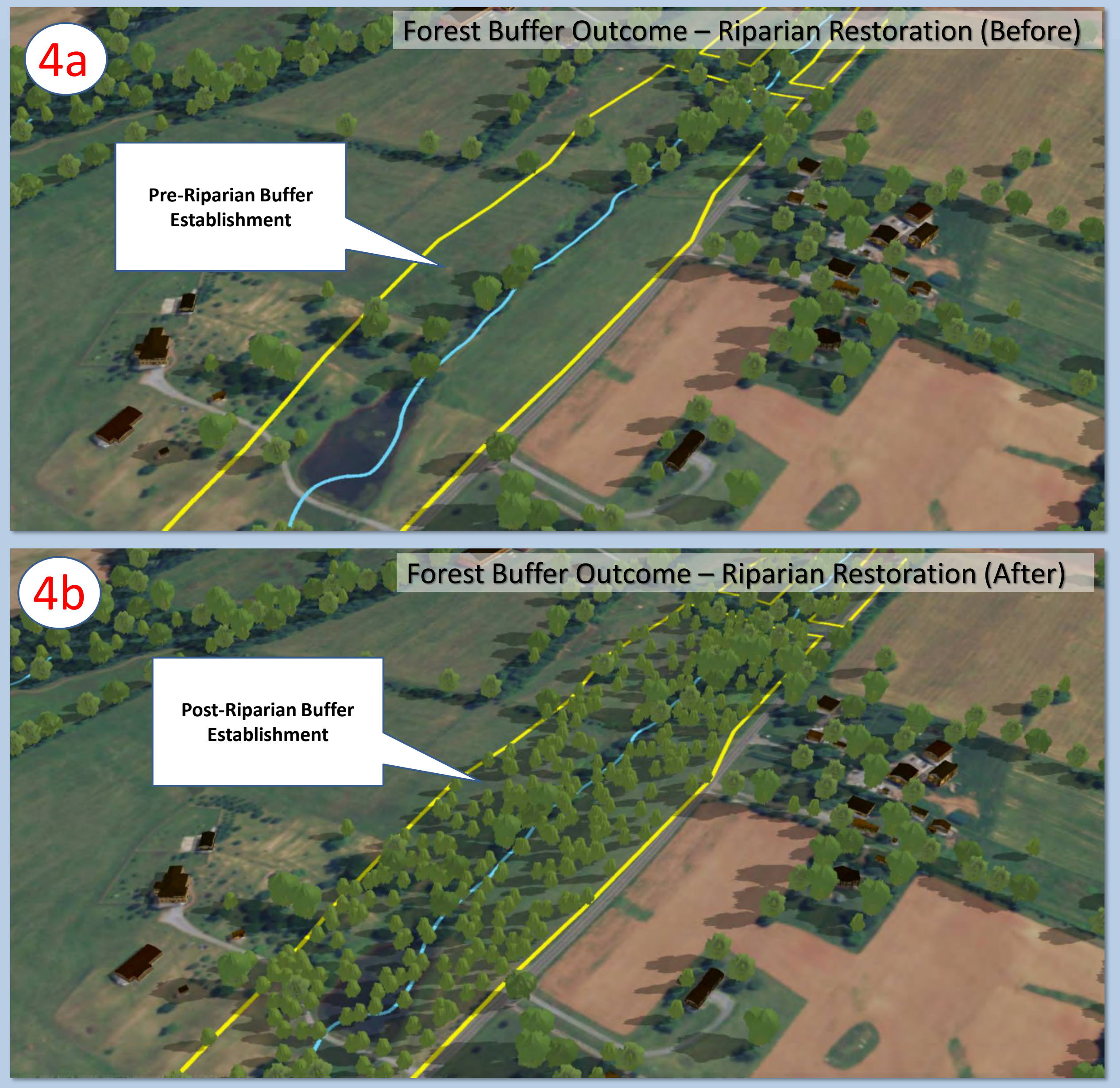
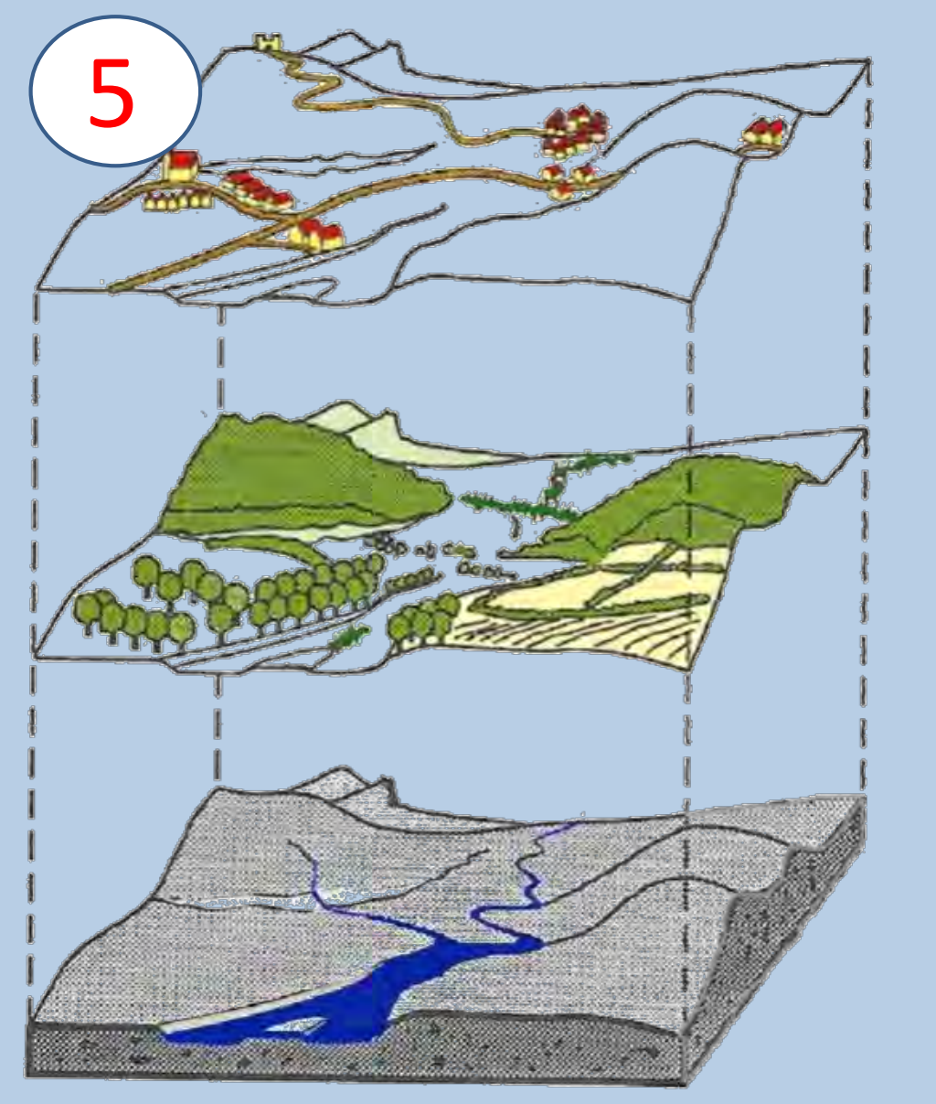


Figure 4. 3D landscape visualization of potential forest buffer restoration project in Hunting Creek Watershed in Frederick County, Maryland. Figure 4a shows before the restoration project occurred and 4b shows the restored riparian buffer. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source of data: Frederick County Maryland LiDAR and building footprint data.

Structural Elements of a 3D Base Map

The vertical dimension of landscapes is represented visually by distinguishing among terrain, vegetation, and cultural features (Figure 5). Each of these elements is derived independently from LiDAR source data, with building footprints used to separate buildings from vegetation.



Cultural Elements:
- Settlements
- Infrastructure
- Other built objects

Vegetation:
- Natural vegetation
- Agricultural land
- Greenways and landscape corridors
- Forests

Bio-physical Main Structures:
- Relief (topography, morphology)
- Hydrology

Figure 5. Landscape elements with vertical structure. Source: Walz et al 2016.

For More Information

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Next Steps

- ☐ Identify case study locations,
- ☐ Build visualizations,
- ☐ Design testing scenarios/quasi-experiments,
- ☐ Conduct user testing,
- ☐ Summarize results,
- ☐ Build story maps to communicate results, and
- ☐ Export scenes to virtual reality applications.

Potential Chesapeake Bay Watershed Application Areas

The Chesapeake Bay Watershed Agreement (CBWA) contains 10 Goals and 31 Outcomes that establish desired future conditions for a restored ecosystem. Many of these Goals and Outcomes involve manipulating the structural configuration of the landscape.

The Chesapeake Bay Program (CBP) Partnership has many stakeholders who, collectively, represent a diverse set of interests and technical knowledge. Given these diverse audiences, communicating science can be a challenge.

Examples of environmental issues that could be represented through landscape visualization include:

- Floodplain management (Climate Resiliency Outcome) (Figure 3),
- Riparian forest buffer establishment (Forest Buffer Outcome) (Figure 4a and 4b),
- Scenic landscape protection (Land Conservation Goal) (Figure 7),
- Wetlands protection and restoration (Wetlands Outcome) (Figure 8),
- Land change and development (Land Use Methods Outcome),
- Urban forests (Tree Canopy Outcome),
- Habitat connectivity (Vital Habitats and Stewardship Goal Teams),
- Bay grasses (Submerged Aquatic Vegetation Outcome),
- Fish passage (Fish Passage Outcome),
- Farm and forest land protection (Protected Lands Outcome),
- Stream health (Stream Health Outcome), and
- Sea level rise (Climate Resiliency Outcome).

Place vs. Space in Stakeholder Engagement

A fundamental premise of this research is that 3D landscape visualization is perceived differently by different audiences. In terms of human geography, "space" is often associated with the physical or natural elements of a landscape, whereas "place" incorporates social, cultural, historical, and personal factors (Dourish 2006). Space is concerned with the environment in general and policies that transcend specific localities. Conversely, place is concerned with the neighborhood, town, or community and is less focused on translating local conditions and issues to the broader geographic perspective (Figure 6).

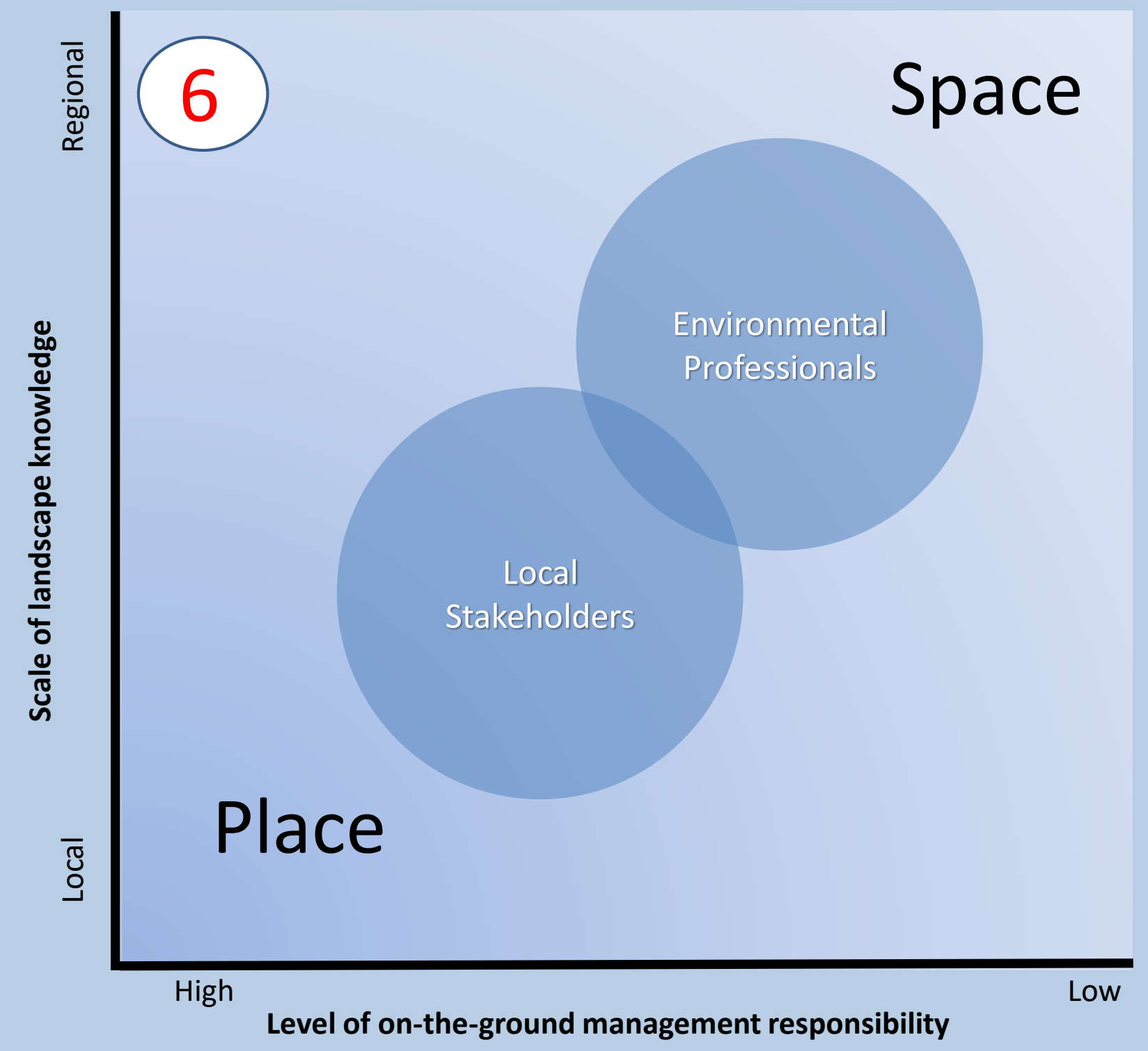

Figure 6. Potential perspectives of environmental professionals vs. local stakeholders regarding 3D landscapes and their use in communicating environmental issues. Modified from Price et al 2012.

Interactive Web Scenes

Interactive web scenes of the landscapes included in this poster are available at https://gis.chesapeakebay.net/viz/3dlandscape

Research Context and Questions

This research focuses on the use of 3D landscape visualization to communicate conservation and ecological restoration issues within the Chesapeake Bay watershed in the mid-Atlantic United States.

Specific research questions include the following:

- Is there a role for 3D mapping/landscape visualization to support science communication objectives?
- Under what circumstances and for what CBWA topics is it useful?
- Do different stakeholder groups (i.e., – scientists/environmental managers versus local stakeholders) perceive or value 3D mapping/landscape visualization differently?
- Are static images, animations, or interactive web scenes preferred?

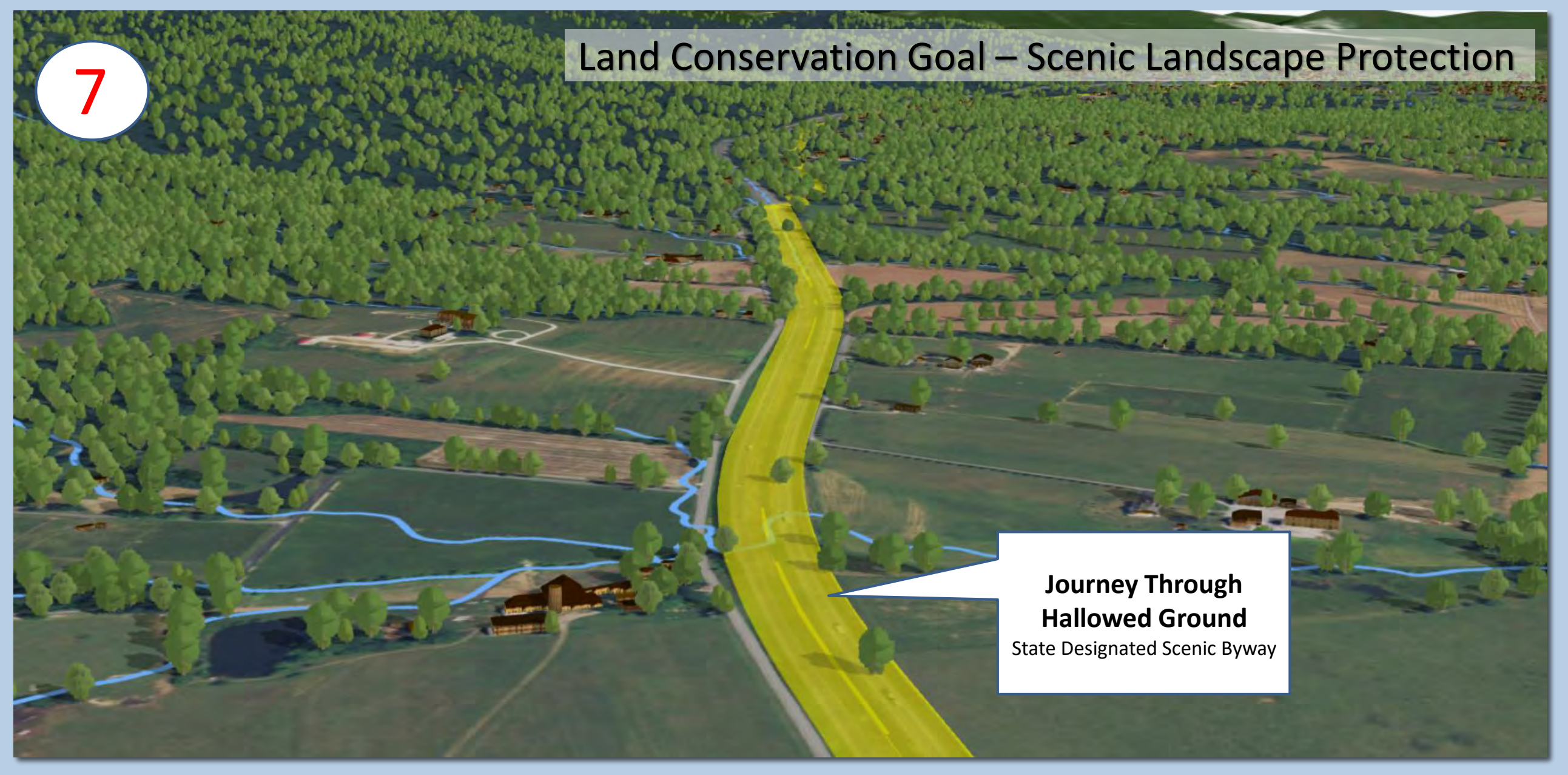

Figure 7. 3D landscape visualization of scenic byway in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source: Byway data – Maryland State Highway Administration.

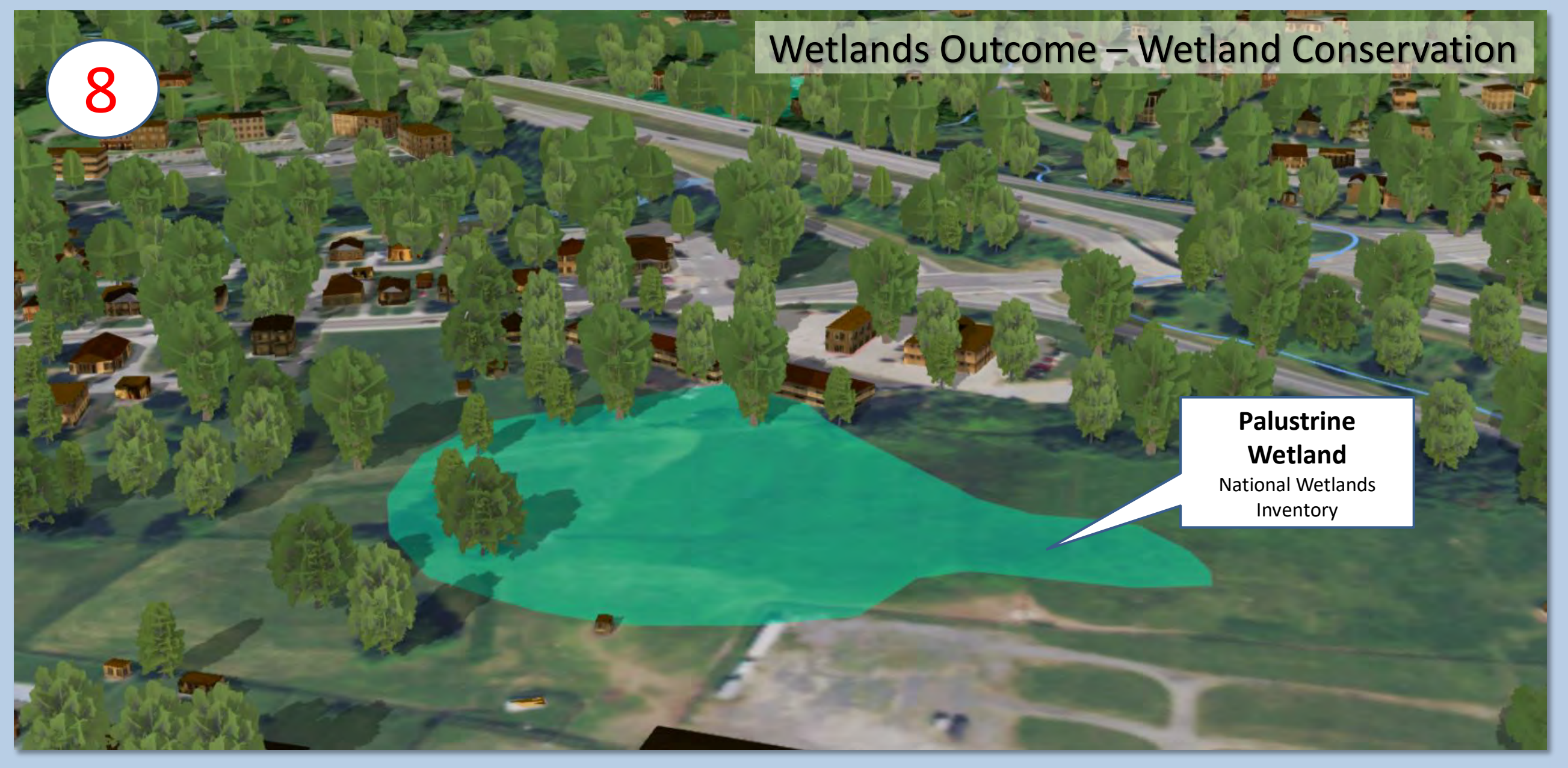

Figure 8. 3D landscape visualization of wetland in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source: ESRI USA Wetlands - wetlands of the United States from the National Wetlands Inventory produced by the US Fish and Wildlife Service.

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North American Cartographic Information Society Annual Conference
October 2019

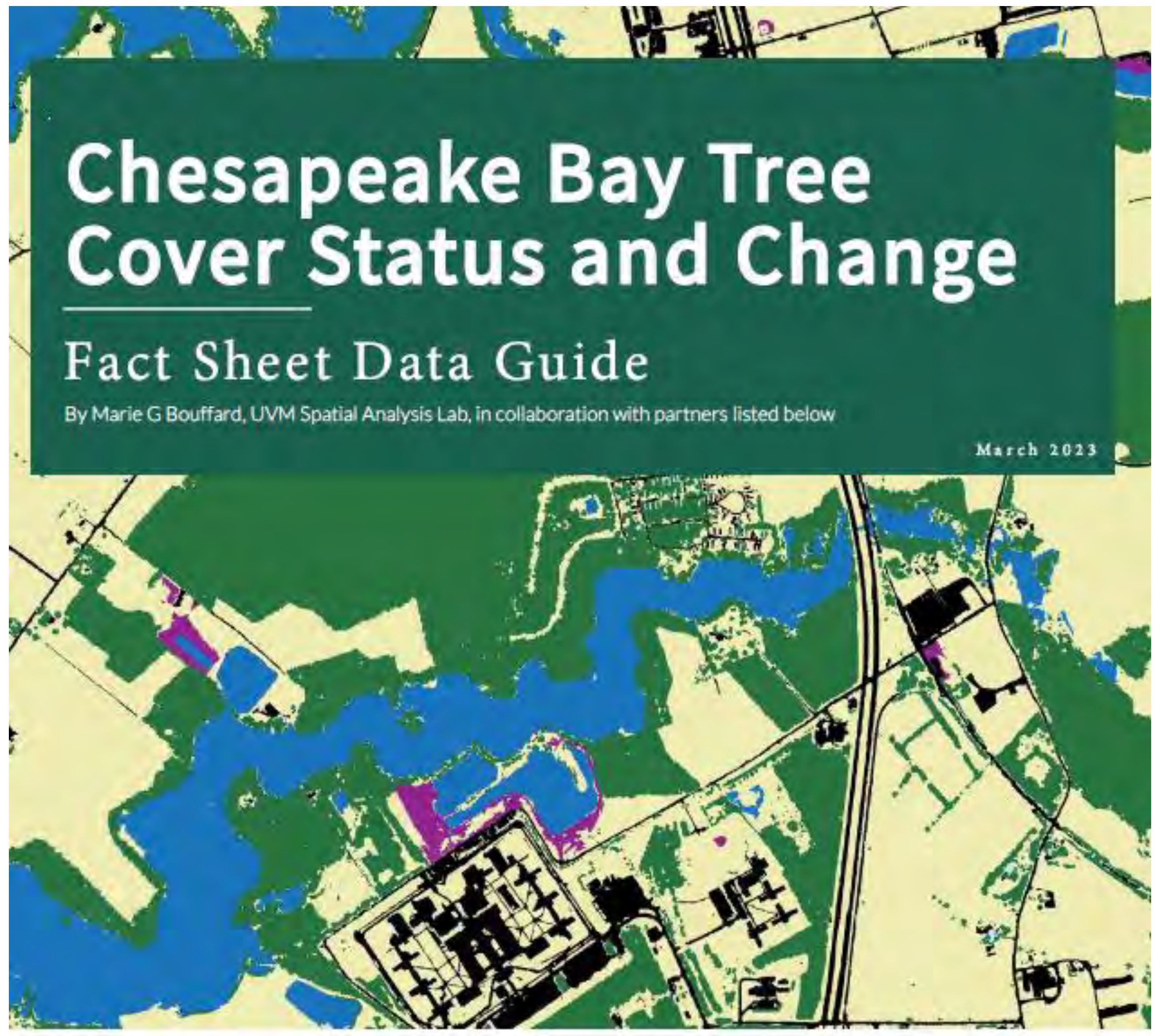
Chesapeake Tree Cover Status & Change Fact Sheets

Why do trees matter?

Trees provide numerous public benefits in the form of ecosystem services. Ecosystem services refer to all the ways we benefit from the services that healthy natural systems provide, such as improved air quality, reduced stormwater runoff, carbon sequestration, temperature regulation, and wildlife habitat.

Why map tree cover?

It is important to map and monitor tree cover change over time to detect trends that can inform management decisions. This information can be used to improve access to ecosystem services, decide where new trees should be planted, and ensure healthy tree cover for future generations.

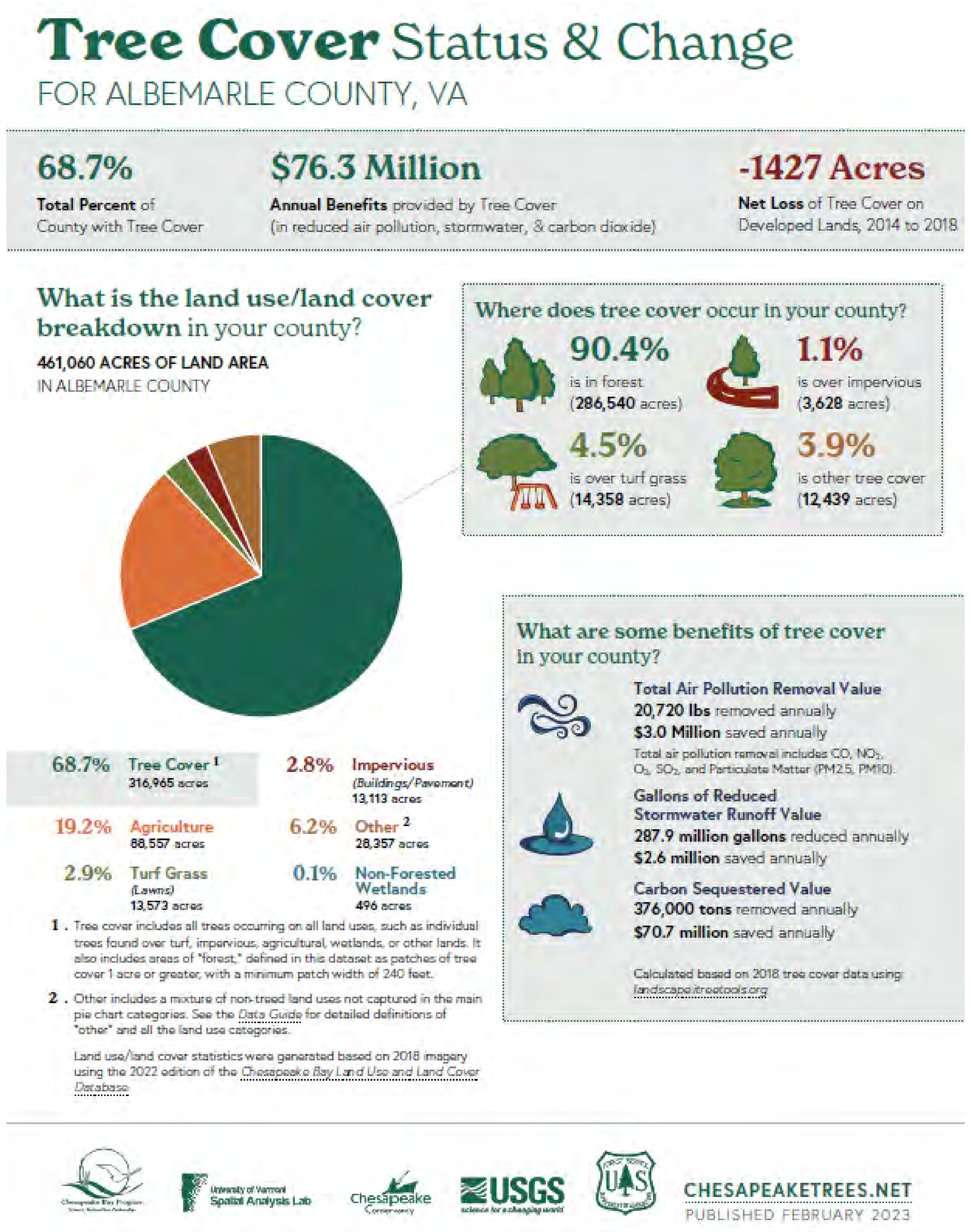


Chesapeake Bay Tree Cover Status and Change

Fact Sheet Data Guide

By Marie G Bouffard, UVM Spatial Analysis Lab, in collaboration with partners listed below

March 2023



Tree Cover Status & Change

FOR ALBEMARLE COUNTY, VA

68.7%
Total Percent of County with Tree Cover

$76.3 Million
Annual Benefits provided by Tree Cover (in reduced air pollution, stormwater, & carbon dioxide)

-1427 Acres
Net Loss of Tree Cover on Developed Lands, 2014 to 2018

What is the land use/land cover breakdown in your county?

461,060 ACRES OF LAND AREA
IN ALBEMARLE COUNTY

68.7%	Tree Cover [1] 316,965 acres	2.8%	Impervious *(Buildings/Pavement)* 13,113 acres
19.2%	Agriculture 88,557 acres	6.2%	Other [2] 28,357 acres
2.9%	Turf Grass *(Lawns)* 13,573 acres	0.1%	Non-Forested Wetlands 496 acres

1 . Tree cover includes all trees occuring on all land uses, such as individual trees found over turf, impervious, agricultural, wetlands, or other lands. It also includes areas of "forest," defined in this dataset as patches of tree cover 1 acre or greater, with a minimum patch width of 240 feet.

2 . Other includes a mixture of non-treed land uses not captured in the main pie chart categories. See the *Data Guide* for detailed definitions of "other" and all the land use categories.

Land use/land cover statistics were generated based on 2018 imagery using the 2022 edition of the *Chesapeake Bay Land Use and Land Cover Database*

Where does tree cover occur in your county?

90.4% is in forest (286,540 acres)	1.1% is over impervious (3,628 acres)
4.5% is over turf grass (14,358 acres)	3.9% is other tree cover (12,439 acres)

What are some benefits of tree cover in your county?

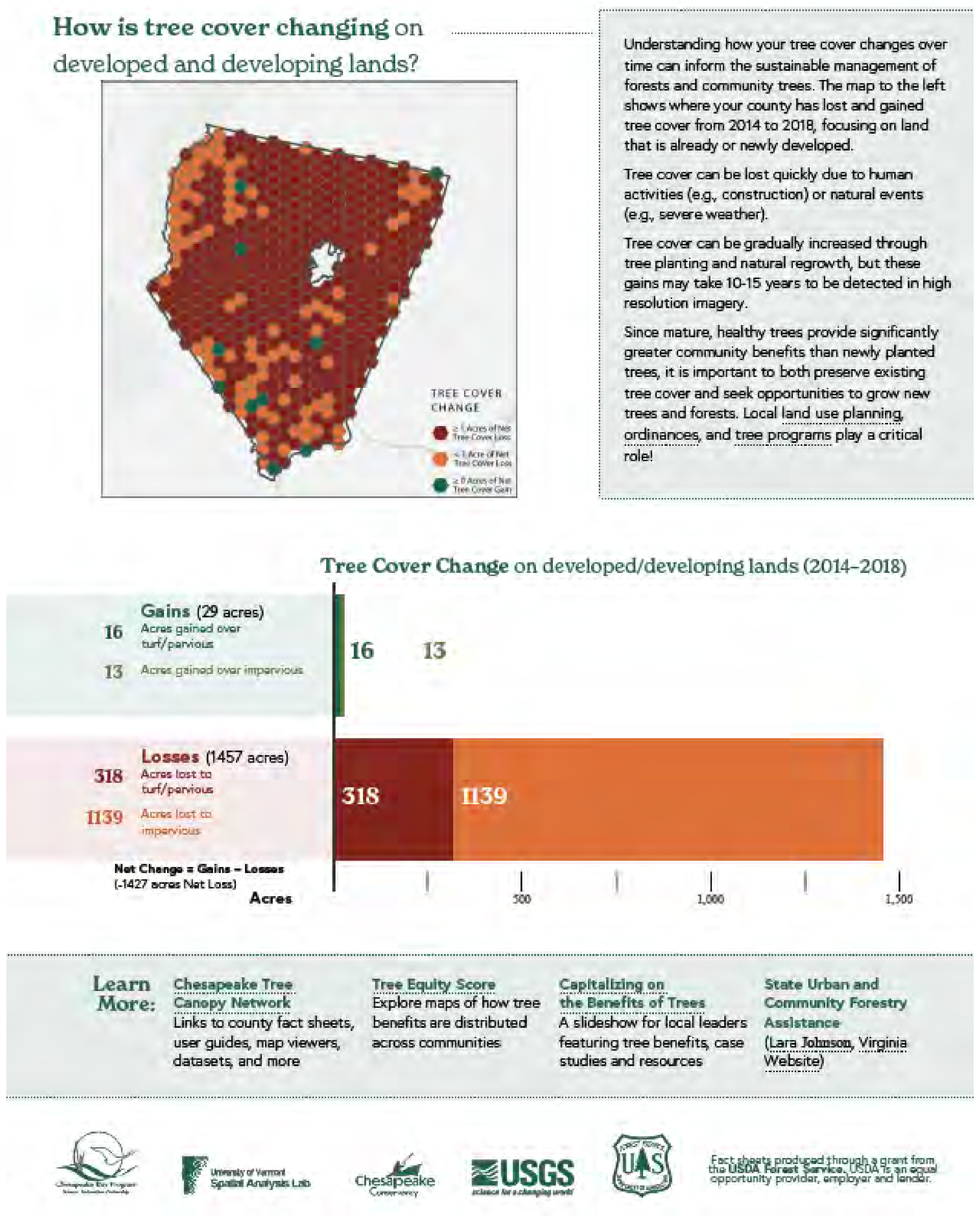
Total Air Pollution Removal Value
20,720 lbs removed annually
$3.0 Million saved annually
Total air pollution removal includes CO, NO_2, O_3, SO_2, and Particulate Matter (PM2.5, PM10).

Gallons of Reduced Stormwater Runoff Value
287.9 million gallons reduced annually
$2.6 million saved annually

Carbon Sequestered Value
376,000 tons removed annually
$70.7 million saved annually

Calculated based on 2018 tree cover data using: landscape.itreetools.org

CHESAPEAKETREES.NET
PUBLISHED FEBRUARY 2023



How is tree cover changing on developed and developing lands?

Understanding how your tree cover changes over time can inform the sustainable management of forests and community trees. The map to the left shows where your county has lost and gained tree cover from 2014 to 2018, focusing on land that is already or newly developed.

Tree cover can be lost quickly due to human activities (e.g., construction) or natural events (e.g., severe weather).

Tree cover can be gradually increased through tree planting and natural regrowth, but these gains may take 10-15 years to be detected in high resolution imagery.

Since mature, healthy trees provide significantly greater community benefits than newly planted trees, it is important to both preserve existing tree cover and seek opportunities to grow new trees and forests. Local land use planning, ordinances, and tree programs play a critical role!

Tree Cover Change on developed/developing lands (2014–2018)

Gains (29 acres)
16 Acres gained over turf/pervious
13 Acres gained over impervious

Losses (1457 acres)
318 Acres lost to turf/pervious
1139 Acres lost to impervious

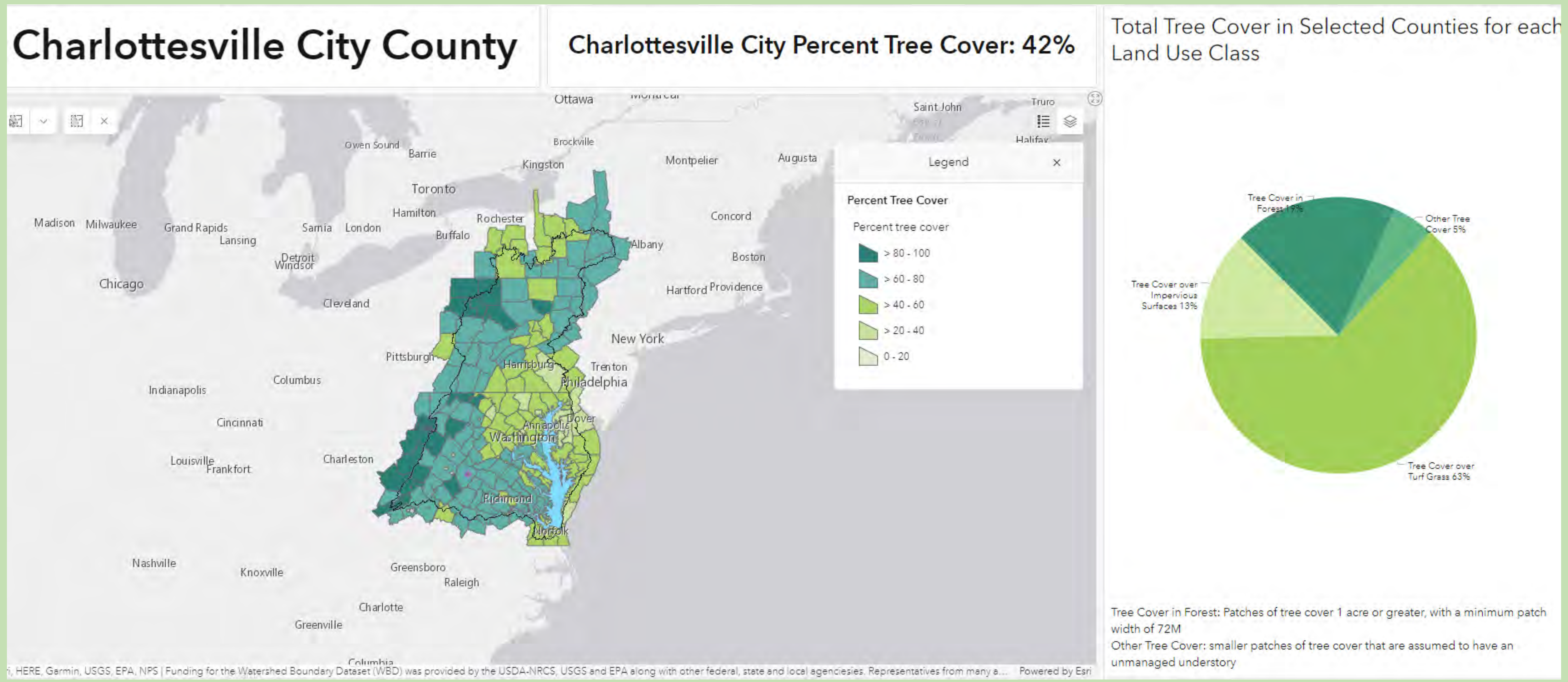
Net Change = Gains – Losses
(-1427 acres Net Loss)

Learn More:

Chesapeake Tree Canopy Network Links to county fact sheets, user guides, map viewers, datasets, and more	**Tree Equity Score** Explore maps of how tree benefits are distributed across communities	**Capitalizing on the Benefits of Trees** A slideshow for local leaders featuring tree benefits, case studies and resources	**State Urban and Community Forestry Assistance** (Lara Johnson, Virginia Website)

Fact sheets produced through a grant from the USDA Forest Service. USDA is an equal opportunity provider, employer and lender.

Coming Soon: State of Chesapeake Forests Storymap



Charlottesville City County

Charlottesville City Percent Tree Cover: 42%

Total Tree Cover in Selected Counties for each Land Use Class

i, HERE, Garmin, USGS, EPA, NPS | Funding for the Watershed Boundary Dataset (WBD) was provided by the USDA-NRCS, USGS and EPA along with other federal, state and local agenciesies. Representatives from many a... Powered by Esri

Tree Cover in Forest: Patches of tree cover 1 acre or greater, with a minimum patch width of 72M
Other Tree Cover: smaller patches of tree cover that are assumed to have an unmanaged understory

SCAN ME

Find your County Tree Cover Fact Sheet!

Access the Fact Sheet Data Guide

SCAN ME

Rising Water Temperature in Chesapeake Bay and Watershed

Management Responses to Ecological Impacts

Watershed Recommendations

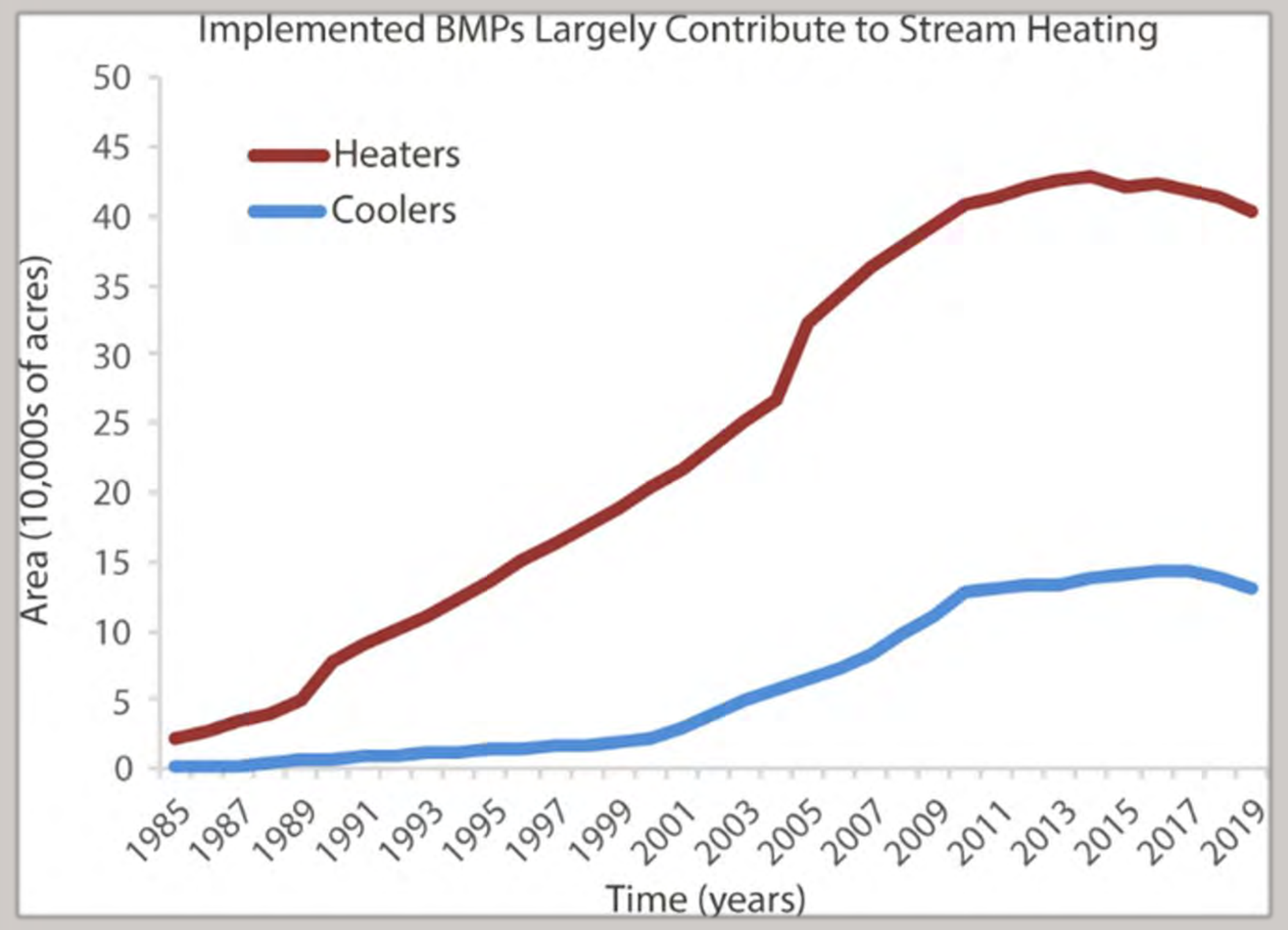
Moderate water temperatures through cooling strategies

Protect Coldwater fisheries

- Accelerate conservation actions like:
  - Maintain and increase intact forested watersheds to protect the Coldwater streams now supporting healthy and vulnerable aquatic life (e.g., brook trout).
  - Continue analyses and mapping/modeling to identify stream reaches with thermally resilient groundwater inputs for targeting habitat restoration efforts.

Restore Aquatic Habitats in Urban Streams and Rural Watersheds

- Strategically conserve and restore aquatic habitats which:
  - Improves connectivity between healthy forested habitats
  - Provides access to thermal refugia.



Modernize Water Quality Standards (WQS)

- Update current WQS to strengthen capabilities to address climate-related rising water temperatures and drive targeted protection and restoration strategies.

Enhance "Cooler" Reduce "Heater" Best Management Practices

- Minimize the extent that some water quality BMPs further heat waterways.
- Use cooler BMPs (e.g., forest buffers, good agricultural stewardship practices, stormwater infiltration) to reduce the amount of heated runoff.

Drivers and Ecosystem-Level Impacts

Nontidal Waters in the Watershed

Water temperatures are rising in the Chesapeake Bay Watershed

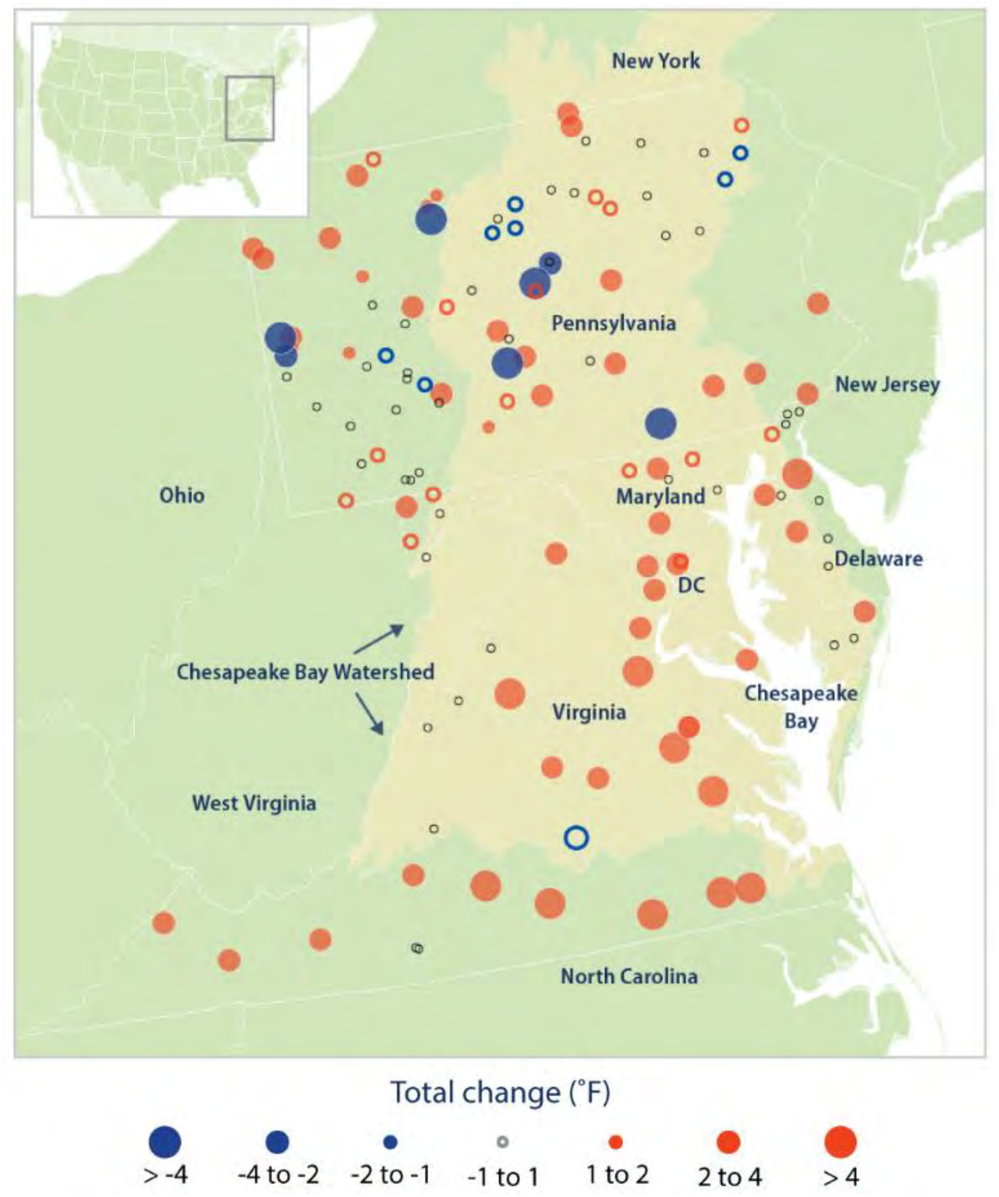
- Land use has a significant impact on temperatures of stream flow and precipitation-induced runoff from land surfaces.
- Trees and riparian forests play a central role in stream temperature moderation.

Water temperatures can affect sensitive species

- Economically and ecologically important aquatic species (e.g., brook trout) are negatively impacted by warming water temperatures and extreme heat events.

Stream temperature monitoring is critical

- Monitoring and analysis strategies need updating in the light of climate and land use change.
  - E.g., higher-frequency monitoring during critical periods to understand impacts.

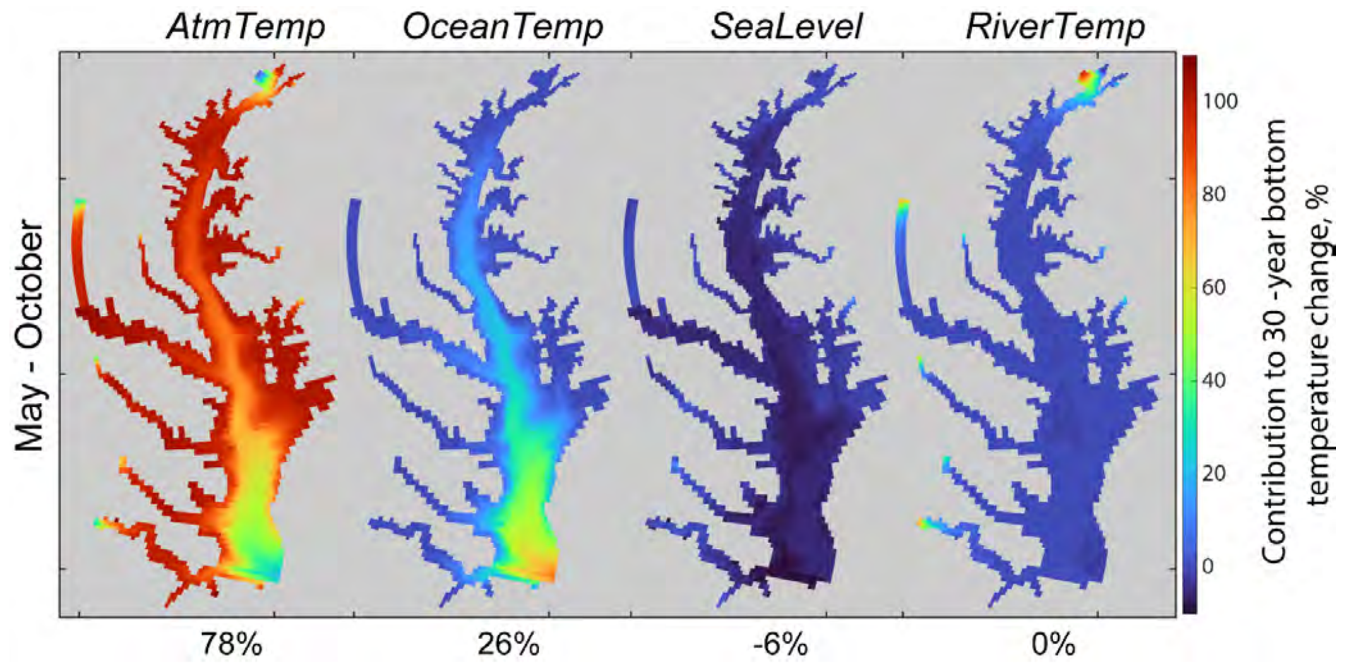


Rice, K. C., & Jastram, J. D. (2015). Rising air and stream-water temperatures in Chesapeake Bay region, USA. *Climatic Change*, *128*, 127-138.

Tidal Bay and Tributaries

Tidal water temperatures are rising in the Bay

- Changes in tidal water temperatures are primarily driven by global atmospheric forcing (e.g., increasing air temperatures) and the warming ocean boundary.



Hinson, K. E., Friedrichs, M. A., St-Laurent, P., Da, F., & Najjar, R. G. (2022). Extent and causes of Chesapeake Bay warming. *JAWRA Journal of the American Water Resources Association*, *58*(6), 805-825.

Species	Impacts
Blue Crab 	+ Higher productivity; reduced winter mortality − Reduced habitat; increased predation
Eastern Oyster 	+ Longer spawning season; more food − Additional stressors on vulnerable populations
Striped Bass 	+ Increased growth rates − Seasonal shifts; unsuitable temps; reduced habitat

Ecological implications

- Key species are predicted to experience negative and positive effects depending on sensitivities, life stage, and habitat requirements in different locations within the estuary.

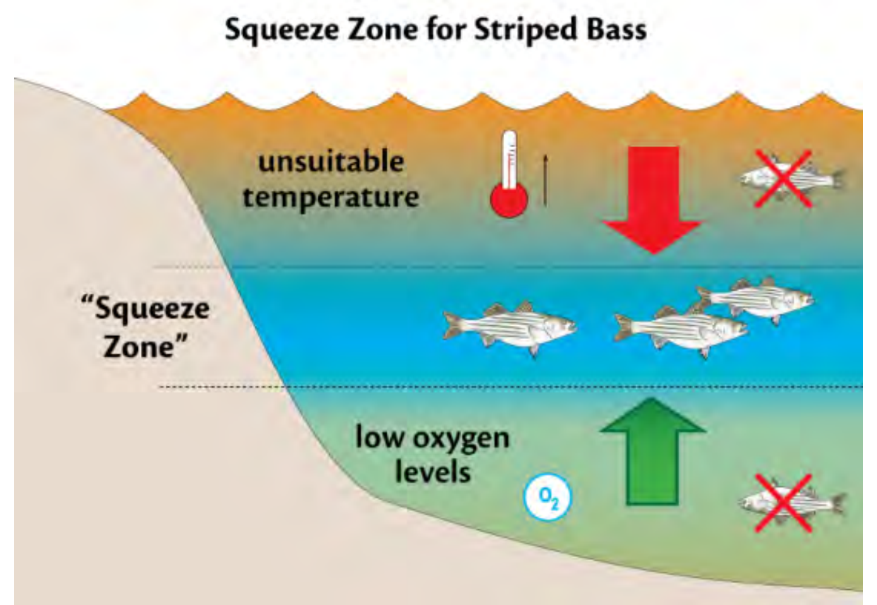


Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Boesch 2008.

- Heat-tolerant widgeongrass will likely be dominant, while eelgrass will likely disappear.
- Northward shifts in key fish species range and changes in Bay habitat suitability (e.g., squeeze zone; loss in marsh and seagrass habitat).
- Species from the south becoming more prevalent.

Tidal Recommendations

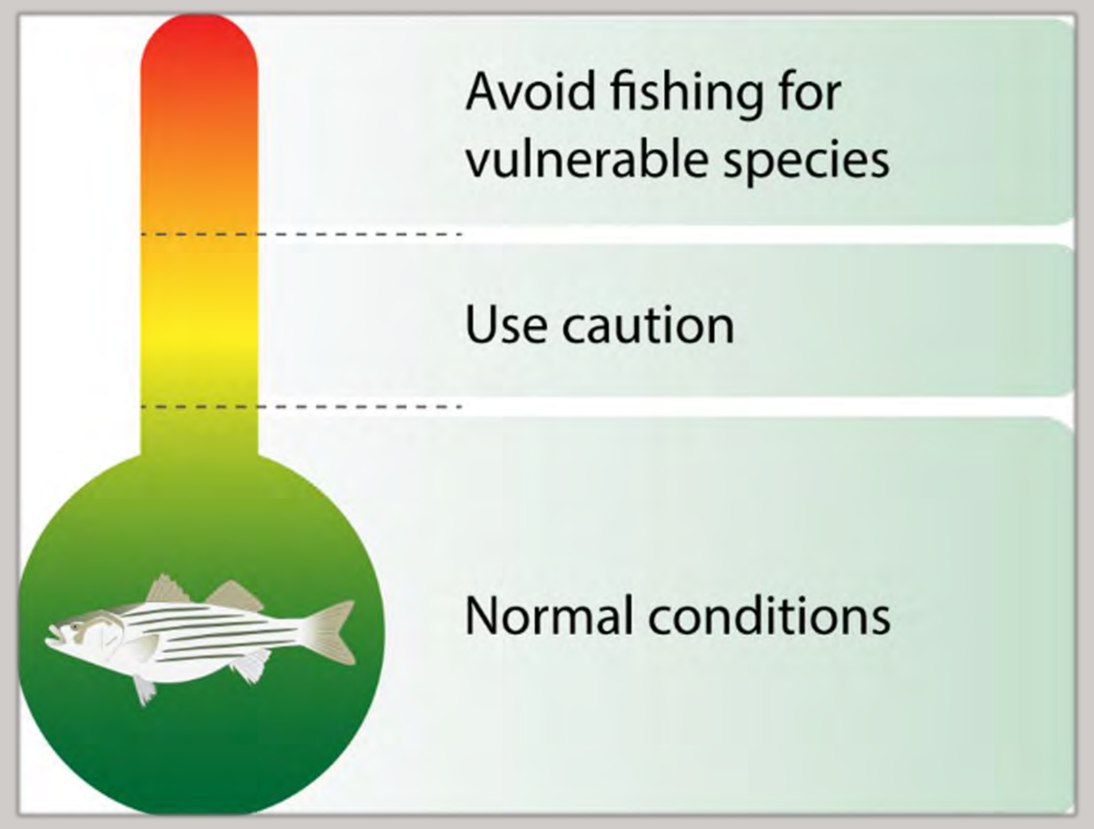
Minimize impacts to the Chesapeake Bay and adapt management

Apply Bay environmental thresholds to inform fisheries management

- Establish fishing guidance based on temperature and dissolved oxygen thresholds to reduce vulnerability on key recreational fish species (e.g., striped bass, summer flounder).
- Engage with fisheries stakeholders to explore incorporation of environmental thresholds influenced by climate change to inform fisheries management in the Bay.

Communicate Temperature Risk

- Better communicate the impacts of rising water temperatures and expected scenarios for existing and future seagrass community structure and Bay fisheries.



Avoid fishing for vulnerable species

Use caution

Normal conditions

Create heat wave alert system

- Collaborate with scientists, resource managers, meteorologists, and communicators to develop a publicly available marine heat wave alert system connected to key fisheries species and seagrass habitat. Consider incorporating other key parameters (e.g., dissolved oxygen, salinity).

Target nearshore projects

- Develop common criteria and metrics to help target, site, and design natural infrastructure projects and implement in the nearshore, where ecological, community, and climate resilience benefits are maximized across multiple habitat types, such as oyster reefs, underwater seagrass beds, and marshes.

Scan to go to the full STAC Rising Water Temperature Workshop Report

Scan to go to the UMCES Workshop Summary

Moving Forward

Increase Trees
Better communicate the benefits of conserving mature trees and don't just rely on new tree planting.

Updated Standards
State water quality standards need to address climate-related changes to water temperature.

Adapt Fisheries
Future management and monitoring of fisheries must adapt as fisheries change with rising water temperatures.

Prioritize BMPs
Implement cooling BMPs/natural infrastructure that reduce heated runoff from developed areas, farms, & forests.

Target Restoration
Factor rising water temperatures into our tools for targeting the lands to conserve and where to apply BMPs.

Communicate
Help people to understand why water temperatures are rising and what they can do about it.

Land-sea opportunities
Consider shorelines/nearshore environments for restoration and habitat protection of at-risk species.

STAC Report Authors &Acknowledgements

Thank you to our STAC workshop steering committee members: Bill Dennison, co-chair, UMCES (Member, CBP STAC; and co-chair, CBP STAR Team); Rebecca Hanmer, co-chair USEPA retired (Chair, CBP Forestry Workgroup); Rich Batiuk, USEPA retired (CoastWise Partners); Frank Borsuk, USEPA Freshwater Fisheries Biologist; Katherine Brownson, U.S. Forest Service; Matthew Ernhart, Stroud Water Research Center (Member, CBP Citizens Advisory Committee); Scott Phillips, USGS (co-chair, CBP Scientific, Technical Assessment, and Reporting Team); Julie Reichert-Nguyen, NOAA CBO (Coordinator, CBP Climate Resiliency Workgroup); Renee Thompson, USGS (Coordinator, CBP Healthy Watersheds Goal Implementation Team); Bruce Vogt, NOAA CBO (Coordinator, CBP Sustainable Fisheries Goal Implementation Team).

Plastic Pollution: An Emerging Issue That Should Be Considered By The Chesapeake Bay Program For 2025 And Beyond

Kelly Somers, US EPA Region 3; Kristin Saunders, UMCES; Matt Robinson, US EPA Region 3; Bob Murphy, Tetra Tech

The Problem with Plastics

Research in the Chesapeake Bay indicates this emerging problem is extensive and could impact human health and the environment

- 100% of samples (n=30) collected by Bikker et al. (2020) in the Chesapeake Bay mainstem contained microplastics. Highest concentrations found in urban and suburban tributaries.
- Murphy et al. (2022) surveyed the Anacostia and Potomac Rivers and found microplastics in all trophic levels with the dominant particle type being fiber. 23% of fish collected (n=200) had microplastics in their stomach contents.
- Lopez et al. (2021) showed through modeling that the Chesapeake Bay could serve as a major sink for plastic pollution.

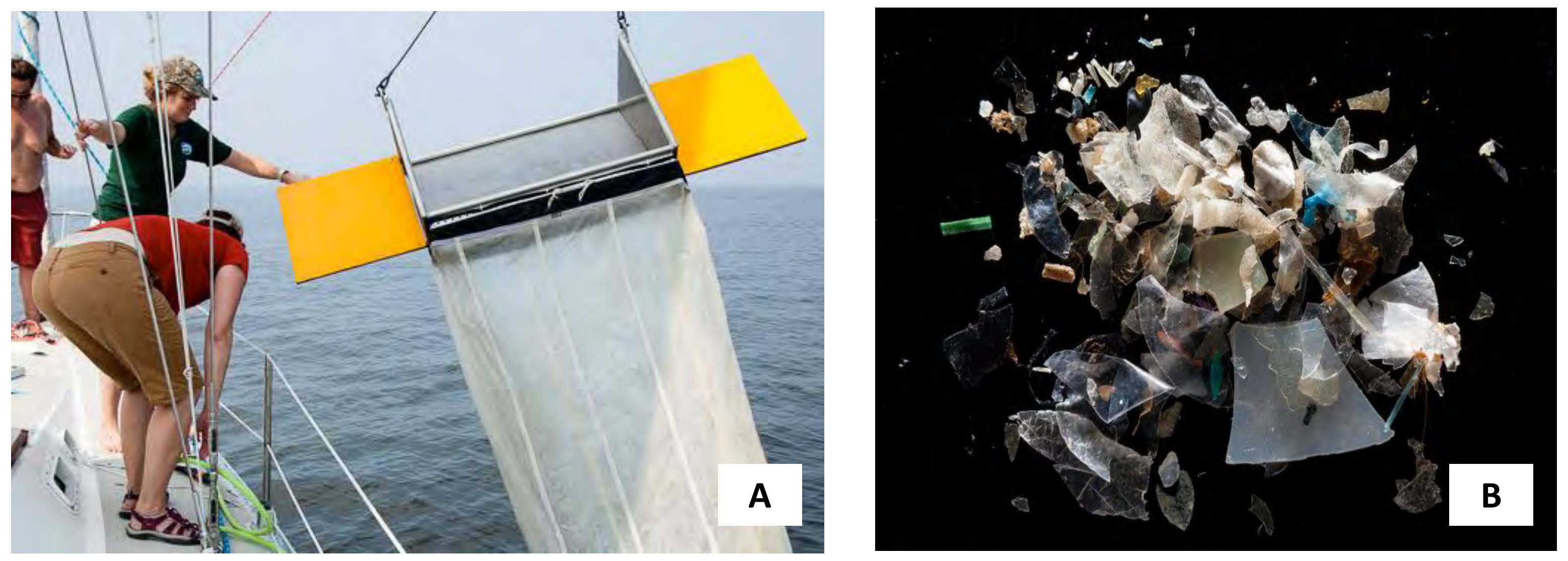


Figure 1 – (A) Sampling for microplastics with manta trawl in Chesapeake Bay; (B) Microplastics collected from the Magothy River (Photos: Will Parson, Chesapeake Bay Program Office)

The Plastic Pollution Action Team

- The Plastic Pollution Action team was formed in response to a 2019 STAC led workshop assessing the state of knowledge, data gaps and relationships to management.
- The Plastic Pollution Action Team reports to the Chesapeake Bay's Management Board with support from the STAC and the STAR
- The PPAT is multi-disciplinary group of experts that have representation from the federal, state, local, NGO, private and academia sectors.
- The PPAT seeks to reduce the presence and impacts of plastic pollution on the CB.
- The PPAT meets periodically to:
  - discuss updates on ecological risk research being conducted;
  - provide guidance to research supporting PPAT goals;
  - Update as needed the science strategy to address questions and research gaps discovered during execution of ecological risk research;
  - Discuss current source reduction efforts or policies;
  - Report out to CBP groups for feedback as requested including MB, STAR, STAC, Goal Implementation Teams, the Integrated Monitoring Networks Workgroup, and Toxics Workgroup

New and Ongoing PPAT Work

The PPAT will continue to provide technical oversite to new and ongoing projects in 2023-2024.

1. Development of ecological risk assessment of plastic pollution exposure in Striped Bass (*Morone saxatilis*) in the Chesapeake Bay and its tributaries.
2. Develop a monitoring and analytical reference guide and monitoring strategy for plastic pollution in the Chesapeake Bay watershed.
3. Develop a source reduction strategy for plastic pollution in the Chesapeake Bay watershed.

Results from Ecological Risk Assessment

Microplastics have been found to impact feeding, respiration, growth, and immune response in coastal fish species. Since 2020, The PPAT has been developing an ecological risk assessment (ERA) examining the impacts of microplastics on Striped Bass (*Morone saxatilis*). The PPAT chose to focus on this endpoint given its role as an apex predator in the Chesapeake Bay and its importance as a recreational and commercial fishery species.

There are three phases to the development of the ERA:

Phase 1: Development of quantitative food web models to identify the most important prey species to Striped Bass

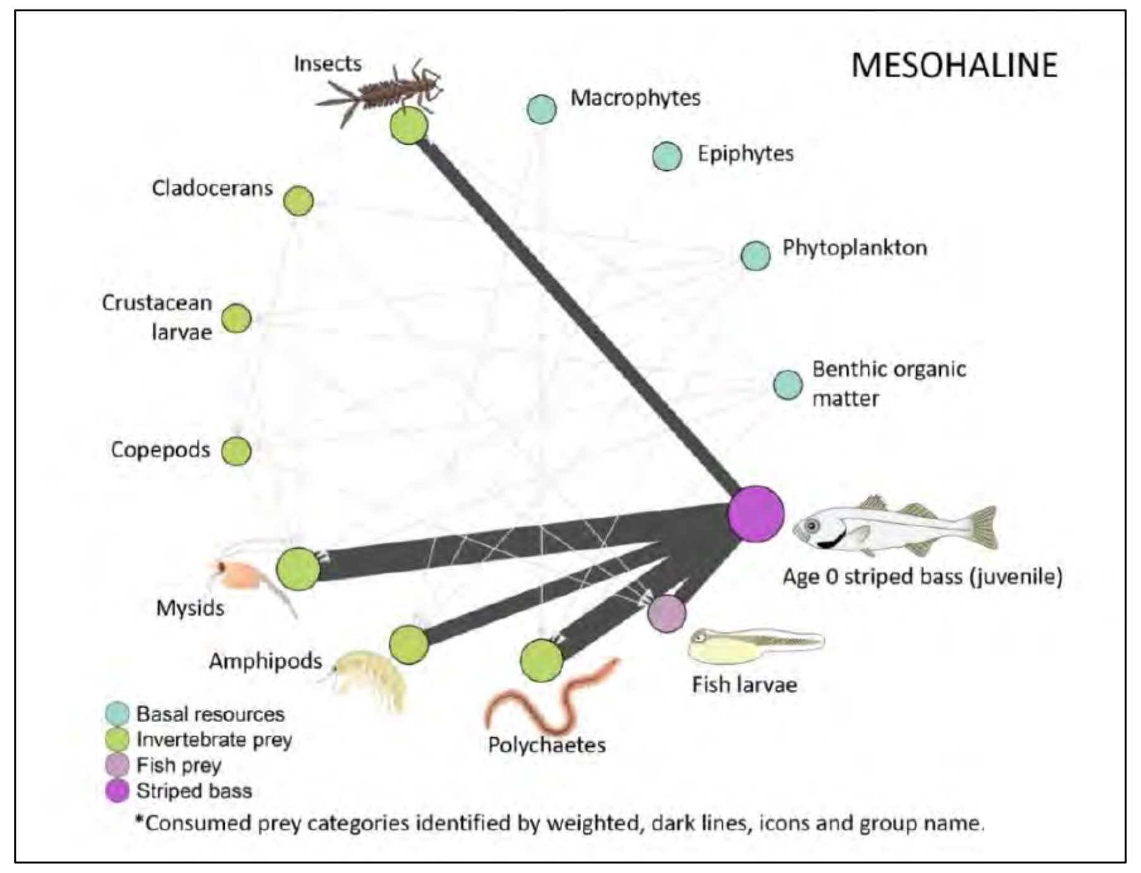


Figure 2 – Quantitative food web model developed by Murphy et. al (2021) for Striped Bass in the mesohaline portion of the Potomac River. Similar models were developed for other salinity zones throughout the river and the bay mainstem.

Phase 2: Literature review to identify which prey species have been found to contain microplastic

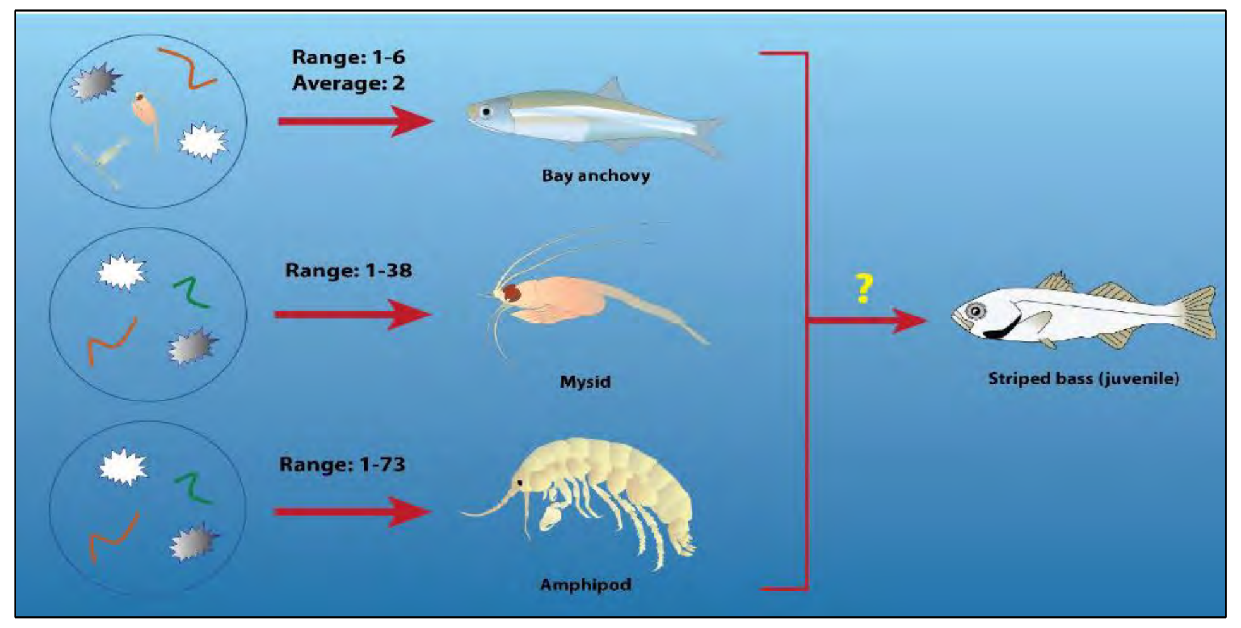
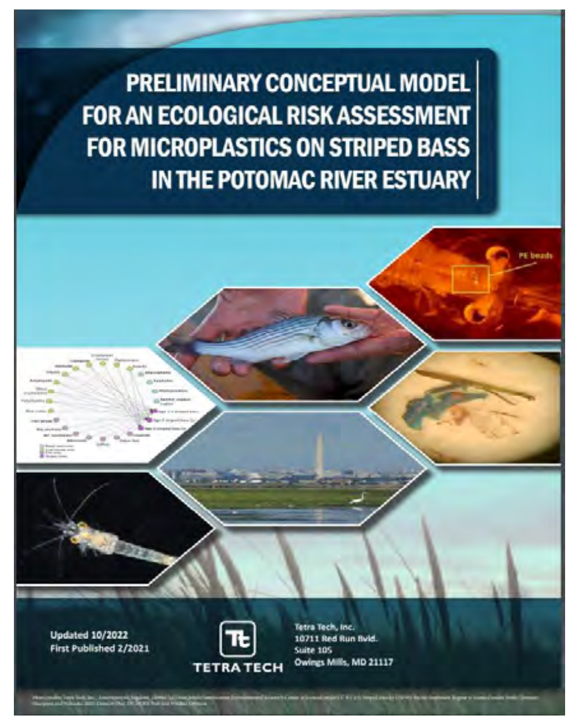


Figure 3 – Graphic displaying major prey species for Striped Bass identified by the semi - quantitative food web models. A literature review of studies performed outside the CB has shown these species to be contaminated with microplastics (Murphy et. al 2022).

Phase 3: Contextualize the risk – Determine through experimentation the physiological impacts of microplastic consumption on Striped Bass.

Next Steps: EPA Region III is working with Tetra Tech and the Chesapeake Biological Lab to sample one prey species in the Chesapeake Bay, mysid shrimp, for microplastics and conduct feeding experiments with Striped Bass in the lab to determine impacts from eating prey contaminated with microplastics.

PPAT Supported Publications



PRELIMINARY CONCEPTUAL MODEL
FOR AN ECOLOGICAL RISK ASSESSMENT
FOR MICROPLASTICS ON STRIPED BASS
IN THE POTOMAC RIVER ESTUARY

Updated 10/2022
First Published 2/2021

TETRA TECH

Tetra Tech, Inc.
10711 Red Run Blvd.
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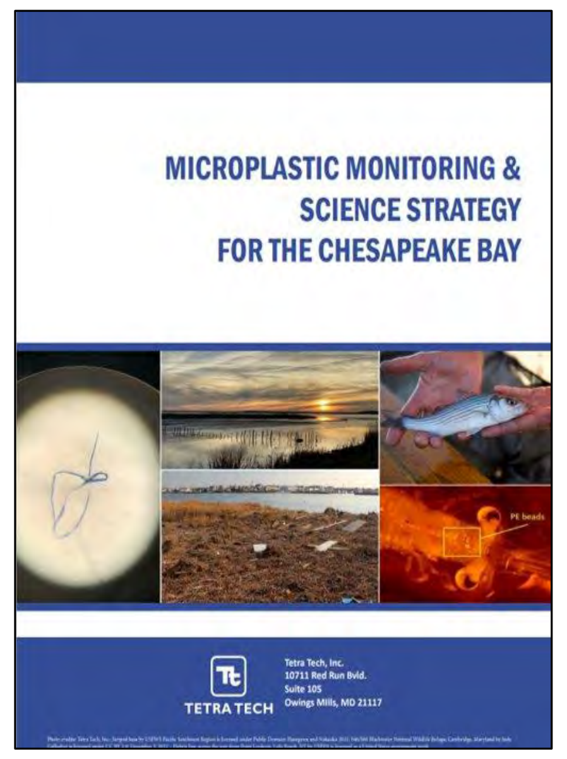
Owings Mills, MD 21117

Potential Linkages between Microplastics and 2014 Chesapeake Bay Watershed Agreement Outcomes

Tetra Tech, Inc.
August 1, 2022

TETRA TECH

Prepared by:
Paige Hobaugh
Bob Murphy



MICROPLASTIC MONITORING &
SCIENCE STRATEGY
FOR THE CHESAPEAKE BAY

TETRA TECH

Tetra Tech, Inc.
10711 Red Run Blvd.
Suite 105
Owings Mills, MD 21117

The Plastic Pollution Action Team has provided technical oversite and review of the reports which were funded by the EPA R3 Water Division and completed through a contract with Tetra Tech. Copies of all documents can be found on the PPAT webpage: https://www.chesapeakebay.net/who/group/plastic-pollution-action-team

1. Preliminary Conceptual Model for an Ecological Risk Assessment (ERA) for Microplastics (MP) on Striped Bass in the Potomac River Estuary (Published 2/2021; Updated 10/22).
2. Microplastic Monitoring and Science Strategy for the Chesapeake Bay
3. Uniform Size Classification and Concentration Unit Terminology for Microplastics.
4. Linkages Report on Microplastics and Chesapeake Bay Agreement Goals.

Integrating Plastic Pollution into Chesapeake Bay Goals

- **Plastic pollution is a pervasive problem in the Chesapeake Bay and could impact human health and living resources**
- **Strategic investment in research Is needed**
  - More research and understanding is needed on the impacts of plastics on Chesapeake Bay living resources and human health.
- **Monitoring and management is an important next step**
  - Implementation of the science strategy will put us on a path for understanding the impacts of plastic pollution on Striped Bass and other ecosystem endpoints
  - CBPO should support the development and implementation of a plastics monitoring program to determine extent of plastic pollution and types of plastics (i.e. polymers) found in the watershed. This will assist with future source reduction efforts.
- **Source reduction planning has been requested by the PSC**
  - The PPAT was directed by the PSC in 2021 to develop a Source Reduction Strategy for Plastics in the Chesapeake Bay and watershed.
- **Integrating plastics as a contaminant of concern in 2025 and beyond is recommended**
  - CBPO should include plastics as an emerging contaminant of concern in future planning efforts to better protect human health and the environment
- **CBPO should continue to support the Plastic Pollution Action Team**
  - Continuing to support resources towards the PPAT will be a strategic investment on the Bay and its watershed

https://www.chesapeakebay.net/who/group/plastic-pollution-action-team

Chesapeake Bay Program
Science. Restoration. Partnership.

Chesapeake Bay Watershed Data Dashboard: Tools to Support & Inform Restoration Management

Jackie Pickford[1], Kaylyn Gootman[2], Ruth Cassilly[3]

Adapted from materials created by Emily Trentacoste[2] & John Wolf[4].

[1]Chesapeake Research Consortium; [2]Environmental Protection Agency; [3]University of Maryland; [4]US Geological Survey.

What is the Watershed Data Dashboard?

The Data Dashboard an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

It consolidates the vast amount of scientific and technical information available to environmental managers and planners in a single cohesive location, making it easier for partners at all levels to get information about their area of interest.

What can you do with the Dashboard?

Some uses of the Dashboard include:

- Targeting restoration efforts geographically, by sector, or by practice
- Developing scenarios to run on the Chesapeake Assessment Scenario Tool (CAST)
- Outreach and communication of water quality information
- Building local watershed stories to engage with stakeholders

What information does the Dashboard contain?

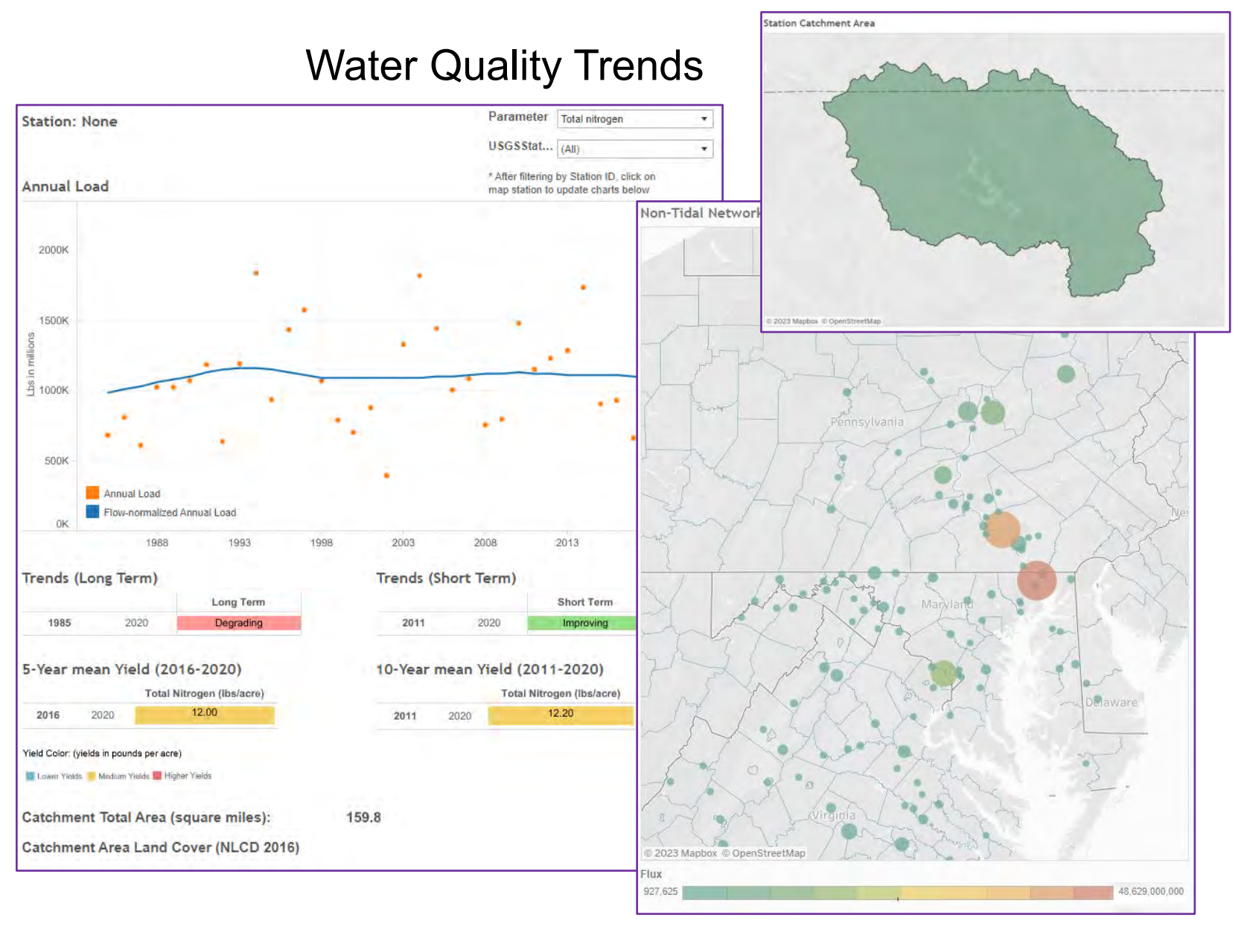
The Dashboard is organized in modules based on the type of information and the questions a planner may be trying to answer. The headings below reflect the modules and their individual sections.

Module: Non-tidal Water Quality (Streams & Rivers)

Water Quality Trends

Information on the amount of nutrients and sediment at the monitoring stations throughout the watershed and trends over time that account for stream flow (flow-normalized).

Water Quality Trends



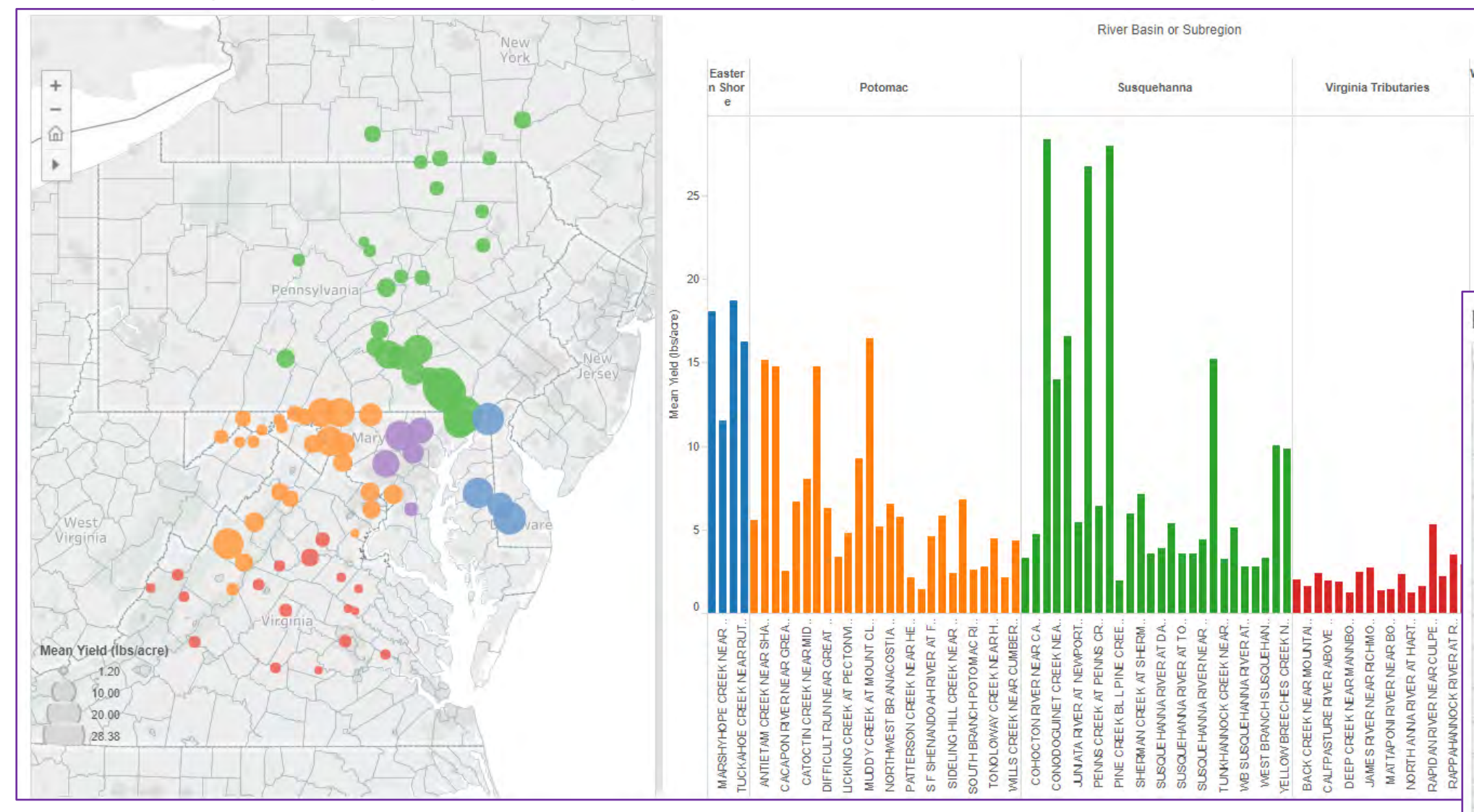
What can I do with this information?

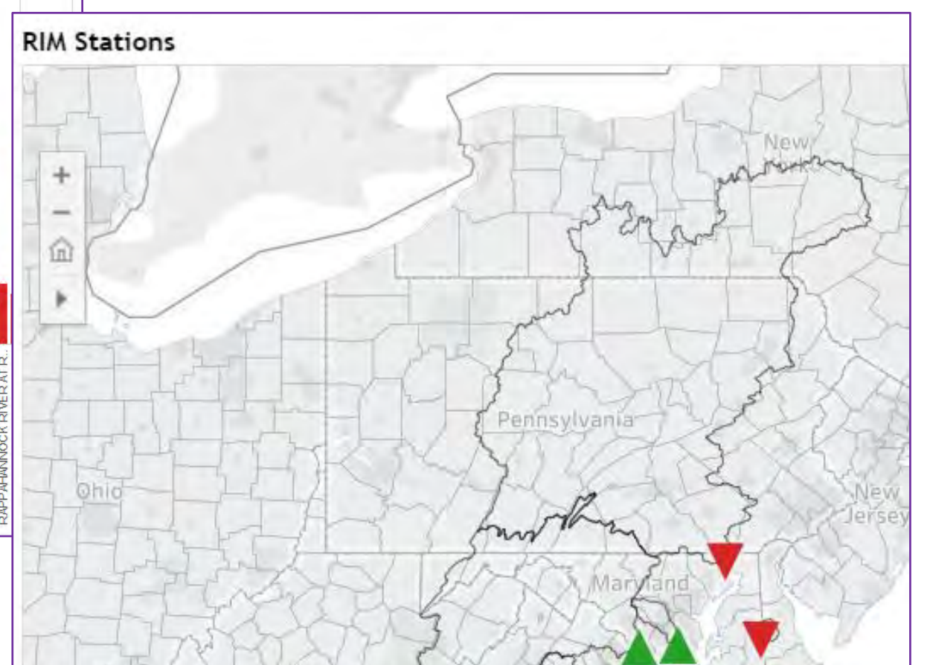
- **Learn the status** of nutrient and sediment levels in streams and rivers in your area of interest.
- **Compare** the amount of nutrients and sediment **between streams and rivers** across the region.
- **Identify changes over time** in nutrient and sediment levels in streams and rivers.
- **Assess progress** by determining if nutrient and sediment conditions are improving or degrading.
- **Target or prioritize watersheds** for restoration efforts by identifying those with high amounts of nutrients and sediment, especially relative to size.
- **Explore the tidal connection** by reviewing the amounts of nitrogen and phosphorus that directly enter the Bay tidal waters from its nine major rivers.
- **Understand important drivers of water quality** such as watershed characteristics like size and land-cover/land-use.

Comparing Watersheds

Provides the average amount of nutrients and sediment at monitoring stations accounting for watershed size (lbs pollutant/acre/year watershed), allowing for easy comparison across the region and within sub-regions.

Comparing Sub-region Monitoring Trends

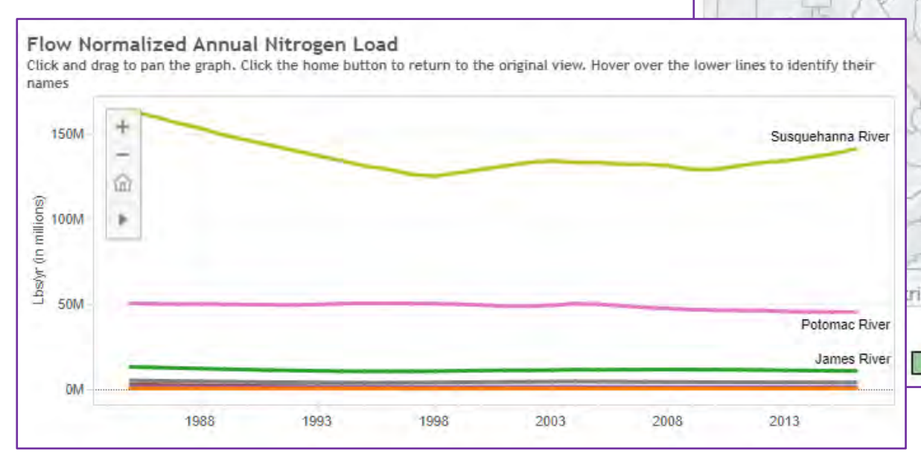




River Contributions to Tidal Waters

Trends accounting for stream flow (flow-normalized) of nitrogen and phosphorus in the nine major rivers at locations where they flow directly into the Bay's tidal waters.

Stream Flow Nitrogen Trends



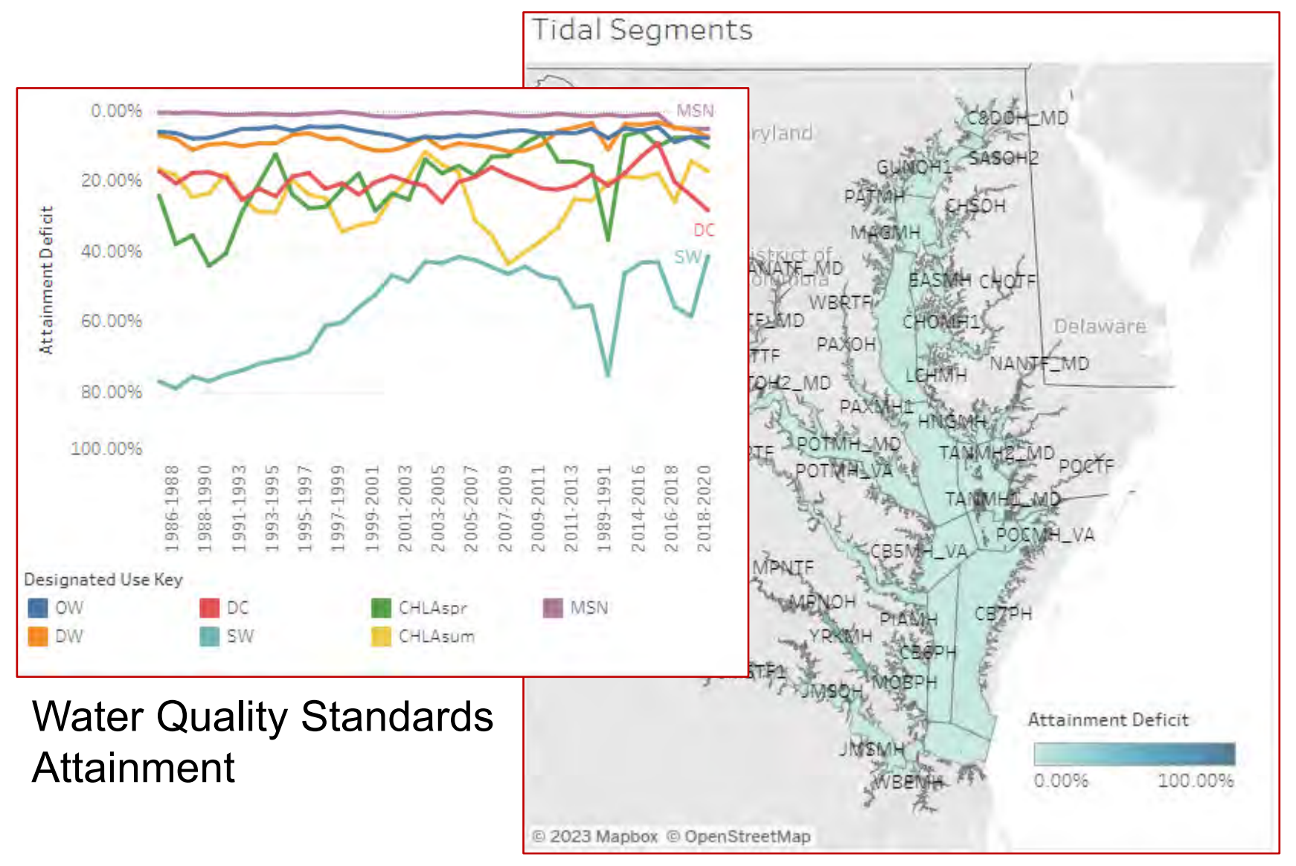
Check it Out Yourself!

http://gis.chesapeakebay.net/wip/dashboard

Module: Tidal Water Quality & Living Resources

Water Quality Standards Attainment

Information on attainment of water quality standards for protecting aquatic life in tidal areas. 'Attainment deficit' depicts how far away non-attaining areas are from meeting standards.



Water Quality Standards Attainment

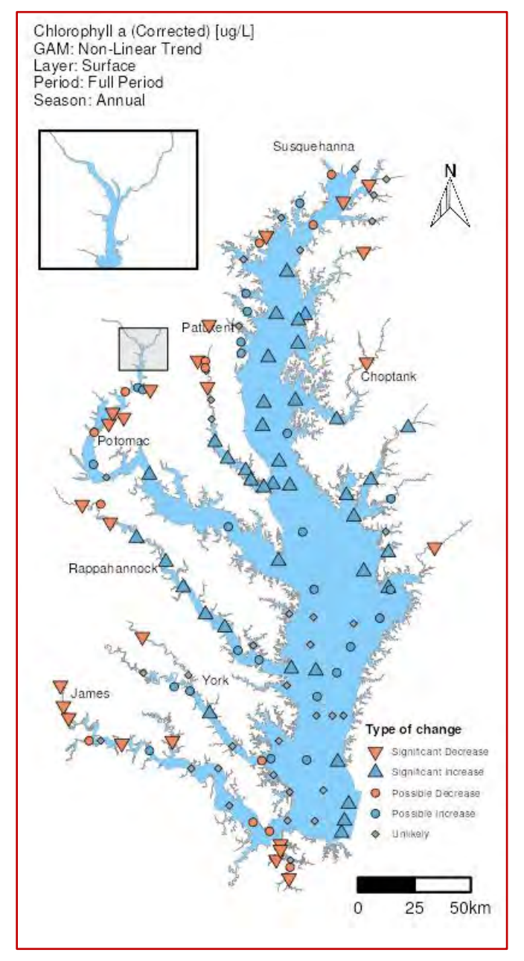
What can I do with this information?

- **Learn the status** of water quality and living resources in your tidal area of interest.
- **Identify changes over time** in water quality standards, water quality and living resources.
- **Assess progress** by determining if conditions are improving or degrading, and by comparing to goals.
- **Target or prioritize** areas for management actions by identifying tidal areas in need of restoration and identifying effective upstream watersheds for efforts.
- **Explore management options** by understanding specific influences on submerged aquatic vegetation in tidal areas, or identifying influential wastewater treatment plants.
- **Understand important drivers** of water quality and living resources such as influential areas of the watershed and wastewater treatment plants discharging to tidal waters.

Tidal Water Quality Monitoring

Water quality monitoring data and trends at the Bay's tidal monitoring stations. These parameters include secchi depth for water clarity, concentrations of nitrogen, phosphorus, suspended sediment and dissolved oxygen, and temperature.

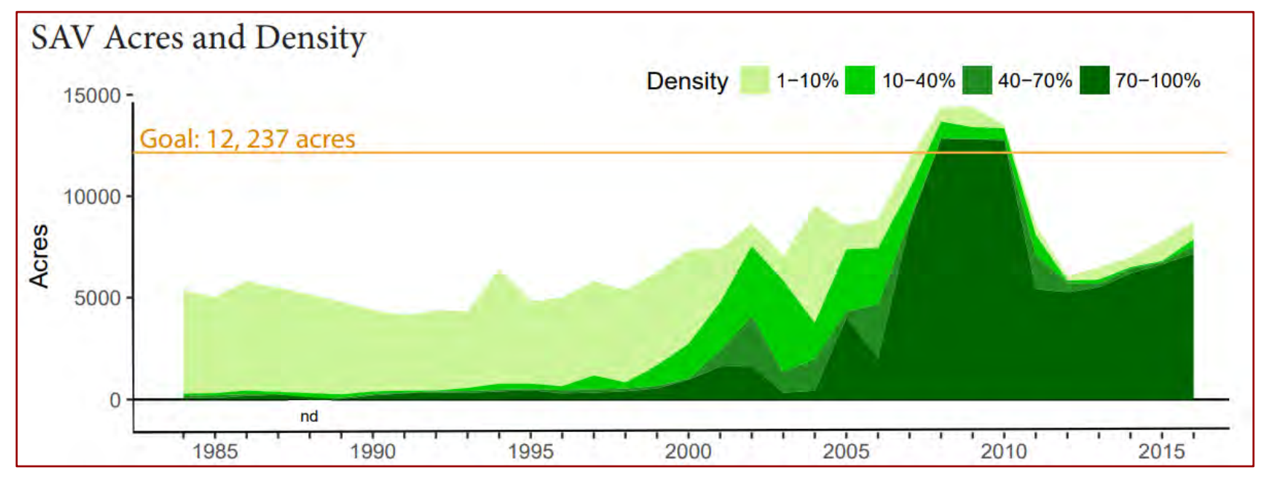
Tidal Water Quality Monitoring



Submerged Aquatic Vegetation

Provides fact sheets with annual acreage and density data for submerged aquatic vegetation for different areas of the tidal waters with similar vegetation populations, and timelines of events that influence, contribute to, or explain the changes.

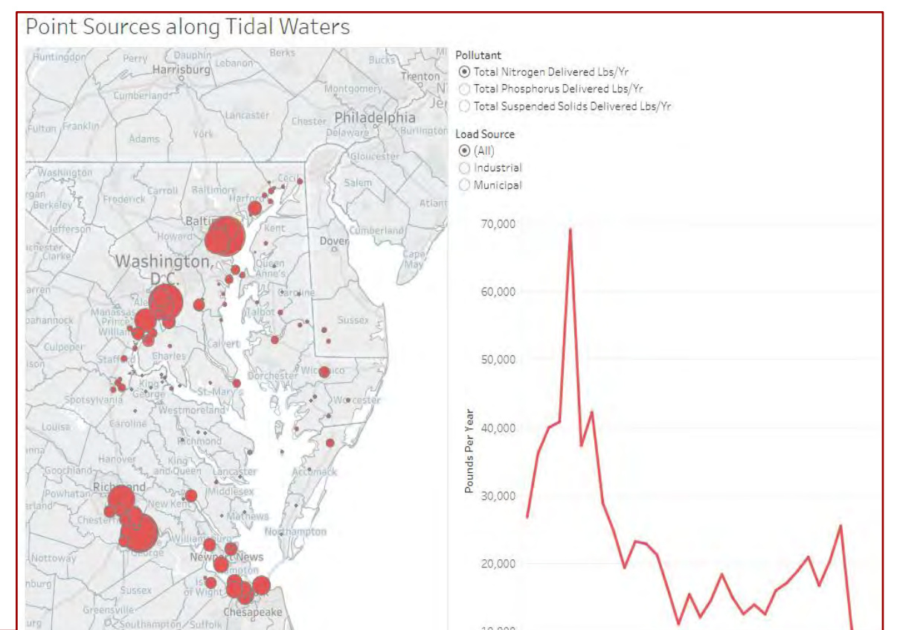
SAV Segment: Susquehanna Flats (CB1TF2 and NORTF)



Wastewater Treatment Plant Discharges

Locations of wastewater treatment plants that discharge directly to tidal waters, and discharges of nutrient and sediment over time from these plants.

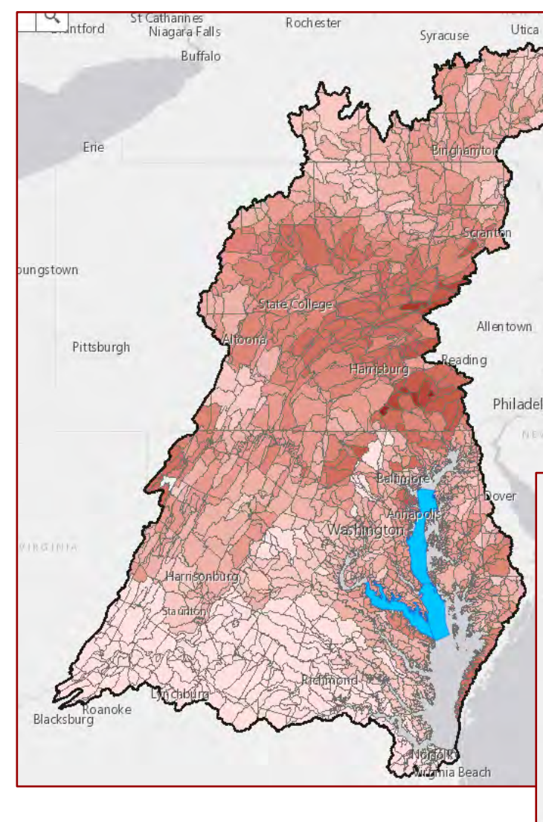
Point Sources Along Tidal Waters



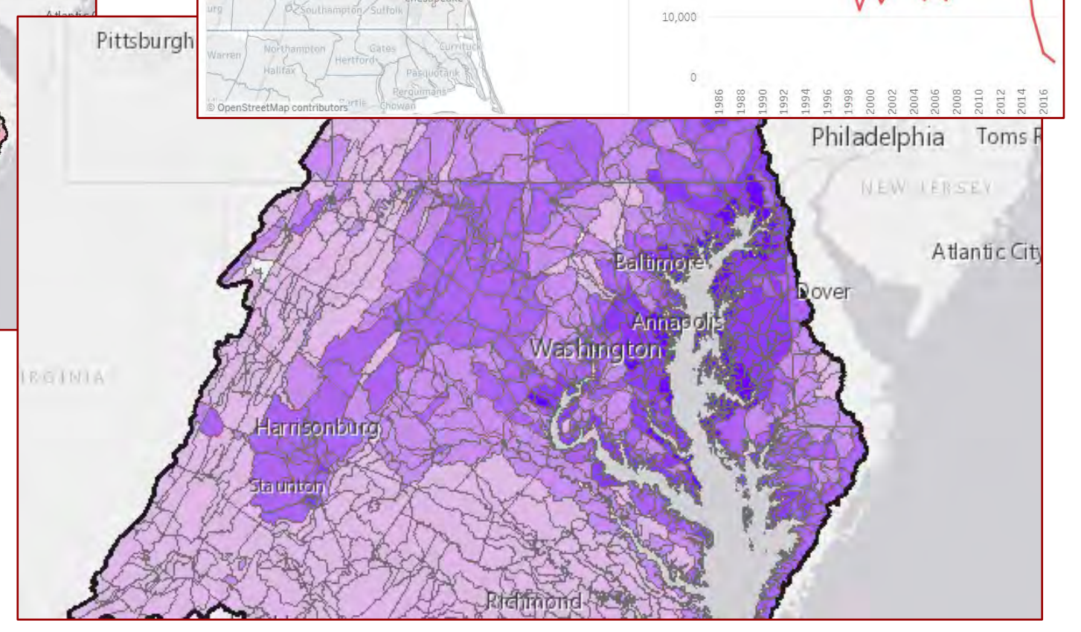
Most Effective Watersheds Influencing Bay

Provides maps that demonstrate influence of watershed on the tidal waters, including:

- The estimated effectiveness of different parts of the watershed on improving dissolved oxygen in the main stem of the Bay (relative effectiveness).
- The estimated proportion of locally generated pollution that makes it to the Bay's tidal waters (delivery factors).
- The discrete watersheds of the 92 Bay TMDL tidal segments.



Nitrogen Relative Effectiveness

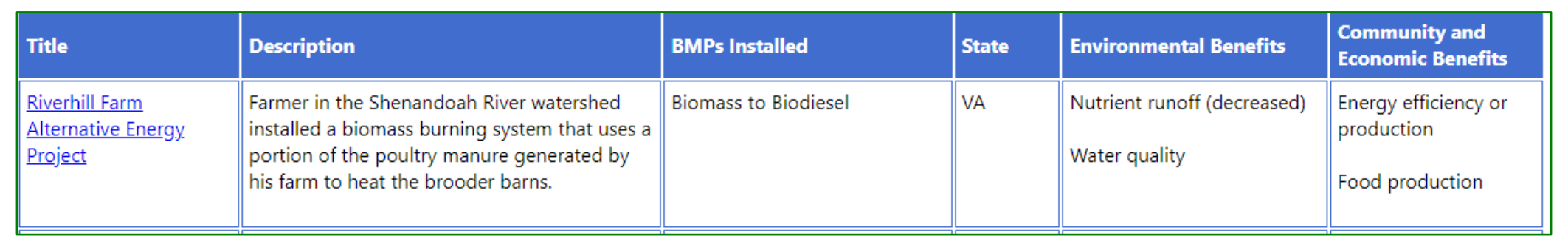


Phosphorus Delivery Factors

Module: Prioritizing Other Benefits

Beyond Environmental Benefits Database and Search Tool

Search for case studies in the Chesapeake Bay watershed by location, BMP, environmental benefit and community and economic benefit, etc.



Title	Description	BMPs Installed	State	Environmental Benefits	Community and Economic Benefits
Riverhill Farm Alternative Energy Project	Farmer in the Shenandoah River watershed installed a biomass burning system that uses a portion of the poultry manure generated by his farm to heat the brooder barns.	Biomass to Biodiesel	VA	Nutrient runoff (decreased) Water quality	Energy efficiency or production Food production

Beyond Environmental Benefits Database

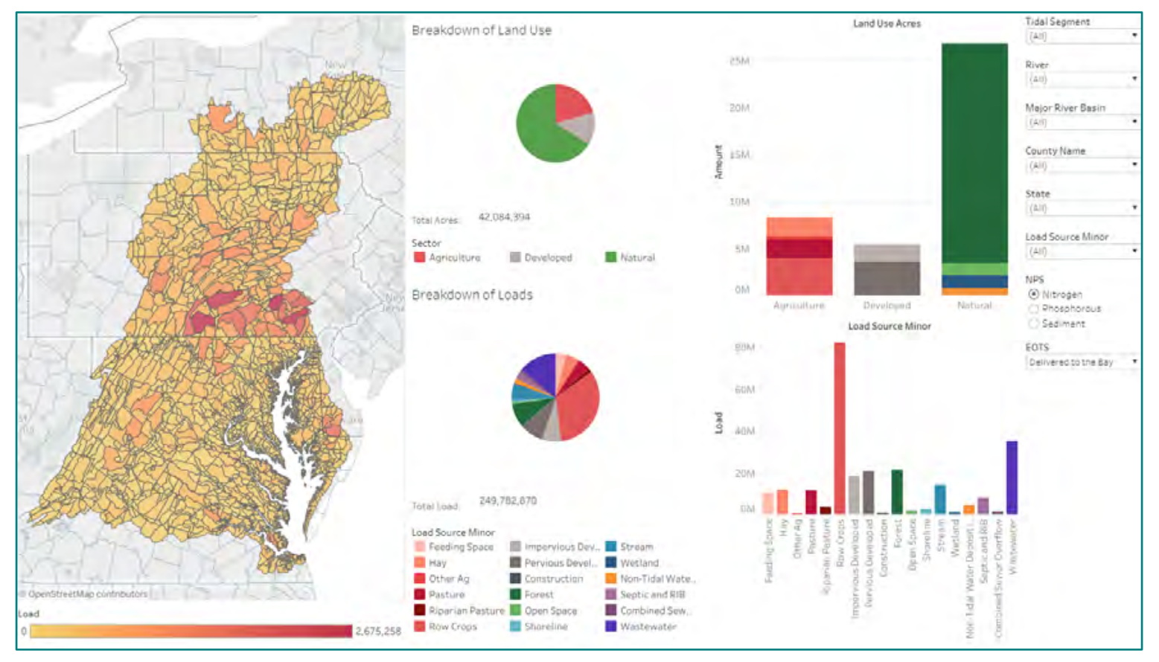
Co-benefits of Water Quality BMPs

Provides information on co-benefits associated with water quality best management practices (BMPs).

Module: Targeting Restoration Efforts

Understanding Sources

Information on land use and estimated nutrient and sediment loads at different geographies and scales across the Chesapeake Bay watershed from the most recent Progress run of the Phase 6 Watershed Model.



Understanding Sources of Nutrient and Sediment Loads

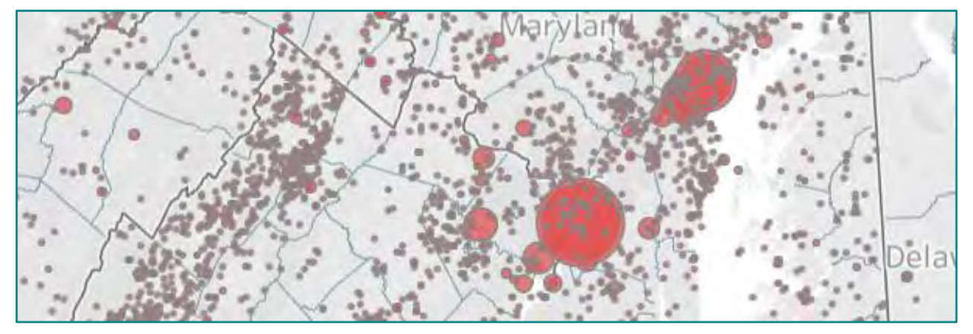
What can I do with this information?

- **Learn the sources** of nutrients and sediment in your area of interest.
- **Understand important drivers** of water quality including landscape features that influence streams and the Bay.

Wastewater Treatment Plants

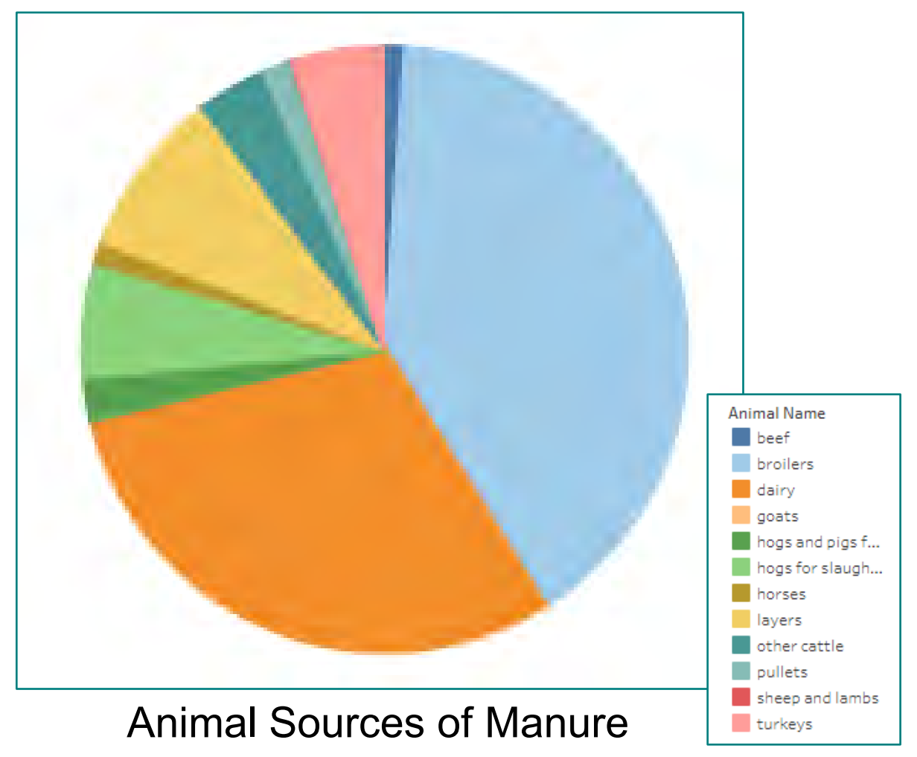
Locations of wastewater treatment plants throughout the Chesapeake Bay watershed and annual nutrient and sediment discharges reported from 2020.

Point Sources and 2020 Nitrogen Loads



Nutrient Application Management

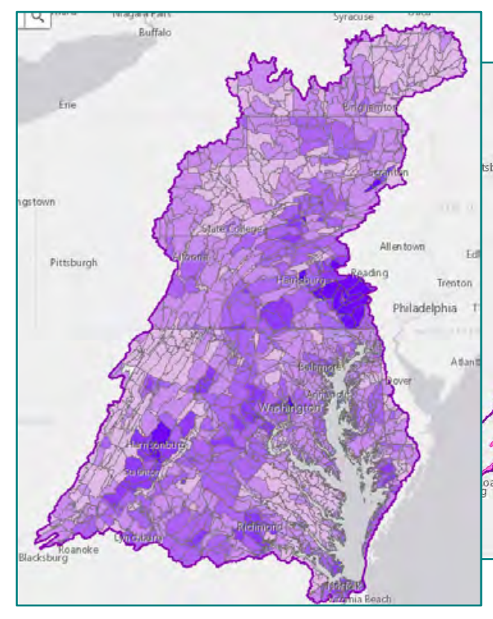
Provides estimates of nutrient application across the Chesapeake Bay watershed by county and by nutrient source (fertilizer, manure, biosolids), and animal sources of manure.



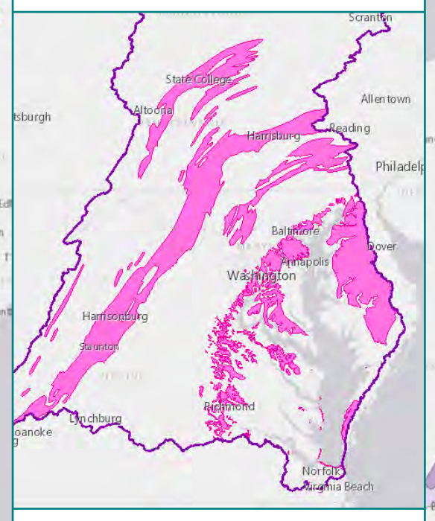
Animal Sources of Manure

Geographic Targeting

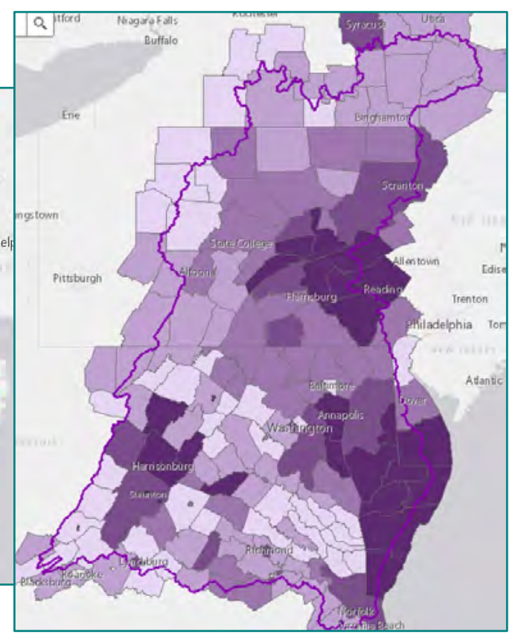
Provides spatial information across the watershed that can be utilized to geographically identify areas for restoration.



Highest Loading Areas (Phosphorus)

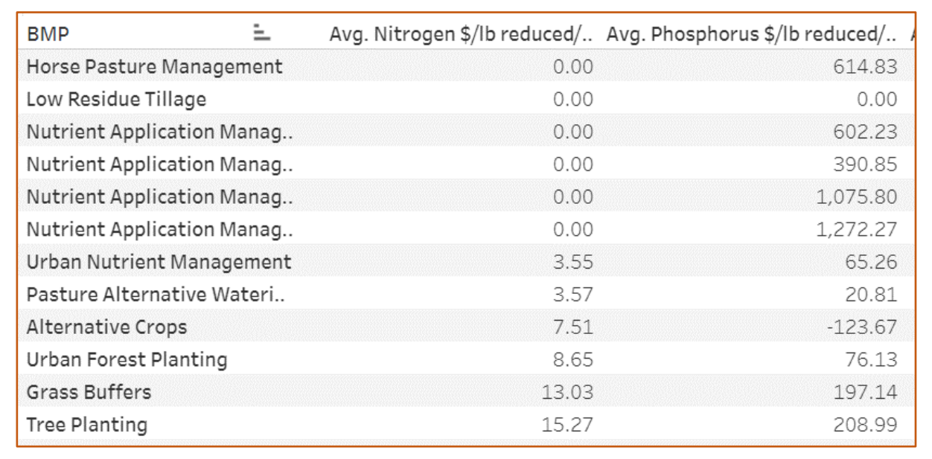


Vulnerable Groundwater



Estimated Soil Phosphorus Content on Agricultural Lands

Module: Management Practices



BMP	Avg. Nitrogen $/lb reduced/..	Avg. Phosphorus $/lb reduced/..
Horse Pasture Management	0.00	614.83
Low Residue Tillage	0.00	0.00
Nutrient Application Manag..	0.00	602.23
Nutrient Application Manag..	0.00	390.85
Nutrient Application Manag..	0.00	1,075.80
Nutrient Application Manag..	0.00	1,272.27
Urban Nutrient Management	3.55	65.26
Pasture Alternative Wateri..	3.57	20.81
Alternative Crops	7.51	-123.67
Urban Forest Planting	8.65	76.13
Grass Buffers	13.03	197.14
Tree Planting	15.27	208.99

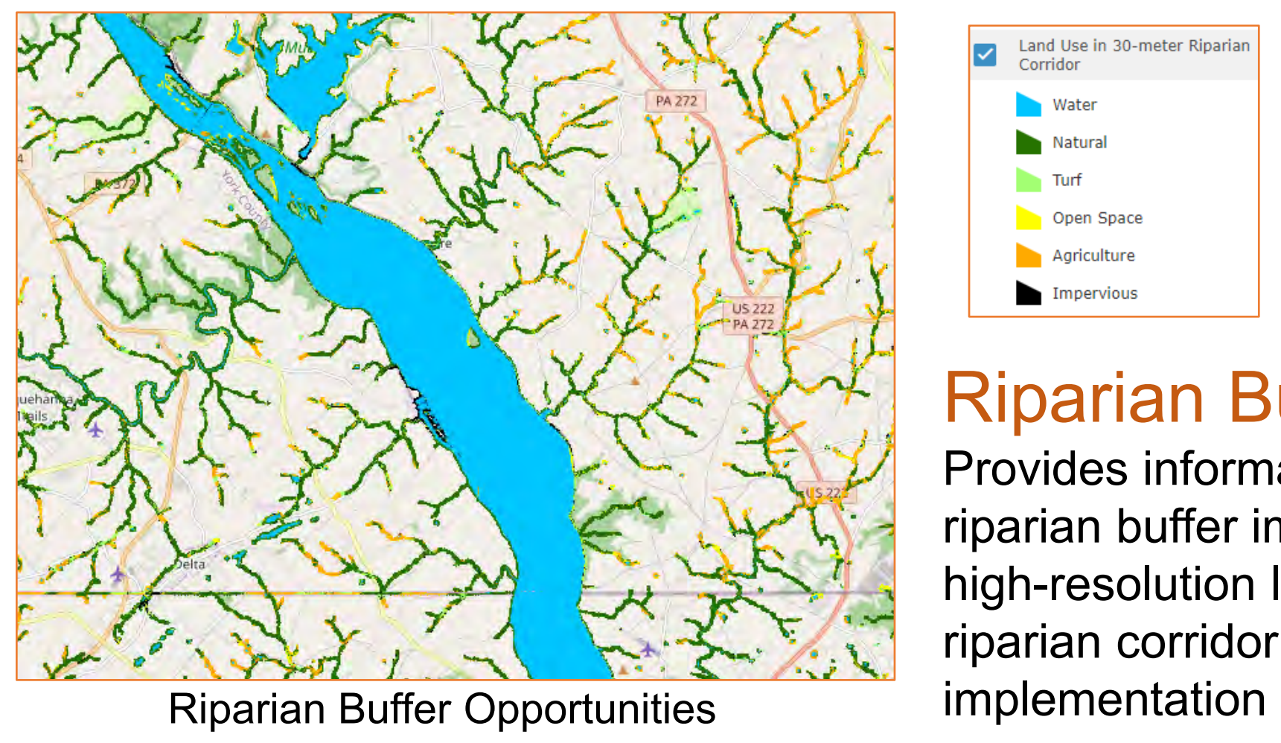
Practice Cost ($) per lb Nutrient Reduction

Management Practice Implementation

Provides information on the current reported implementation (2020 Progress), cost-effectiveness, and pollution reduction efficiency of Chesapeake Bay Program best management practices (BMPs) in each county.

What can I do with this information?

- **Learn the status** of implementation of different management practices by county across the Chesapeake Bay watershed
- **Assess progress** by determining how much of the available area for different management practices has implementation
- **Target or prioritize** areas for management practices by identifying areas that have less implementation.
- **Explore management options** by learning about the cost-effectiveness and pollution reduction effectiveness of each management practice.
- **Choose management practices** to use in scenarios on the Chesapeake Assessment Scenario Tool (CAST).
- **Identify opportunities** for implementation of riparian buffers at different geographic scales.



Riparian Buffer Opportunities

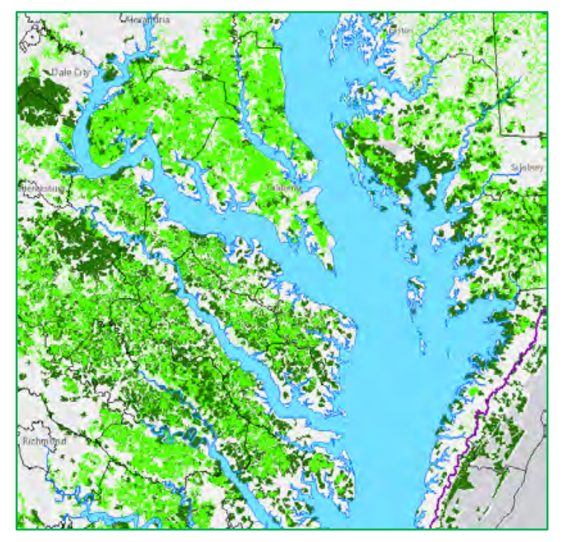
Riparian Buffer Opportunities & Locations

Provides information on the estimated acres of land available for riparian buffer implementation by different geographies based on high-resolution land use data. Contains map displaying boundary of riparian corridor along streams available for grass and buffer implementation and conservation.

Module: Land Policy and Conservation

Planning for Urban Growth & Development

Provides information relevant to growth and development including land use (2013 high-resolution) and current county-level zoning data (if available). Provides information to help identify opportunities across the watershed for Forest Conservation, Agriculture Conservation, and Growth Management.



Forest Conservation Opportunities

What can I do with this information?

- **Assess potential** for growth and development across the Chesapeake Bay watershed.
- **Explore management options** related to smart growth and land conservation practices.
- **Identify** geographic areas with potential for implementation of smart growth or conservation measures.
- **Target or prioritize** areas for management actions based on the likelihood of growth and potential for conservation.

THE JOURNEY TO WORLD-CLASS STRATEGY MANAGEMENT
– THE STRATEGY REVIEW SYSTEM (SRS)

History of SRS

- Program evaluations indicate lack of comprehensive strategy

2014

- 2014 Watershed Agreement
  - 10 goals and 31 outcomes were established
  - GITs developed Management Strategies to explain how outcomes are to be accomplished and how progress will be monitored, assessed and reported

2017

- SRS was created to help the CBP consistently apply **adaptive management** to its work toward achieving the Watershed Agreement outcomes

Vision of SRS

Fulfill **2014 Watershed Agreement** commitment to biennially re-evaluate and update management strategies.

Support PSC charge to use the **Decision Framework** to adaptively manage.

Establish consistent method for identifying changes needed to implement **adaptive management**

Utilize the **Indicators Framework** to track progress toward outcomes, to understand what factors influence outcome achievement, and whether the program did what it said it would do.

Support **evolving partnership needs** related to accountability, transparency, and decision-support identified through stakeholder **research**.

Promote **core values** such as flexibility, trust, open conversation, efficiency, predictability, collaboration, and solution-finding.

Supporting SRS Documents

Logic & Action Plan: Illustrates the link between the factors that could impact the partnership's ability to achieve an outcome and the actions it is taking to manage them. It articulates what the partnership expects to achieve by taking those actions.

Narrative Analysis: Indicates whether the partnership's assumptions about an outcome have changed and whether its actions are having their intended effect. It describes whether new information will impact what the partnership is doing to achieve an outcome and recommends adaptations or course corrections.

Presentation: Summarizes the information in the Logic & Action Plan and Narrative Analysis, as well as any changes the workgroup anticipates making to its Management Strategy. It supports a GIT's request for action, support or assistance

SRS Process Overview

1 **Biennial Meeting**
Begins the SRS Cycle

2 **Document Drafting**
GITs or Workgroups update Logic & Action Plans and prepare Narrative Analyses and Presentations

3 **SRS Planning Team Meeting**
Review draft Logic & Action Plans and Narrative Analyses with the SRS Team and discuss common themes or requests

4 **STAR/C/S Dry Runs**
Practice and receive feedback on presentations

5 **Quarterly Progress Meeting**
Cohorts report their progress to the MB, explain challenges and request action or assistance

6 **STAR Science Needs Meeting**
Discussion of science needs and potential cross-GIT collaborations and resources to support needs

7 **Document Finalization**
Finalize and submit SRS documents – Logic and Action Plans and Management Strategies

Adaptive Management Process

Chesapeake Bay Segment Explorer

Zhaoying (Angie) Wei[1], John Wolf[2]

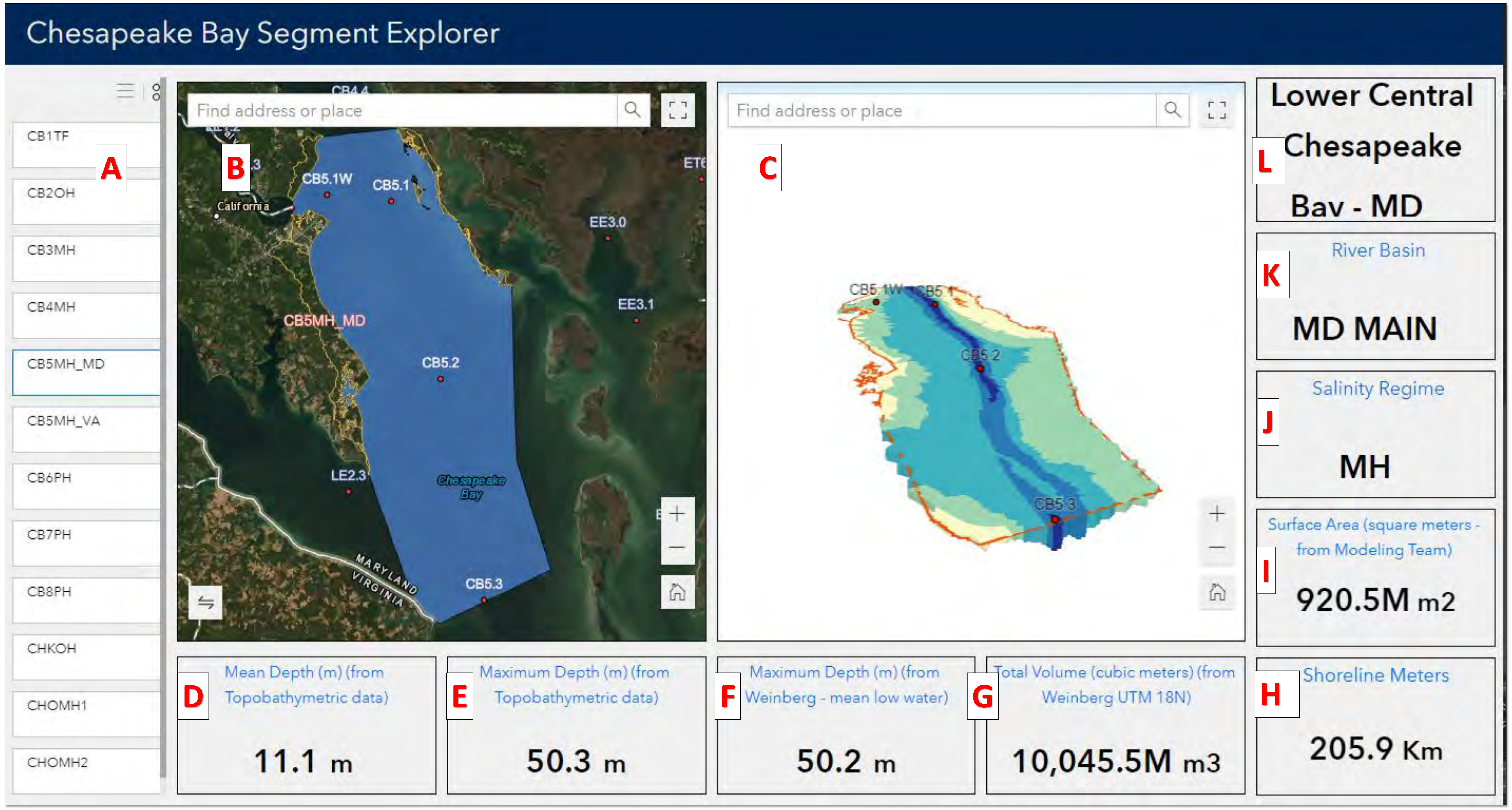
[1] University of Maryland Center for Environmental Science, [2] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Introduction

The Chesapeake Bay Total Maximum Daily Load (TMDL) allocations for nutrients and sediment serve as the basis of comprehensive watershed restoration plans to restore water quality and living resources in the Chesapeake Bay. Water quality standards attainment is evaluated based on a four-dimensional assessment of designated uses in 92 Chesapeake Bay segments[1]. The Chesapeake Bay Segment Explorer is a web application that provides segment-specific physical characteristics as well as both 2D and 3D visualizations of each segment.

3D Visualization and the Chesapeake Bay SCHISM Model

- ❑ The 3D grids used in 3D visualization is constructed based on Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM).
- ❑ SCHISM is a 3D seamless cross-scale model grounded on unstructured grids (UG) for hydrodynamics and ecosystem dynamics.
- ❑ The implementation of the SCHISM grids in Chesapeake Bay is still in progress. This model is currently available in Mainstem, James River and York River segments.
- ❑ For more details on SCHISM, go to http://ccrm.vims.edu/schismweb/



Chesapeake Bay Segment Explorer

Lower Central Chesapeake Bay - MD

River Basin: MD MAIN

Salinity Regime: MH

Surface Area (square meters - from Modeling Team): 920.5M m2

Mean Depth (m) (from Topobathymetric data): 11.1 m

Maximum Depth (m) (from Topobathymetric data): 50.3 m

Maximum Depth (m) (from Weinberg - mean low water): 50.2 m

Total Volume (cubic meters) (from Weinberg UTM 18N): 10,045.5M m3

Shoreline Meters: 205.9 Km

Explanation of the Explorer Interface

The Chesapeake Bay Segment Explorer provides a window into baseline physical characteristics of monitoring segments of the Chesapeake Bay. This Section provides a key to Explorer interface.

A – User selects a Chesapeake Bay segment that populates the other windows in the Explorer application.

B – A two-dimensional map is presented for the chosen segment. The map includes the boundaries of the segment, any tidal water quality monitoring stations found in the segment, and TMDL segmentsheds.

C – A three-dimensional scene depicting the extent of the segment, color-coded by bathymetric depth as represented in the SCHISM model. Both the 2D map and 3D scene are interactive. The 3D scene incorporates vertical exaggeration of 100x.

D – Mean depth of the segment based on high-resolution topobathymetry from CoNED[2].

E – Maximum depth of the segment based on high-resolution topobathymetry from CoNED[2].

F – Maximum depth of the segment from historical Chesapeake Bay soundings (1859 – 2015)

G – Total volume of the segment based on Chesapeake Bay Program high-resolution shoreline and the historical soundings.

H – Th estimated shoreline distance within each segment calculated using Chesapeake Bay Program High resolution shoreline (in Albers Equal Area Projection).

I – Segment surface area provided by the Chesapeake Bay Program Modeling Team.

J – Salinity regime used to segment river basins as follows:

- Tidal Fresh (TF): 0-5 ppt
- Oligohaline (OH): > 0.5-5 ppt
- Mesohaline (MH): > 5-18 ppt
- Polyhaline (PH): > 18 ppt

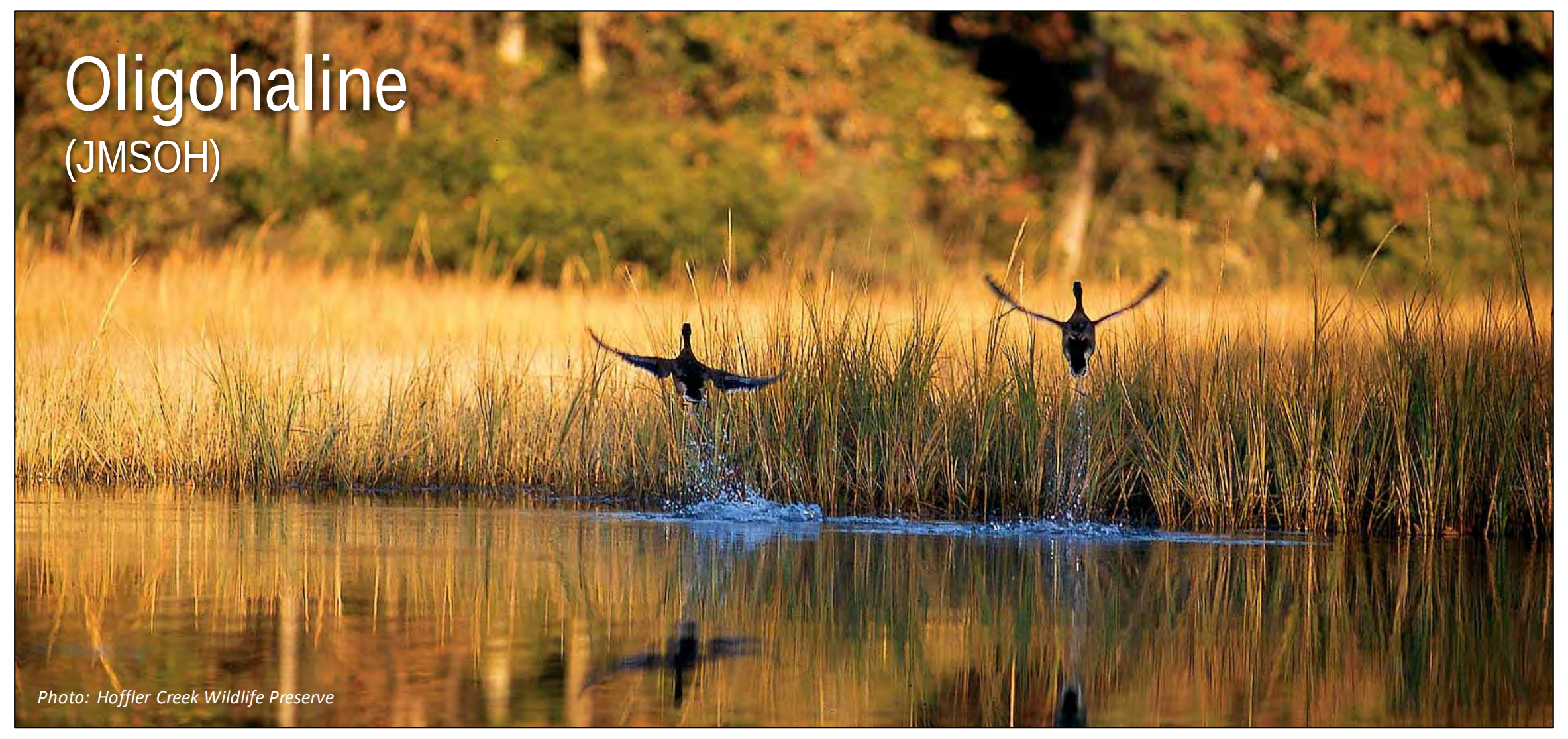
K – River basin was defined as the major tidal tributaries along with mainstem Chesapeake Bay Segments. Tributaries were segmented from mainstem at the mouth of each river.

L – Name of selected segment.

Salinity Regime Examples

Tidal Fresh (JMSTF1)

Photo: Chesapeake Bay Gateways Network



Oligohaline (JMSOH)

Photo: Hoffler Creek Wildlife Preserve

Mesohaline (JMSMH)

Photo: Envision the James (Chesapeake Conservancy)

Polyhaline (CB8PH)

Photo: Commonwealth of Virginia

Technology and Future Plans

The Chesapeake Bay Segment Explorer is an ArcGIS Experience Builder application that leverages a 2D web map and a 3D web scene.

Future plans include the potential integration of the segment explorer with water quality standards attainment information currently presented in the Watershed Data Dashboard. (https://gis.chesapeakebay.net/wip/dashboard)

Interactive Web Application

https://bit.ly/3HrawLc

Note: The Chesapeake Bay Segment Explorer is not recommended for mobile devices at present time.

References

1. USEPA (U.S. Environmental Protection Agency). 2005. Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983-2003. 2005 Addendum. EPA 903-R-05-004. CBP/TRS 278-06. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

2. OCM Partners, 2022: 2016 USGS CoNED Topobathymetric Model (1859 - 2015): Chesapeake Bay Region, https://www.fisheries.noaa.gov/inport/item/55321.

USGS Chesapeake Science Workshop
June 2022

Chesapeake Bay Watershed Most Effective Basins and Disadvantaged Communities

John Wolf [1], Lee McDonnell [2], Autumn Rose[2], Bailey Bosley [1]

[1] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland, [2] USEPA – Chesapeake Bay Program Office, Annapolis, Maryland

Most Effective Basins

The Chesapeake Bay watershed has been evaluated to determine the river basins likely to have the greatest impact on dissolved oxygen in the deepest waters of the Bay from changes in nonpoint source nitrogen pollution. The Environmental Protection Agency is focusing the implementation of management practices in these "**Most Effective Basins**".

Restoring the Deep Waters of the Mainstem Chesapeake Bay

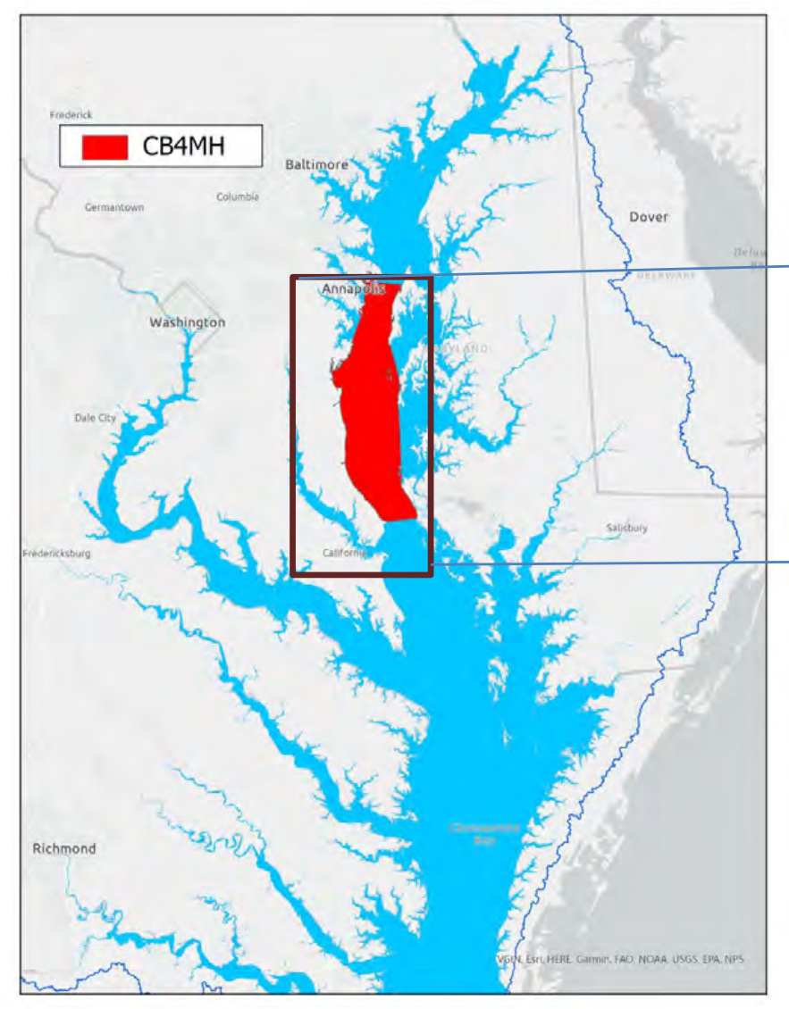


Figure 1. Chesapeake Bay Monitoring Segment CB4MH

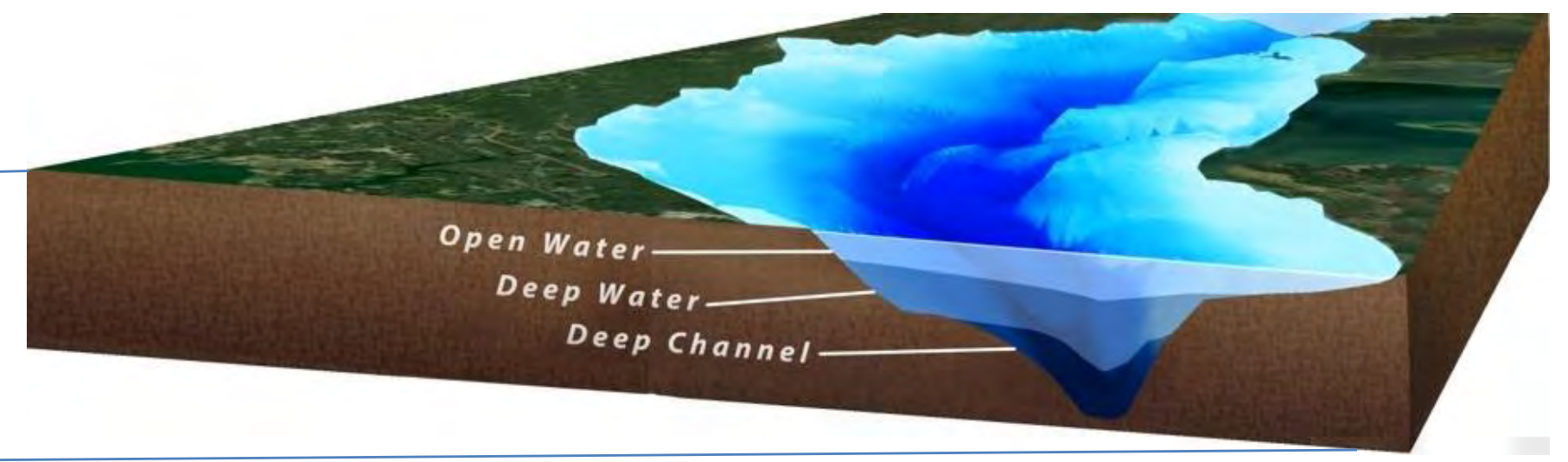


Figure 2. Perspective view of Monitoring Segment CB4MH, showing conceptual delineation of the Deep Water and Deep Channel designated use zones.

The **Chesapeake Bay Pollution Diet** (officially, the Total Maximum Daily Load, or TMDL) is based on restoring conditions in the deepest parts of the mainstem of the Chesapeake Bay. These are represented by the "Deep Water" and "Deep Channel" designated uses.

What is "Load Effectiveness"?

Load effectiveness is a measure of the ability of management practices implemented in a given area (basin) to have a positive impact on dissolved oxygen (DO) in the Bay. Load effectiveness is the combination of three factors: land to water, delivery, and DO response. Each of these factors is described below:

- The *land to water factor* represents **how nitrogen applied to the land moves through the soil and is transported to the water.** It is a measure of the natural propensity of the landscape to deliver nitrogen to waterways.
- The *delivery factor* is an **estimate of the fraction of load reaching a stream**, in a given basin, that will eventually make it to tidal waters.
- The *dissolved oxygen (DO) response factor* is a measure of the Bay's **DO response to nutrient loads** from different areas of the watershed. It is based on estuarine circulation patterns and biogeochemical transformations.

Most Effective Basins – Agriculture

In addition to *load* effectiveness, past analyses of cost per pound of reduction have shown that reducing nitrogen is less costly by far than reducing phosphorus. Furthermore, on average, Best Management Practices (BMPs) placed on agricultural lands have been identified as the most *cost* effective BMPs.

Figure 3. Farmland in Union County, Pennsylvania
Photo Credit: Will Parson, Chesapeake Bay Program

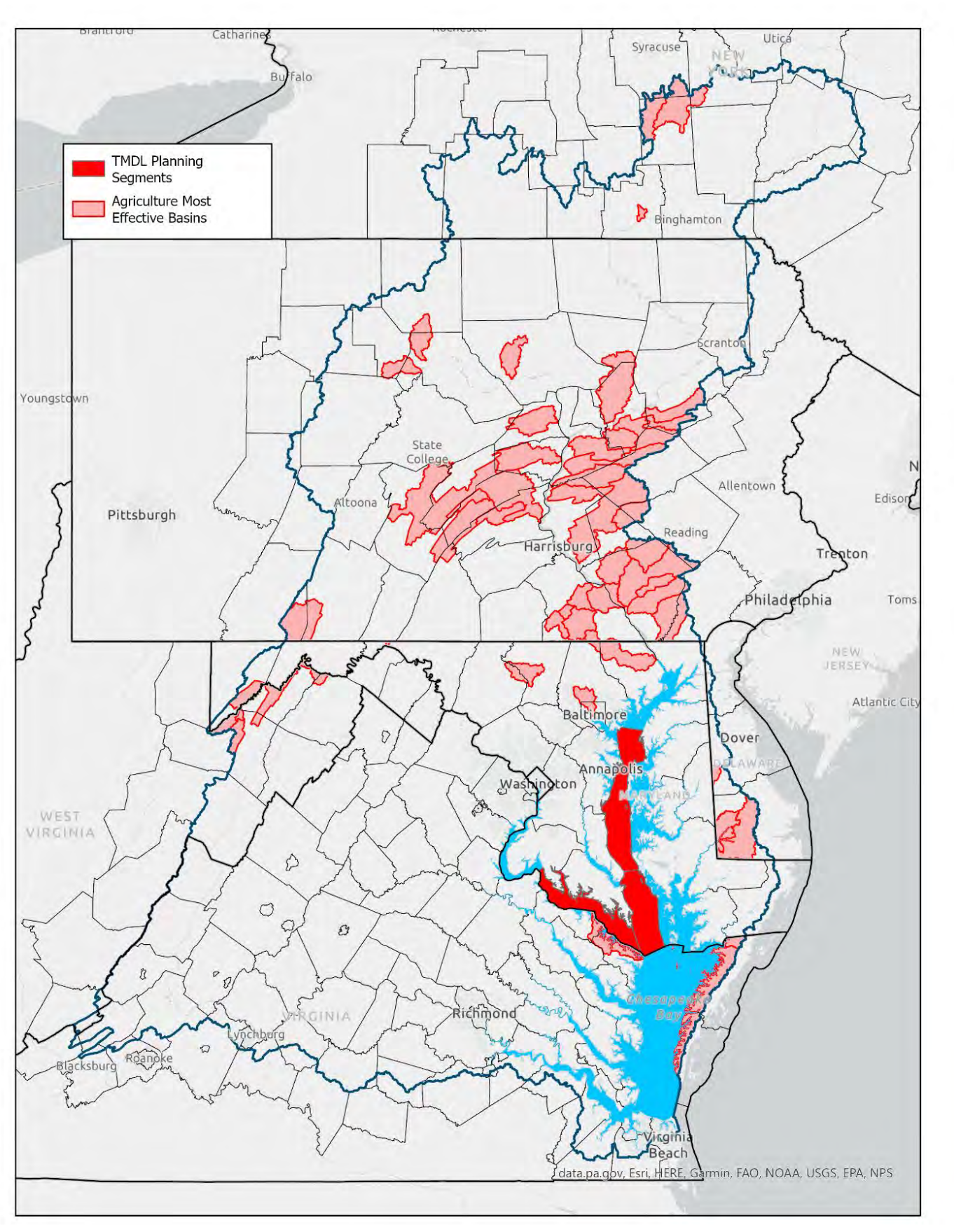


Figure 4. Most Effective Basins (2020), based on nitrogen loads at the State-River basin scale from agricultural sources.

Most Effective Basins – Infrastructure

The Infrastructure Investment and Jobs Act (IIJA), signed into law on November 15, 2021, has authorized significant additional funding for Chesapeake Bay restoration. For Fiscal Year 2022, an additional $15 million is being directed toward areas in the Chesapeake Bay watershed that are most effective for nitrogen reduction from all nonpoint sources.

Figure 5. Breton Bay in St. Mary's County, Maryland
Photo Credit: Will Parson, Chesapeake Bay Program

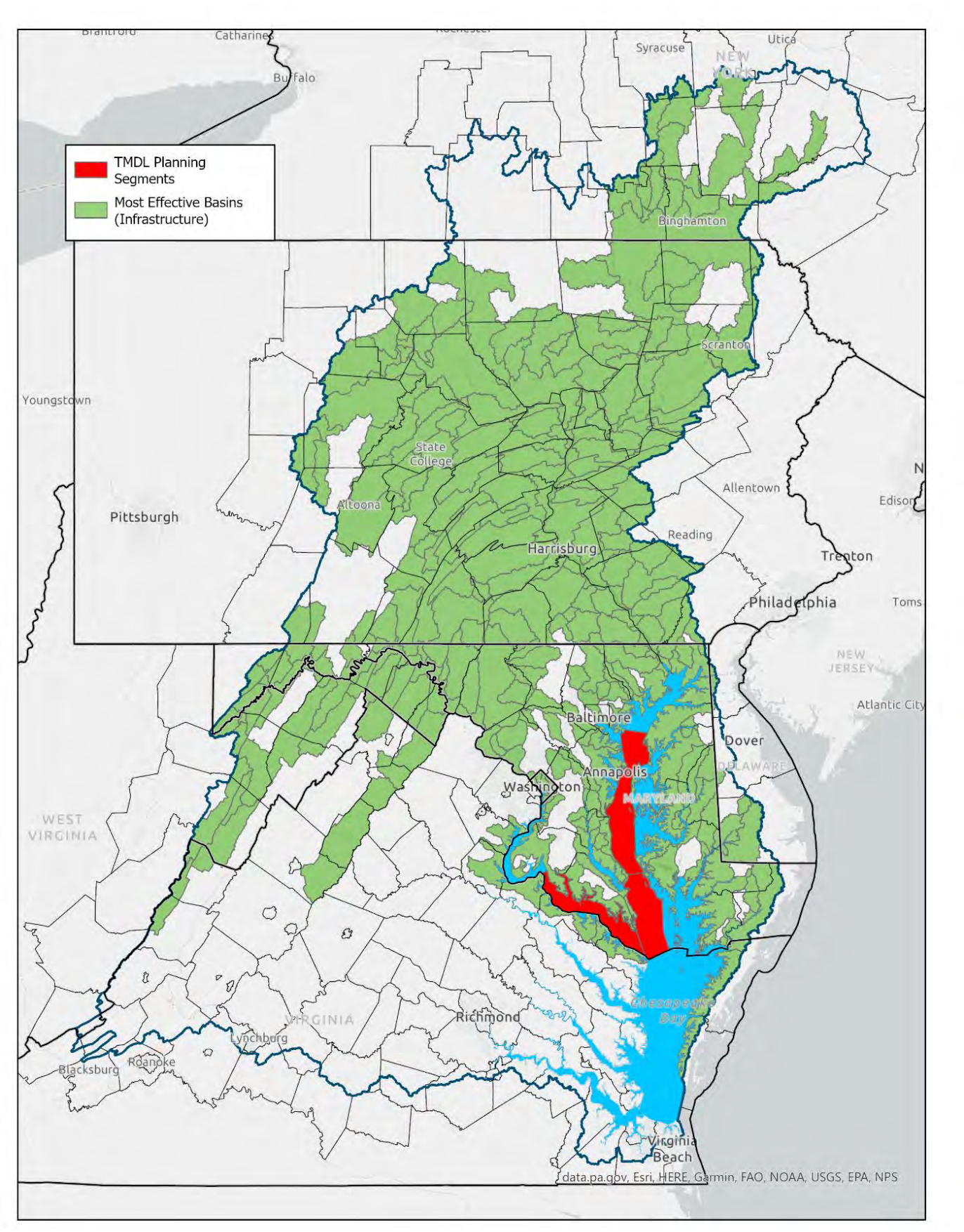


Figure 6. Most Effective Basins (2022) , based on State-River basins with a nitrogen relative effectiveness > 7.0 from all nonpoint sources.

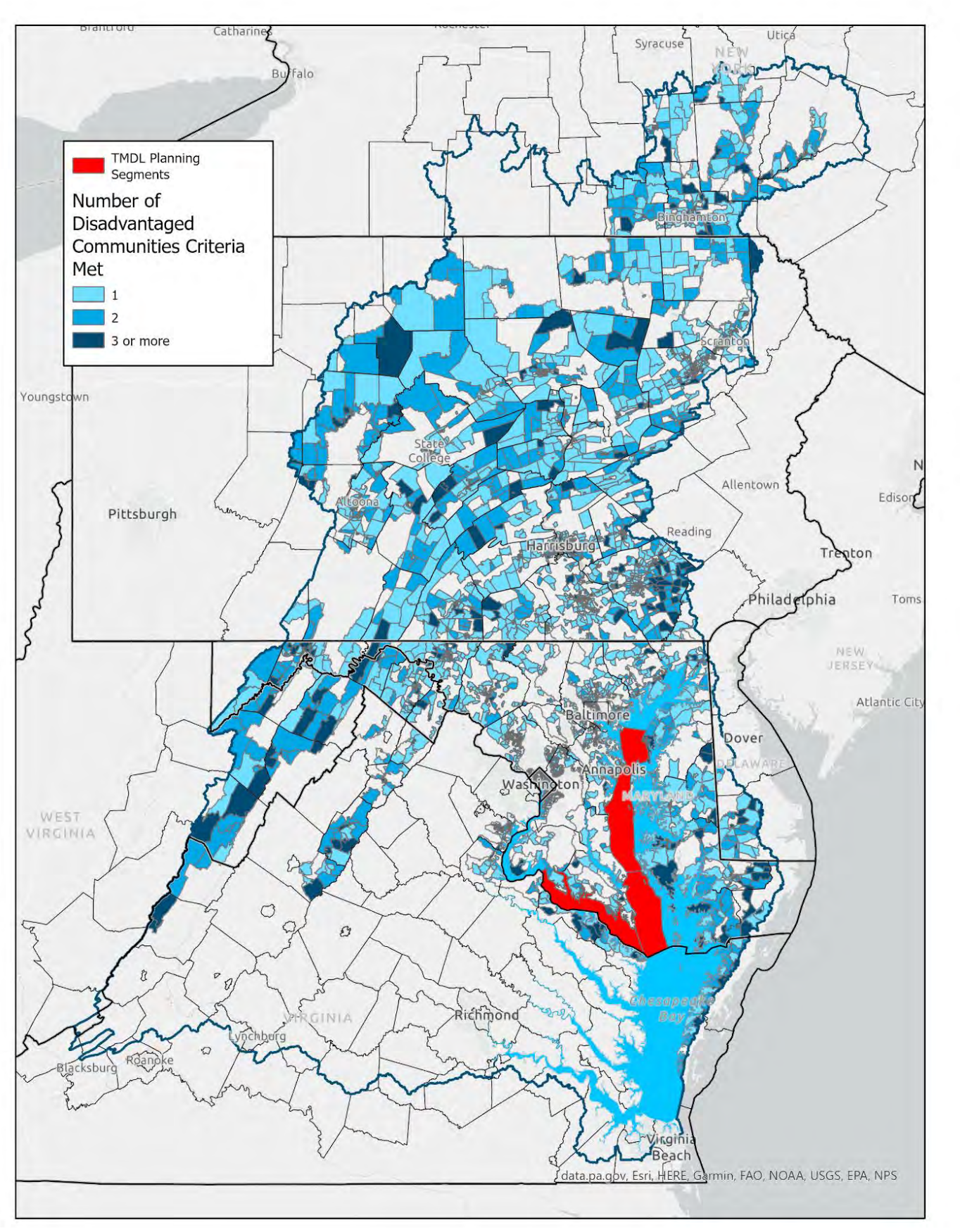


Figure 7. Census block groups containing one or more disadvantaged community criteria within Most Effective Basins (2022).

Disadvantaged Communities

A subset of Most Effective Basins grant funding is being targeted to areas containing one or more **disadvantaged communities**. These include census block groups containing a higher amount of:

- Low-income populations
- Populations under the age of 5
- Populations over the age of 64
- Populations with less than high school education
- Linguistically isolated populations
- Unemployed populations

Figure 8. Middle Branch Park in Baltimore County, Maryland
Photo Credit: Will Parson, Chesapeake Bay Program

For More Information

Chesapeake Bay Program Grant Guidance:

USEPA. 2022. 2022 Chesapeake Bay Program Grant Guidance. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-5/2022%20CBPO%20Grant%20Guidance_May%202022.pdf.

USEPA. 2022. Addendum to the U.S. Environmental Protection Agency Chesapeake Bay Program Office Grant and Cooperative Agreement Guidance: May 19, 2022. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-05/Addendum%20to%20the%202022%20Grant%20Guidance_Final%20May%202022.pdf.

USEPA. 2022. Chesapeake Bay Program Office Most Effective Basins Funding Allocations. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-05/Attachment%2018_MEB%20Funding%20Allocations-May%202022_0.pdf.

Most Effective Basins Grant Funding

By Jurisdiction

Figure 9. Most Effective Basins funding allocation among jurisdictions in thousands of dollars [Ag = agriculture, Inf = infrastructure, Gen = general ($ can be applied anywhere within MEBs), Dis = disadvantaged communities ($ must be applied in area containing one or more disadvantaged communities)]

By Funding Source

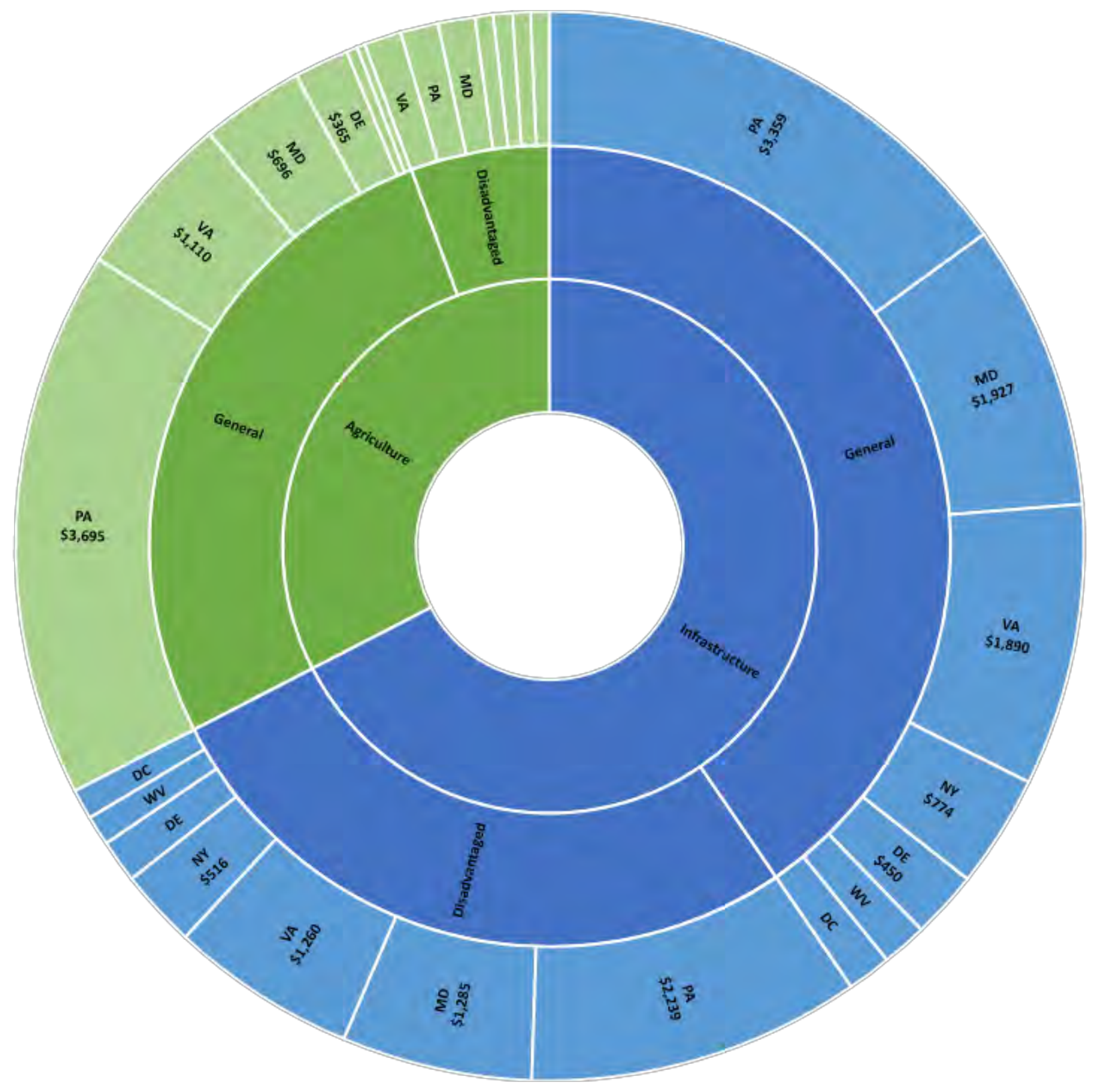


Figure 10. Most Effective Basins funding allocation among funding sources in thousands of dollars [Ag = agriculture, Inf = infrastructure, Gen = general ($ can be applied anywhere within MEBs), Dis = disadvantaged communities ($ must be applied in area containing one or more disadvantaged communities)]

Web Applications

The web applications below provide additional detail and guidance on the interpretation of the Chesapeake Bay Most Effective Basins.

Most Effective Basins and Disadvantaged Communities 2022 Mapping Application
gis.chesapeakebay.net/wip/meb2022/

Most Effective Basins 2022 Story Map Application
gis.chesapeakebay.net/wip/meb2022overview/

Acknowledgments

Thanks to Gary Shenk (USGS), Jeff Sweeney (USEPA), Veronica Hines (Maximus/Attain), and Tim Paris (Maximus/Attain) for contributions to this effort.

Web-based Spatio-temporal Visualization of Water Quality and Habitat Status and Change in Chesapeake Bay

Zhaoying (Angie) Wei[1], Qian Zhang[1], John Wolf[2], Emily Trentacoste[3], Richard Tian[1], Peter Tango[4]

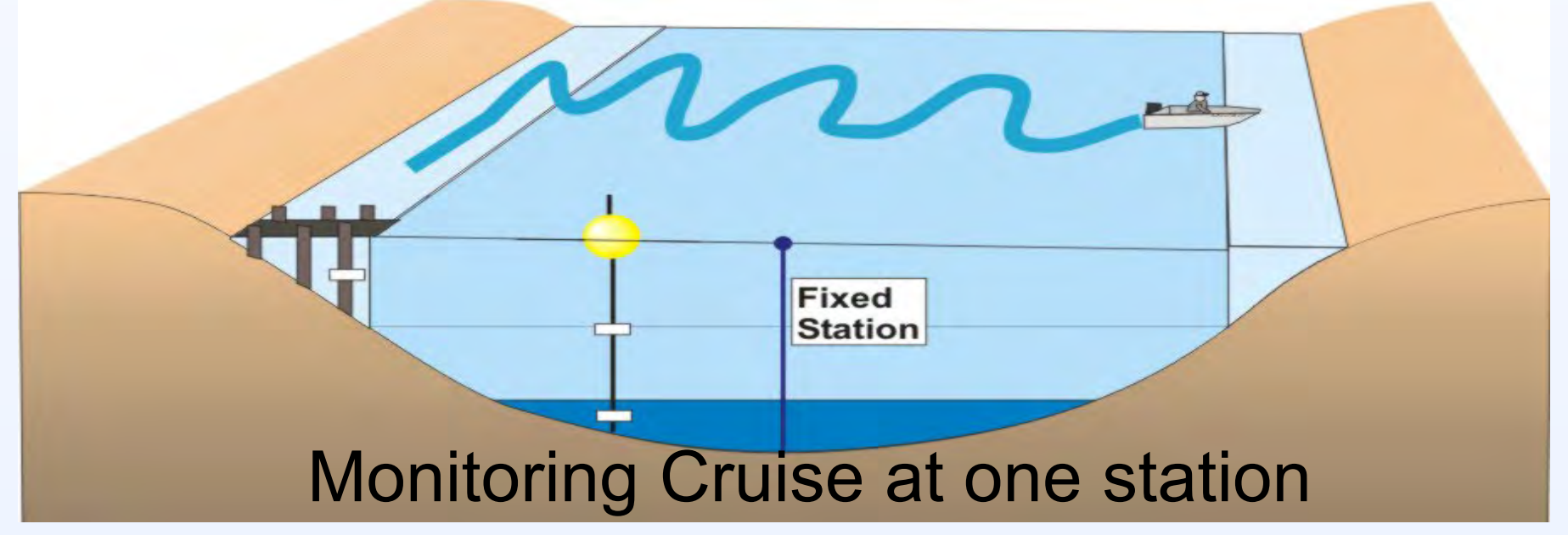
[1]University of Maryland Center for Environmental Science, [2]USGS - Lower Mississippi-Gulf Water Science Center,
[3]USEPA, [4] USGS - MD-DE-DC Water Science Center

Introduction

Spatio-temporal visualization of water quality and living resources data in the Chesapeake Bay has gained popularity in recent years. This web-based 4-dimensional visualization approach provides a good example of utilizing new-generation tools for water quality and habitat depictions and assessments. It shows us how to better integrate, illustrate, and communicate decision-support information from spatio-temporal data.

Chesapeake Bay Monitoring

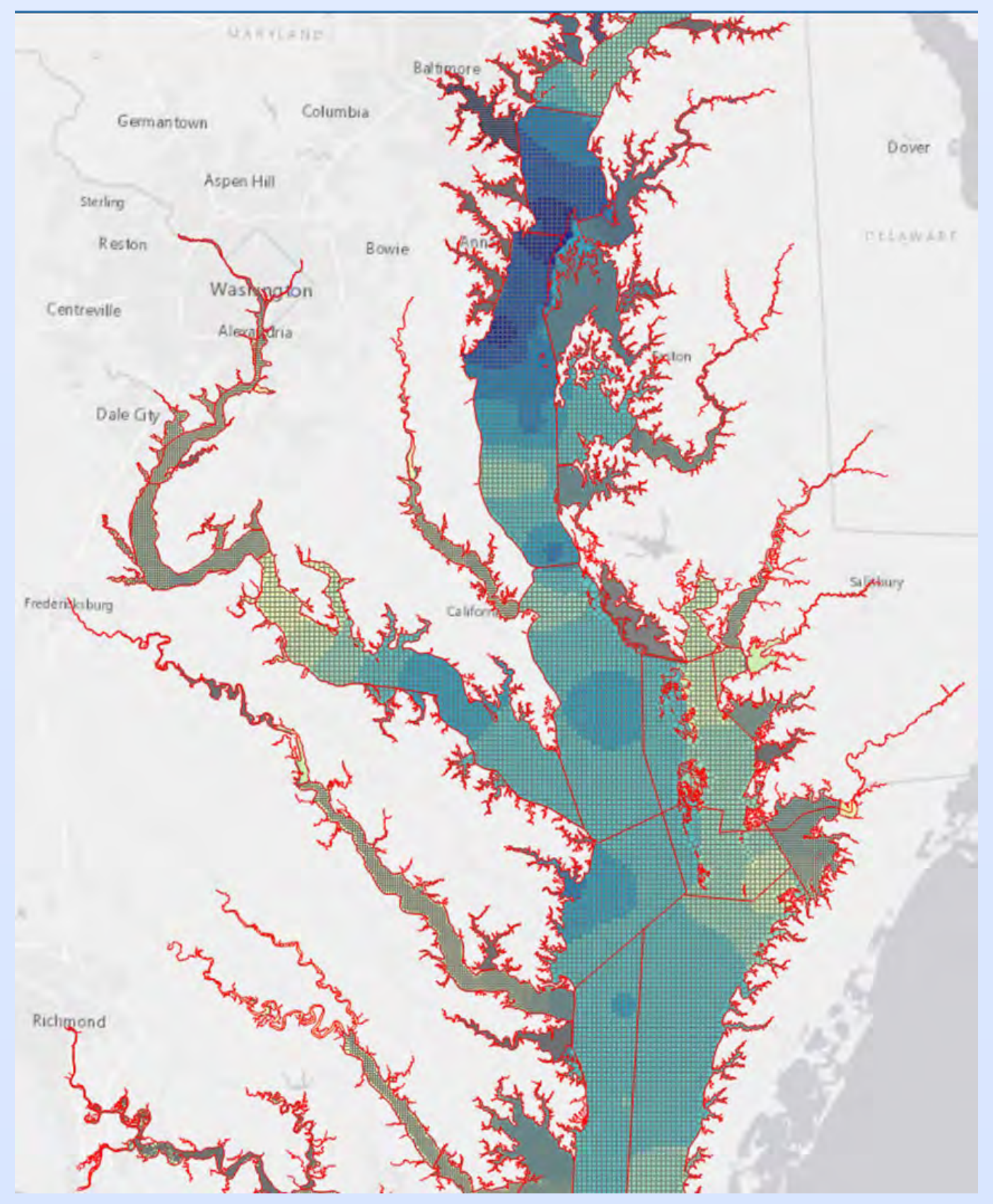
- ☐ Since 1984, MD and VA routinely monitor 19 measured water quality parameters at 49 stations in the Bay's main stem.
- ☐ Cruises are conducted monthly, except 2 cruises per month in June to September.
- ☐ Measurements are taken at one-meter intervals, but every 2 meters below 10 meters.
- ☐ These data are used as input in Chesapeake Bay interpolator.



Monitoring Cruise at one station

Chesapeake Bay Interpolator

- ☐ Cell based interpolator (VOL3D) -current version in use since 2006.
- ☐ Computes water quality concentrations from monitoring data.
- ☐ Cell size 1km x 1km horizontal by 1 m vertical from surface to bottom, in shallow area cell size is 50m x 50m.
- ☐ About 57,000 cells at multiple depths for all 77 segments of the Bay and tributaries. Due to stratification, water quality varies much more vertically than horizontally.

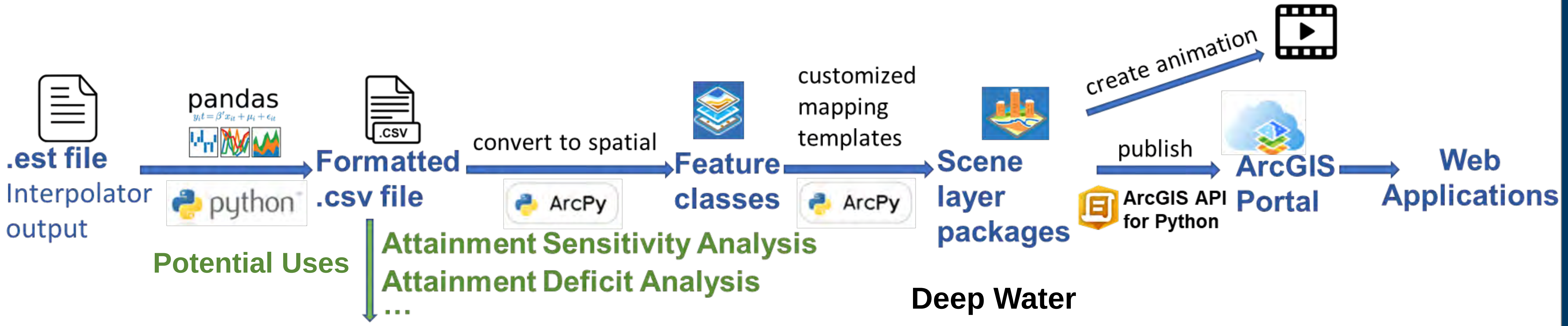


Interpolator cells within monitoring segments

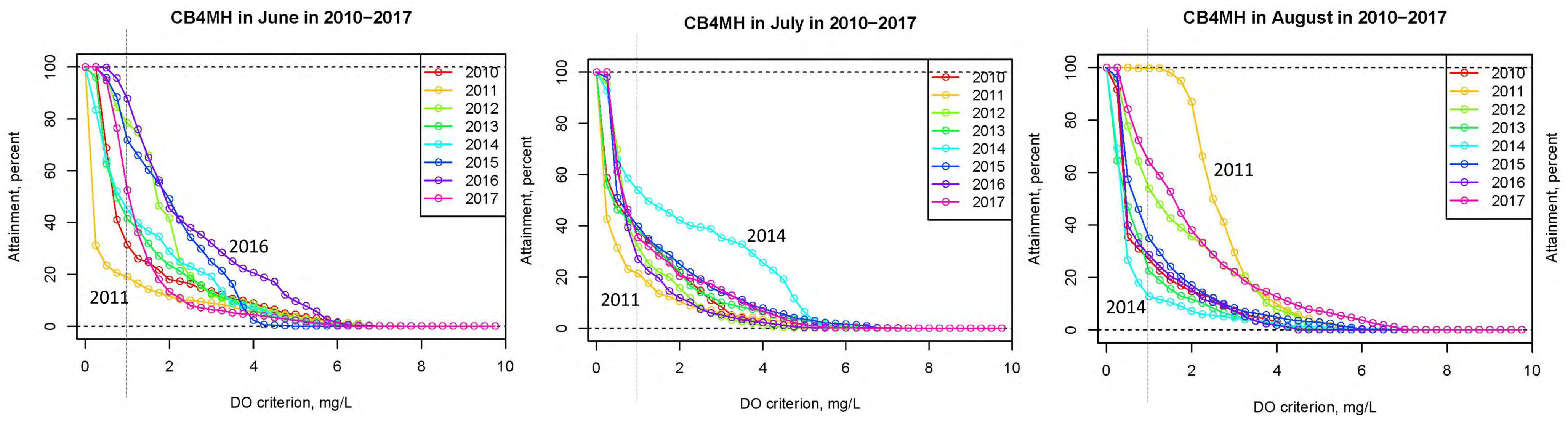
Methodology

In this 4-dimensional visualization for the entire bay, interpolation results from the Chesapeake Bay and Tidal Tributary Interpolator developed by NOAA are utilized as input. We leverage Esri ArcGIS ArcPy 3D mapping capability and open source Python libraries to

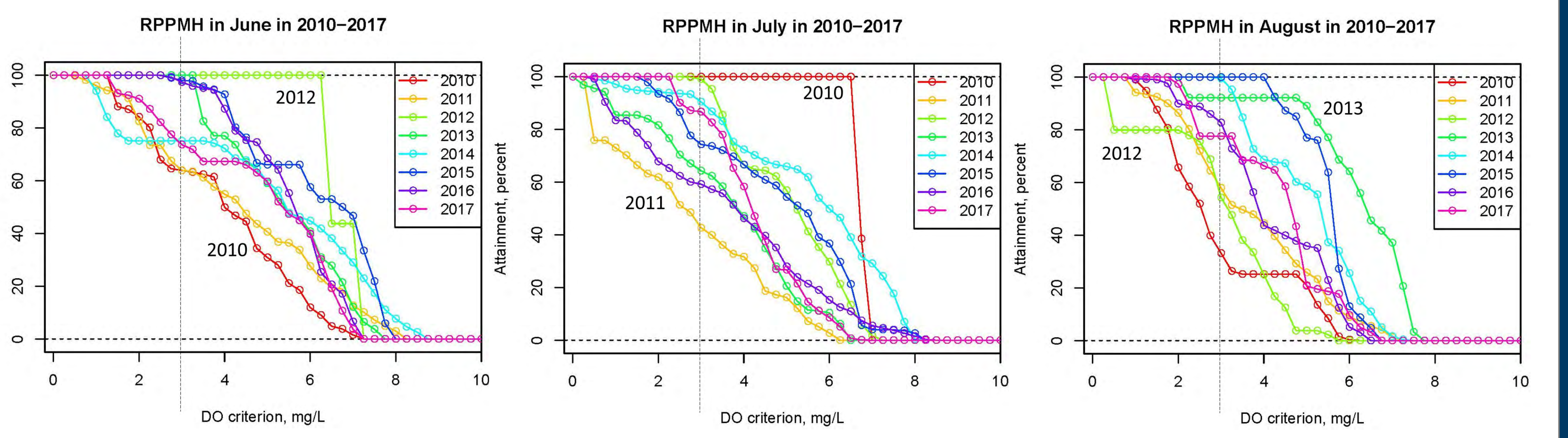
1. (1) restructure the interpolator data
2. (2) map the data for all depths in 3D scenes at various time steps
3. (3) generate shareable web scenes and web applications.



Deep Channel



Deep Water

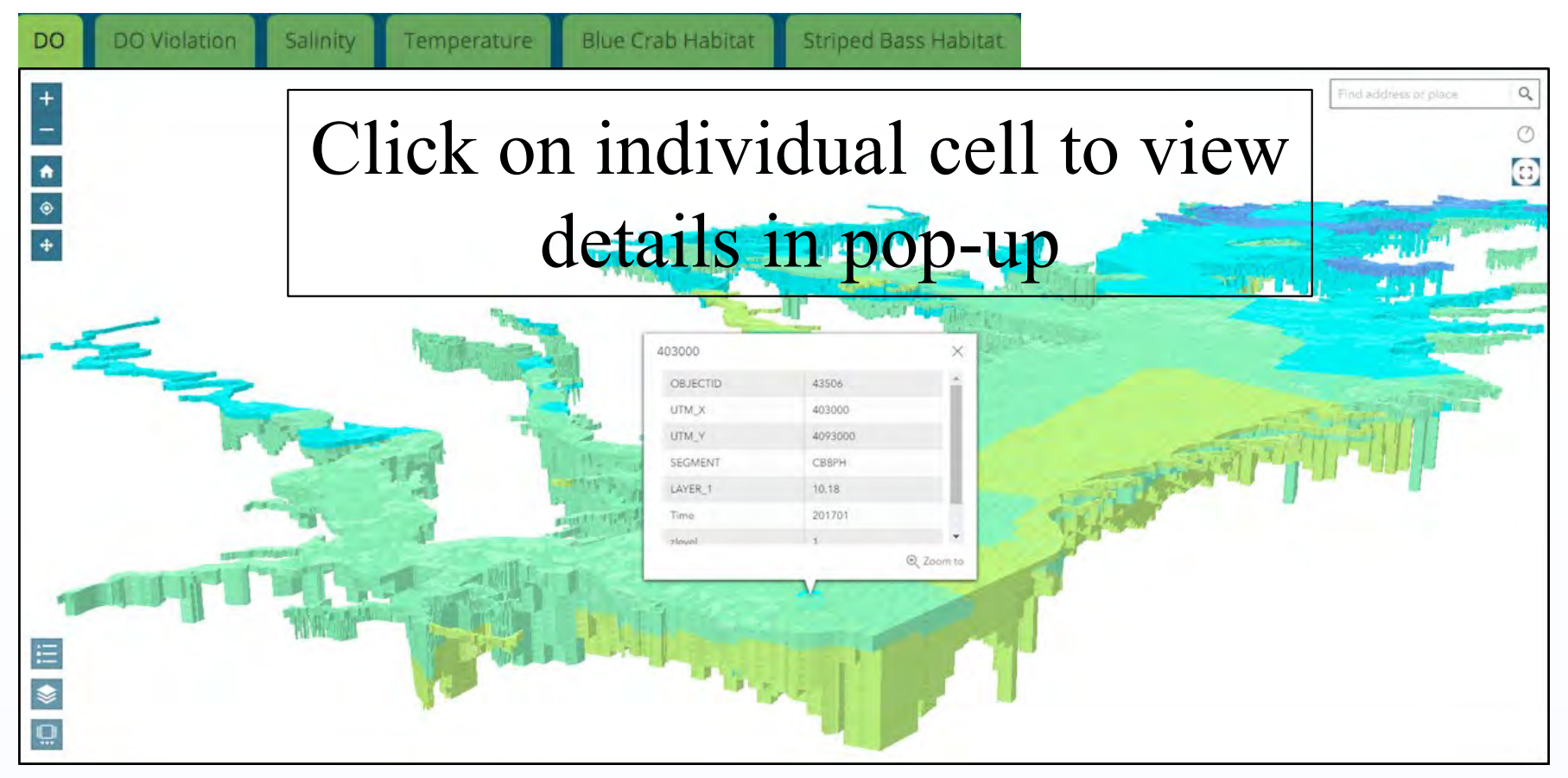


Visualization

We also assess changes in dissolved oxygen violations by comparison to the respective criteria for each designated use of the bay.

https://bit.ly/2IoRqbm

Scan the QR code to launch the web app. It may take a few seconds when first-time launching



Click on individual cell to view details in pop-up

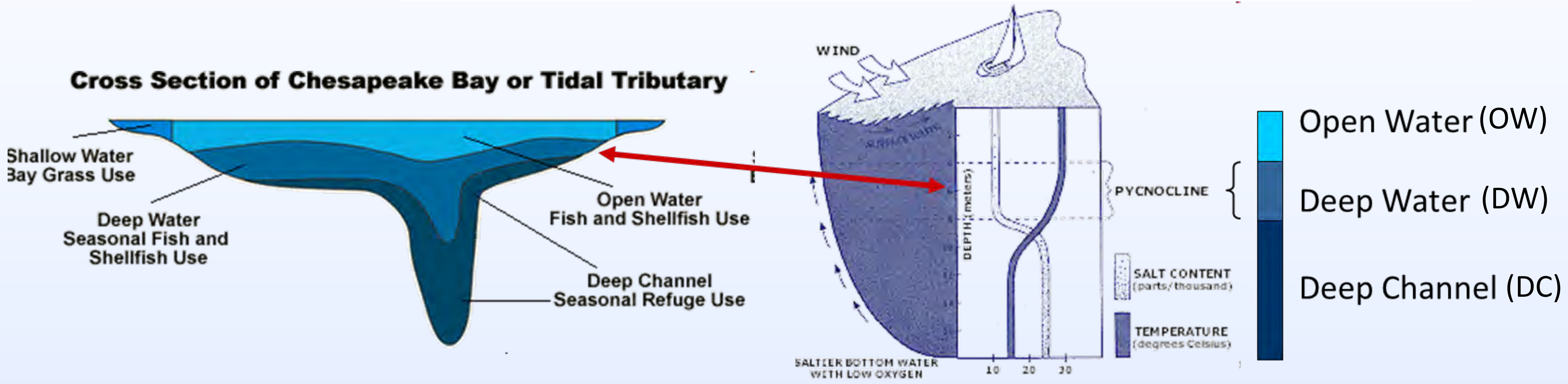
Loop through data of each month using Slides button

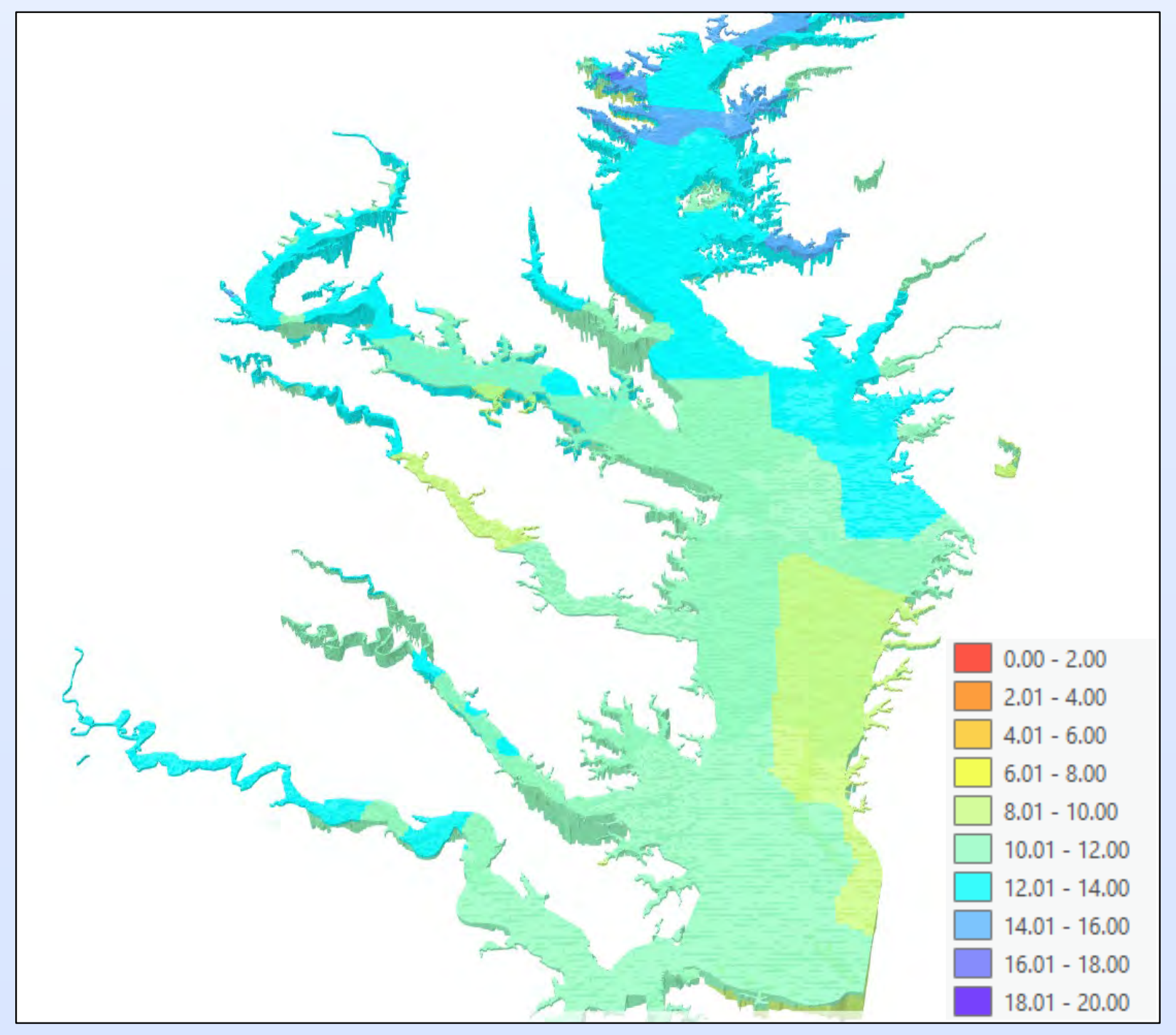
Switch on and off layers of different time and depth

Explore from different angles using Navigate button

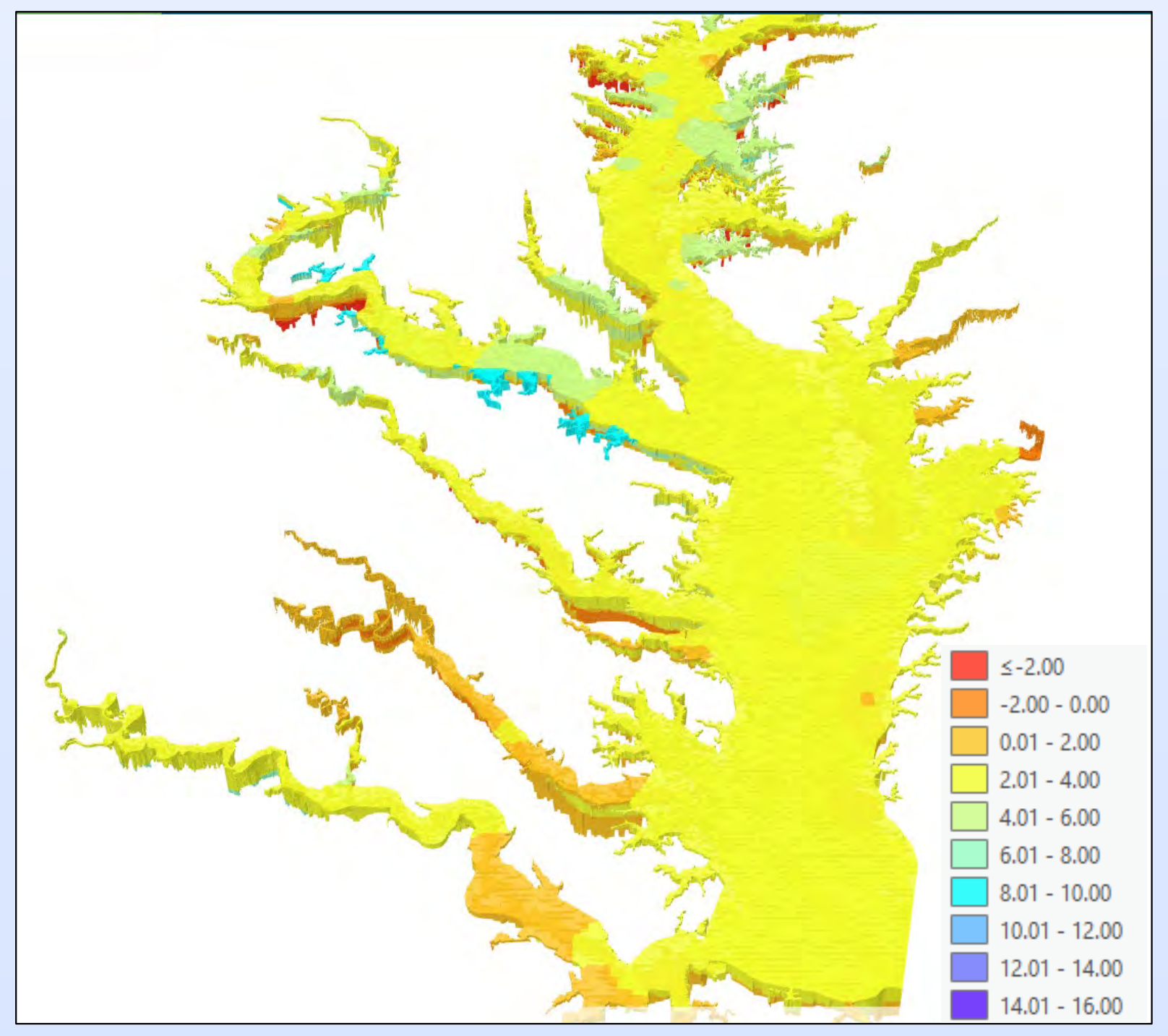
Water Quality

Designated Use	Season	Threshold	Criteria	Applicable Segments
OW	Year-round	30-day mean	5 mg L^{-1}	92
DW	June 1 - Sept. 30	30-day mean	3 mg L^{-1}	18
DC	June 1 - Sept. 30	Bi-weekly mean	1 mg L^{-1}	10





Monthly Dissolved Oxygen (mg/L)



Magnitude of Violation in Dissolved Oxygen (mg/L)

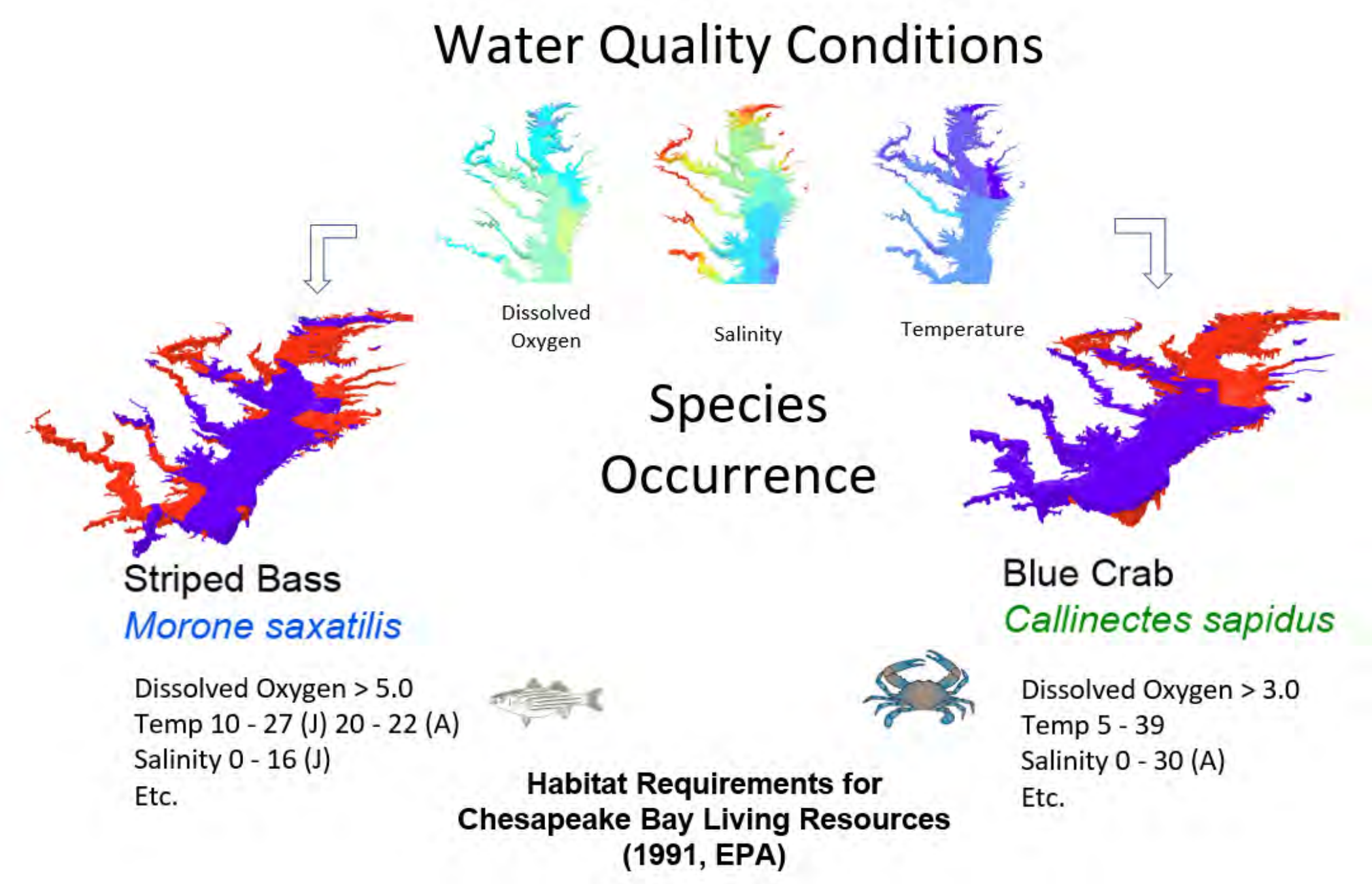
Explore more videos here!

https://bit.ly/31lZXxx

Contact: Zhaoying Wei
zwei@chesapeakebay.net

Living Resource Habitat

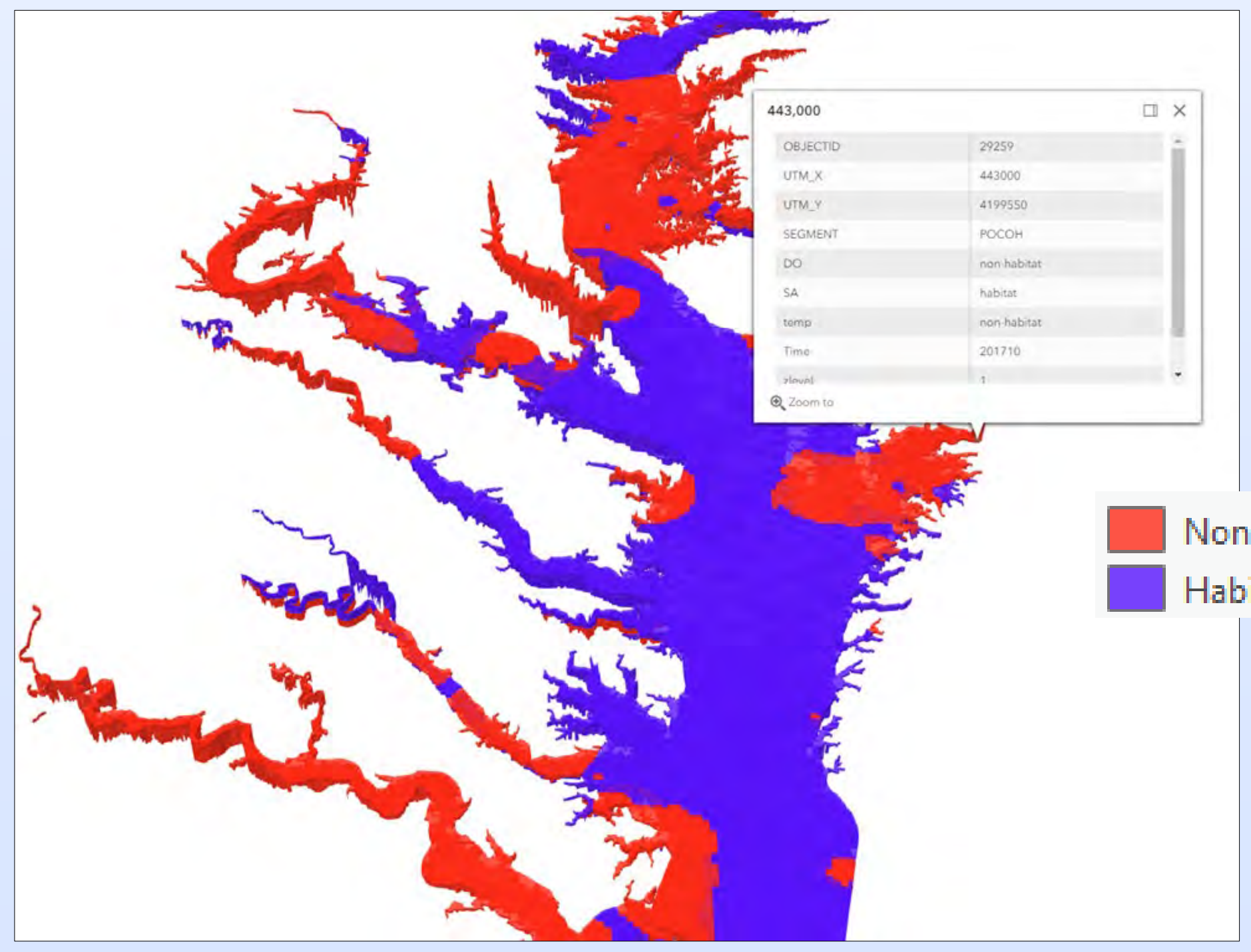
Additionally, habitat status and changes for multiple targeted species are analyzed based on habitat requirements including temperature, salinity and dissolved oxygen.



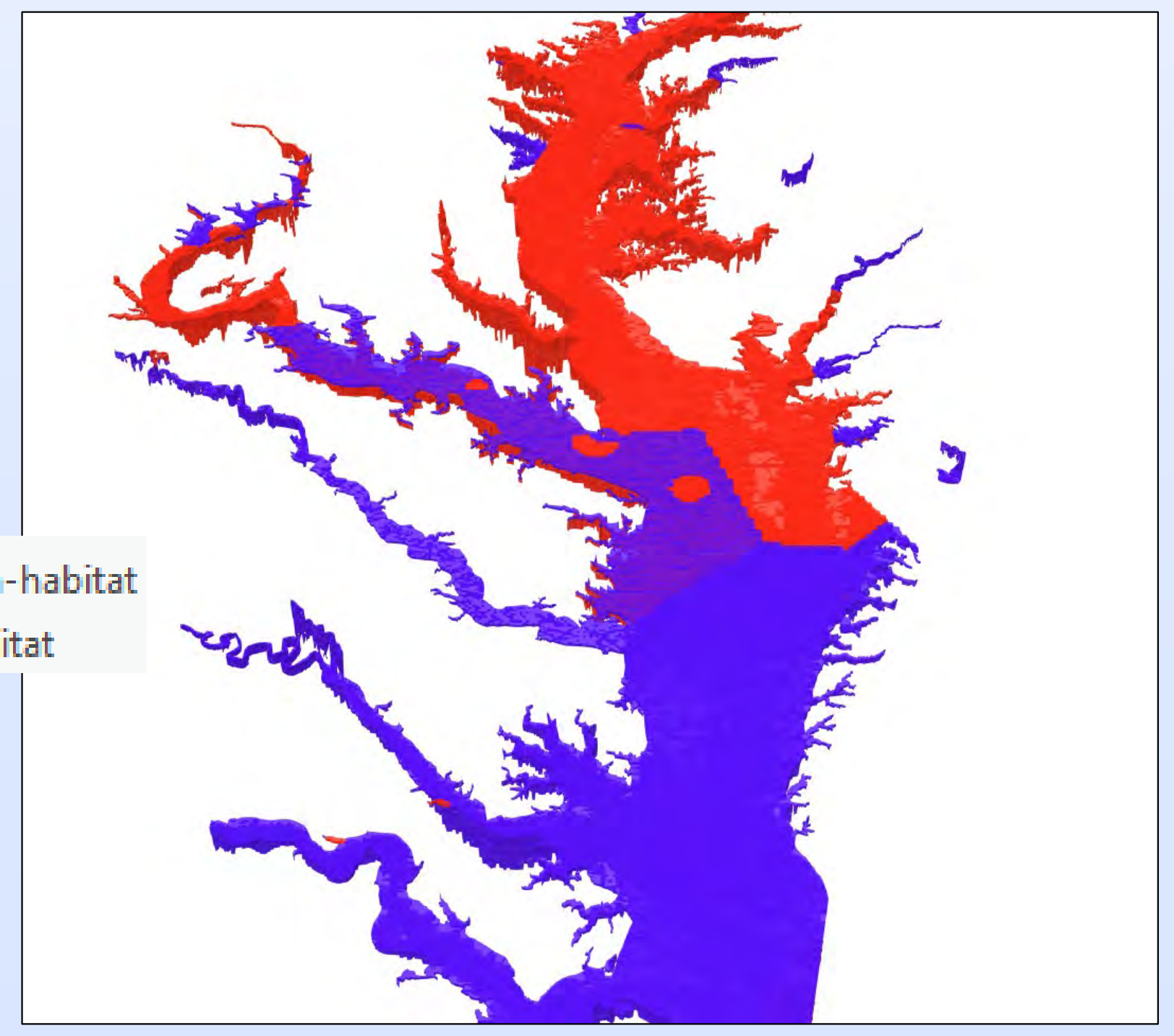
Dissolved Oxygen > 5.0
Temp 10 - 27 (J) 20 - 22 (A)
Salinity 0 - 16 (J)
Etc.

Dissolved Oxygen > 3.0
Temp 5 - 39
Salinity 0 - 30 (A)
Etc.

Habitat Requirements for Chesapeake Bay Living Resources (1991, EPA)



Striped Bass Habitat



Blue Crab Habitat

Data downloadable here (excluding hydrography):
https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/

High-Resolution Mapping Across the Chesapeake Bay Watershed

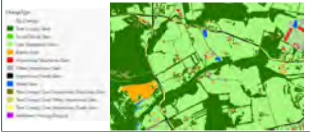
Sarah M. McDonald[1], Labeeb Ahmed[1], Matthew Baker[4], Peter R. Claggett[1], Jacob Czawlytko[2], Elliott Kurtz[2], Sean MacFaden[3], Patrick McCabe[2], Emily Mills[2], Jarlath O'Neill-Dunne[3], David Saavedra[2], Kelly Schulze[3], Rachel Soobitsky[2], Katie Walker[2]

1 Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Chesapeake Bay Program Office, Annapolis, MD 21403
2 Chesapeake Conservancy, Annapolis, MD 21403
3 University of Vermont Spatial Analysis Laboratory, Burlington, VT 05405
4 University of Maryland, Baltimore County, Baltimore, MD 21250

Mapping 1-Meter Resolution Land Use/Land Cover

Land Cover

- Describes the physical land surface
- 12 classes mapped by University of Vermont after initial stakeholder review

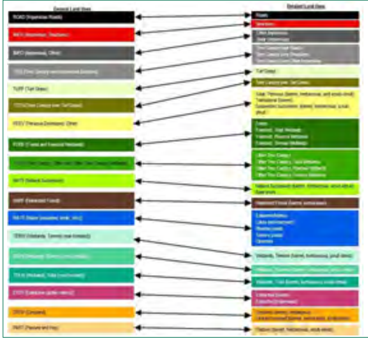


Land Use/Land Cover (LULC)

- Describes how humans manage and use the land
- 54 classes mapped by Chesapeake Conservancy

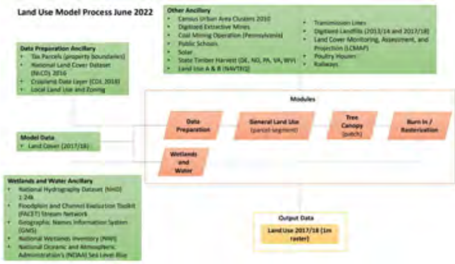
Unique Data Qualities

- Spatial
  - 1-meter resolution
- Categorical
  - 54 LULC classes, visualized with an aggregated 18-class schema
    - The 18-class schema is tree canopy centric
    - Forested wetlands and tree canopy in wetlands are included in the aggregated *forest* and *tree canopy, other* classes
- Temporal
  - Mapped period ranges from 4 to 5 years
- Extent
  - 206 counties within, intersecting, and adjacent to the Chesapeake Bay Watershed (256,000 square kilometers)
- Accuracy
  - >90% expected accuracy for tree canopy and impervious surfaces

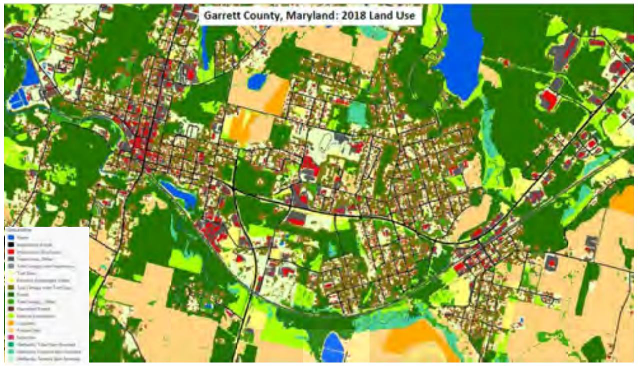


Methods

- Land Use/Land Cover (LULC) is mapped using a collection of models, scripted in PostGIS and open-source Python
- The rule-based models are designed to classify polygons composed of land cover image segments unioned with county parcel data
- A plethora of national, state, and local ancillary data are used to inform the rule-based model's LULC determination



Modelling Scale (Parcel-Segments)



Mapping 1-Meter Resolution Land Use/Land Cover Change

What is the difference between Land Cover Change and Land Use/Land Cover (LULC) Change?

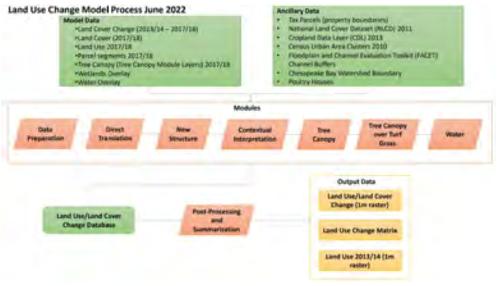
- Land cover change represents change between 12 land cover classes, with 80 transitions mapped across the watershed
- Land use/land cover change represents change between 54 LULC classes, with 974 transitions mapped across the watershed

Methods

- The key driver to mapping Land Use/Land Cover (LULC) change is land cover change
- All land cover change is converted to LULC change
- Land cover change and tax parcels are used to identify areas of land use change not represented as changes in land cover
  - *Low vegetation* in a parcel that became developed in the mapped period (something to *turf grass*)
  - *Tree canopy* in a large forest patch that became fragmented (*forest* to *tree canopy, other*)

Unique model scripted in open-source Python

- Reconcile 1-meter LULC and ancillary data to interpret 2013/14 LULC where LC change occurred
- Create a vector database of LULC information
- Translate vector data to create 1-meter resolution raster of LULC change and change matrices



Why is a Vector Approach Better Suited to Classify LULC and Change?

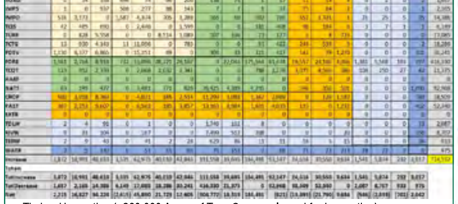
- Vector image segments identify potential variability in land cover within contiguous patches of a single land cover class. This variability may indicate differences in land use. A purely raster based-approach would not account for this variability.


2018 National Agricultural Imagery Program (NAIP), USDA
2018 Land Cover and 2018 Land Cover Segments (UVM)

Why is a Unique Land Use/Land Cover (LULC) Change Model Required to Accurately Map LULC Change?

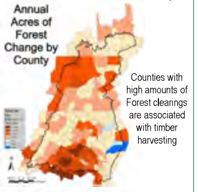
- In a series of LULC datasets, the most recent date is generally most accurate because it leverages the latest ancillary data, imagery, and technological advances. LULC change over an observed 4 to 5-year period only occurs on about 5% of the landscape. To preserve the accuracy of the latest LULC date, only the areas of change need to be updated to represent earlier LULC dates.
- The latest LULC provides the most accurate "end state" context for interpreting the LULC conditions in previous years.
- This approach allows the LULC time series to be adapted to evolving user needs by addressing them in the most recent date of LULC for the entirety of the landscape. Any improvements are held constant back through time by only adjusting the areas of change in the separate change model.

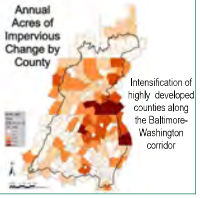
Watershed Trends



- Timber Harvesting (~260,000 Acres of Tree Canopy cleared for harvesting)
  - ~ 80,000 acres of *natural succession* and *harvested forest* transitioned to *forest* and *tree canopy*
- Development (~130,000 Acres of new development)
  - ~50,000 Acres of new impervious and ~79,000 Acres of new pervious development, including *turf grass*, *tree canopy over turf grass*, solar fields, utility right of ways, and construction
  - ~93,000 Acres of *forest* and *other tree canopy* transitioned to development (including *tree canopy over impervious* and *turf grass*)
  - ~40,000 Acres of Agriculture transitioned to development

Watershed Trends Vary Locally

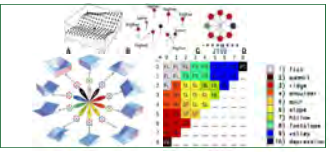




Mapping 1-Meter Resolution (Hyper-Res) Hydrography

What are Geomorphons?

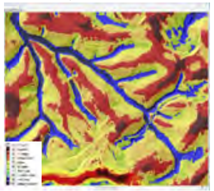
- Landform classification algorithm by Jasiewicz & Stepinski (2013)
- Evaluates 8 directional position and relative elevation bounding line-of-sight to determine landform
- Classifies pattern rather than degree
- Delineates contiguous features rather than pixels
- Adjustable parameters, host of encoded information



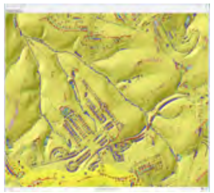
Methods

1. Lidar elevation

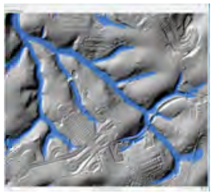
2. Valley-Scale Classification



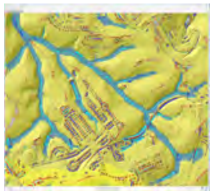
3. Channel-Scale Classification



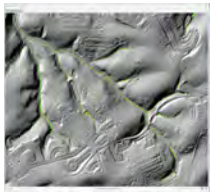
4. Identify Valley Network



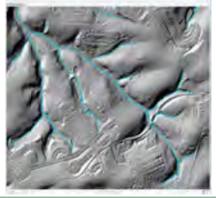
5. Extract Features using valley network



6. Predict Channel Skeleton



7. Connect Stream network



Reach-scale attributes:

- Length and slope
- Width and Bank height
- Stream order
- Essential for temp, hydraulic, WQ modeling
- Others?
- Channel Width, bank height, other attributes detected directly from DEM

Reach Classification:

- Streams
- Rills and gullies
- Roadside ditches
- Agricultural ditches/swales
- Detention features/ponds
- Floodplain depressions
- Other (e.g., anthropogenic features, crevice, slide scars, washes)

How Does this Approach Compare to the National Hydrography Dataset (NHD)?

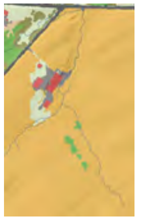
- The Hyper-Res Streams (blue) are more precise than NHD streams (red)
- The Hyper-Res is better suited for precise applications, such as riparian area and other local analyses
- The Hyper-Res streams is assigned attributes not present in NHD

2013 LULC

2013 LULC + LULC Change + Hyper-Res Hydrography

2013 LULC + Hyper-Res Hydrography

2017 LULC + Hyper-Res Hydrography



Devereux Consulting
Data ✦ Research ✦ Analysis ✦ Strategy

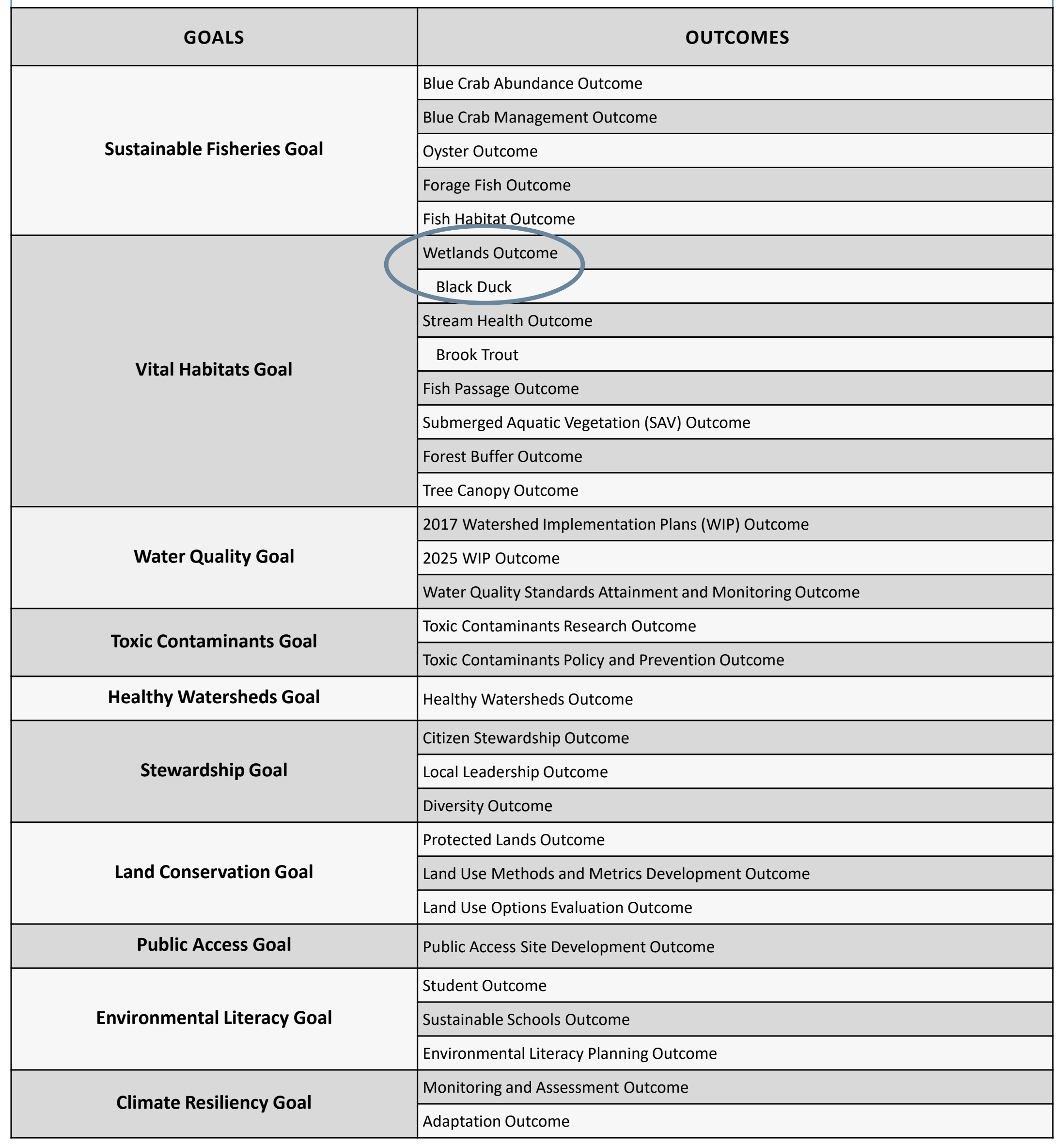
Habitat Tracker

Olivia Devereux & Helen Golimowski, Devereux Consulting, Inc.

habitat-tracker.net

2014 Chesapeake Bay Agreement

10 Goals | 31 Outcomes



GOALS	OUTCOMES
Sustainable Fisheries Goal	Blue Crab Abundance Outcome
	Blue Crab Management Outcome
	Oyster Outcome
	Forage Fish Outcome
	Fish Habitat Outcome
Vital Habitats Goal	Wetlands Outcome
	Black Duck
	Stream Health Outcome
	Brook Trout
	Fish Passage Outcome
	Submerged Aquatic Vegetation (SAV) Outcome
	Forest Buffer Outcome
	Tree Canopy Outcome
Water Quality Goal	2017 Watershed Implementation Plans (WIP) Outcome
	2025 WIP Outcome
	Water Quality Standards Attainment and Monitoring Outcome
Toxic Contaminants Goal	Toxic Contaminants Research Outcome
	Toxic Contaminants Policy and Prevention Outcome
Healthy Watersheds Goal	Healthy Watersheds Outcome
Stewardship Goal	Citizen Stewardship Outcome
	Local Leadership Outcome
	Diversity Outcome
Land Conservation Goal	Protected Lands Outcome
	Land Use Methods and Metrics Development Outcome
	Land Use Options Evaluation Outcome
Public Access Goal	Public Access Site Development Outcome
Environmental Literacy Goal	Student Outcome
	Sustainable Schools Outcome
	Environmental Literacy Planning Outcome
Climate Resiliency Goal	Monitoring and Assessment Outcome
	Adaptation Outcome

Scientific & Restoration Questions Habitat Tracker Can Answer

How many acres of wetlands are newly created (trend over time)?

How many acres of wetlands are in tidal areas, and expected to support black ducks?

How many acres of wetlands are in nontidal areas?

How many projects include a plan for an environmental literacy component (examples: signage, programs)?

Who are the project funders?

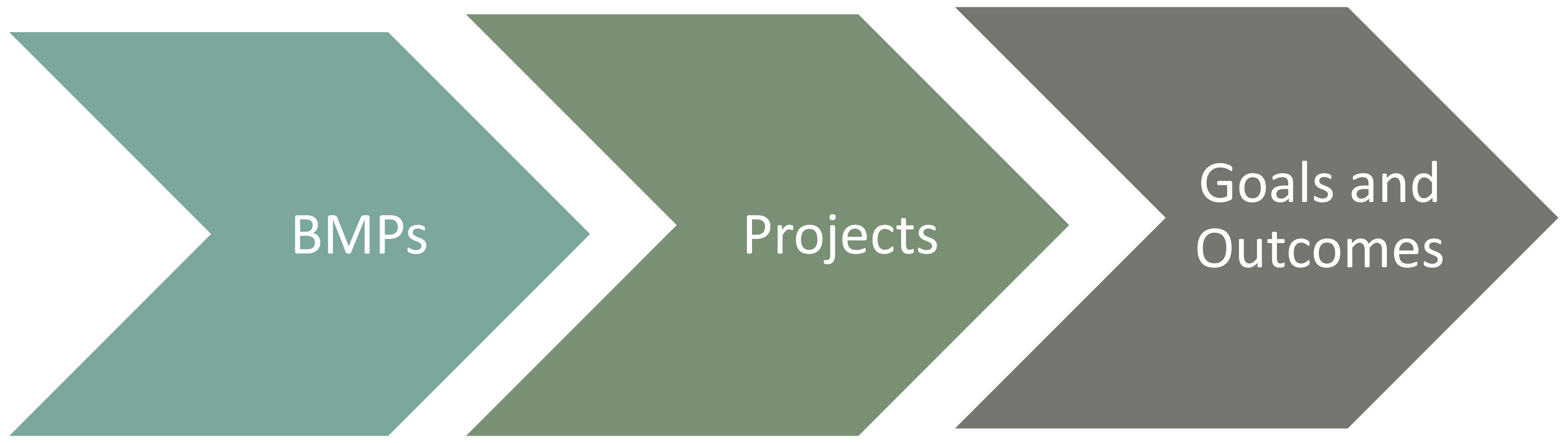
What are the acres of projects supporting Rare Threatened and Endangered (RTE) species, and which ones?

What is the type, number, and extent of management practices implemented on wetlands?

1. **Science:** Integrates multiple levels of project data such as wetland type, land use, community information, supported species, project funders, and more.
2. **Restoration:** Tracks progress toward the Vital Habitats Goal to restore, enhance and protect a network of land and water habitats to support fish and wildlife and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed.
3. **Partnership:** Jurisdictions, Ducks Unlimited, The Nature Conservancy, and other organizations are being asked to provide project data, which will be used for the Chesapeake Bay Progress Outcome reports.

Partnership Using Habitat Tracker

The Habitat Outcome and Attainment Tracking System is a means of collecting and managing the habitat improvement projects implemented in the Chesapeake Bay watershed. A central repository of data from multiple agencies and partners allows a streamlined approach to generate reports needed for ecosystem services tracking and assessments. The Tracking System also facilitates evaluating project implementation goals for trend and targeting analyses.



Habitat Tracker Integrates with Many Chesapeake Bay Goals

Habitat Tracker Features

- Users upload tables in a standard format with both required and optional data fields.
- Users generate pre-defined reports of practice, programs (funders and voluntary), geography, years, and other parameters. Reports are available as downloadable Microsoft Excel files.
- Allows an upload of data by an administrative user, annually.
- Allows replacement of GIS data including physiographic region, wetland type, and tidal/nontidal areas to update all data attributes that rely on those data.
- All reported data can be parsed by year, state, and HUC-12.

Information and Reporting

A standard form is used to help data submitters identify and report projects that are expected to impact wetlands and black ducks. Reported projects are used to assess progress towards meeting the goals and outcomes established in the 2014 Chesapeake Bay Agreement.

Data include project level information and project goals; with less of a focus on tracking CAST management practices, which are limited to water quality outcomes. Projects include preservation and creation of wetlands and habitat appropriate for black ducks in natural, urban, and agricultural areas.

Fields that are tracked and reported by the Habitat Tracker include:
- Geography and land use
- Project and wetland type
- Public accessibility and recreation
- Flood hazard and climate resiliency data
- Habitat for rare, threatened, or endangered species; at risk/heritage species types
- Environmental literacy components and community information
- Project planning priority type
- Project funders
- Project BMPs and inspections

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Fostering Chesapeake Stewardship Goal Implementation Team (GIT 5):

Environmental Literacy * Stewardship * Protected Lands * Public Access * Diversity

Invest in Engagement

18 Million People in the Watershed Who:

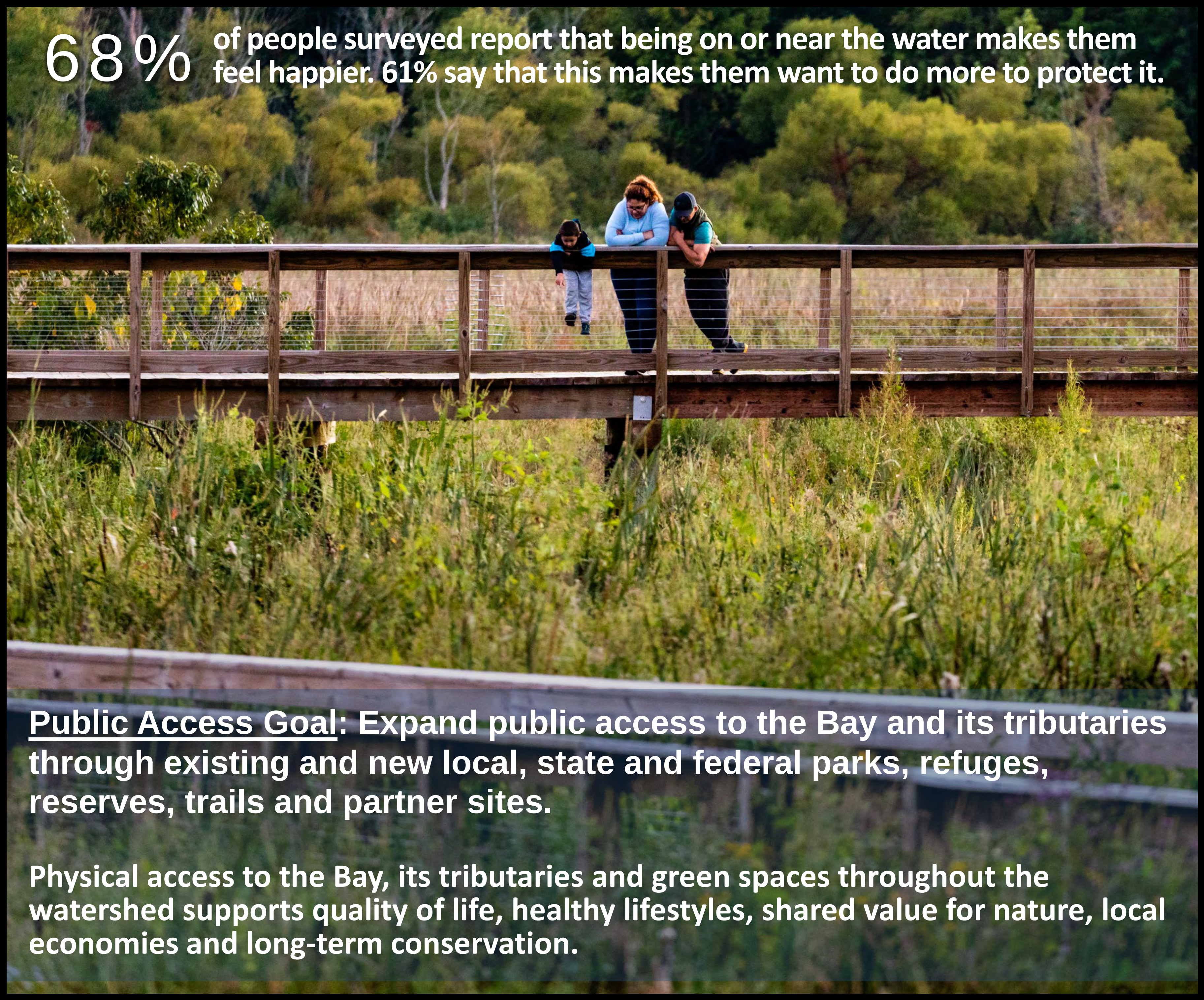
Live
Play
Learn
Work
Vote
$pend
Decide
Act
Care
Love
Use resources
Need clean water & air

Resources and Tools:

- CBP Environmental Justice & Equity Dashboard
- Green Space Equity Mapper
- Chesapeake Conservation Atlas
- CBP Targeting Tools Portal
- Bay Backpack
- Find a Bay Organization
- Chesapeake Behavior Change
- Public Access to Waterways
- Chesapeake Gateways

People who can, should and want to be part of the solution.

Prioritize Health & Quality of Life



68% of people surveyed report that being on or near the water makes them feel happier. 61% say that this makes them want to do more to protect it.

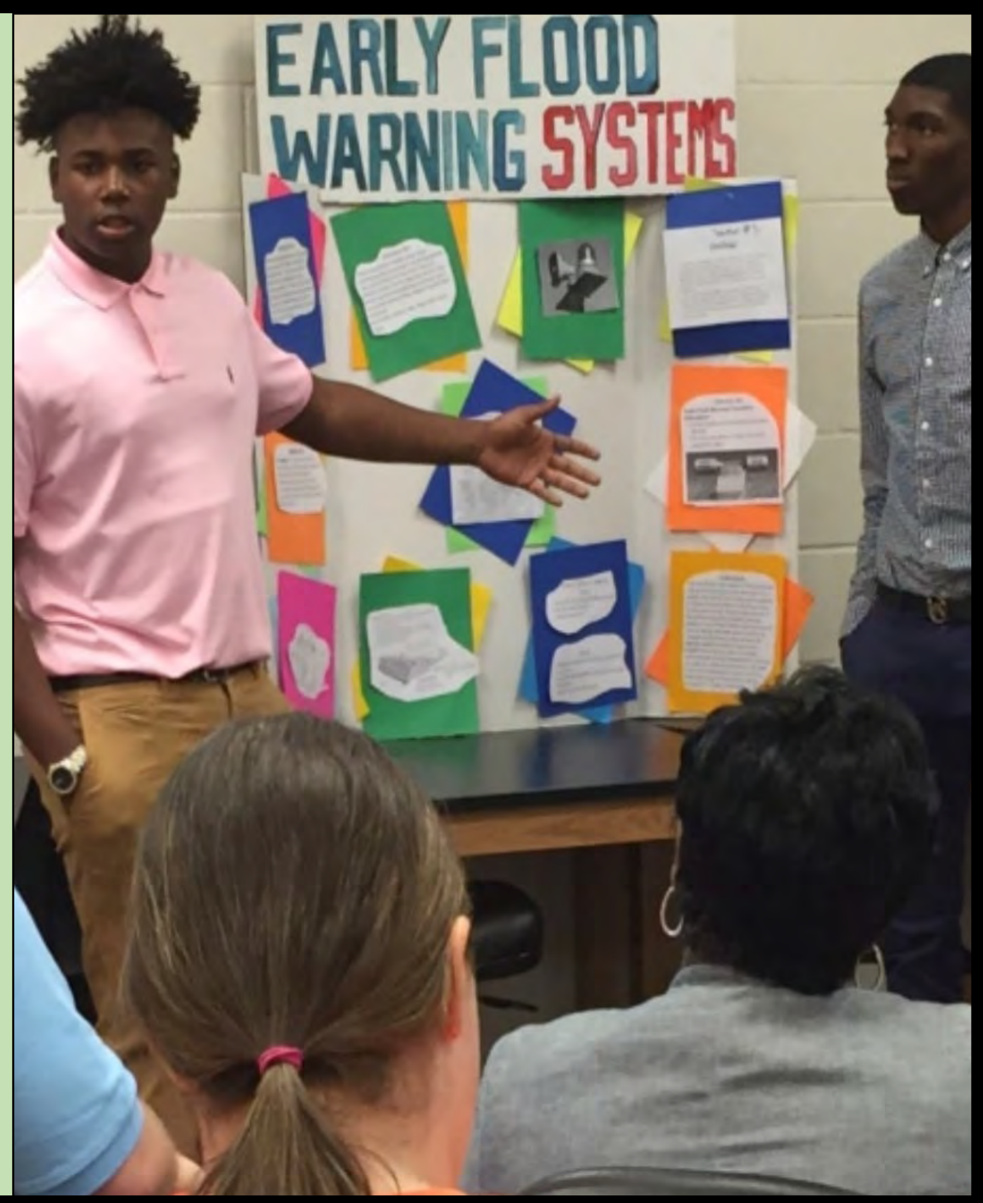
Public Access Goal: Expand public access to the Bay and its tributaries through existing and new local, state and federal parks, refuges, reserves, trails and partner sites.

Physical access to the Bay, its tributaries and green spaces throughout the watershed supports quality of life, healthy lifestyles, shared value for nature, local economies and long-term conservation.

Increase Environmental Literacy

~73% of the 800 school districts in the watershed offer students a MWEE. There are ~3 million K-12 students in the watershed.

Enable students in the region to graduate with the knowledge and skills to act responsibly to protect and restore their local watershed.



What is a MWEE? Meaningful Watershed Educational Experience

It is NOT a one day field trip – it includes multiple outdoor field experiences and an extended set of opportunities for students to:

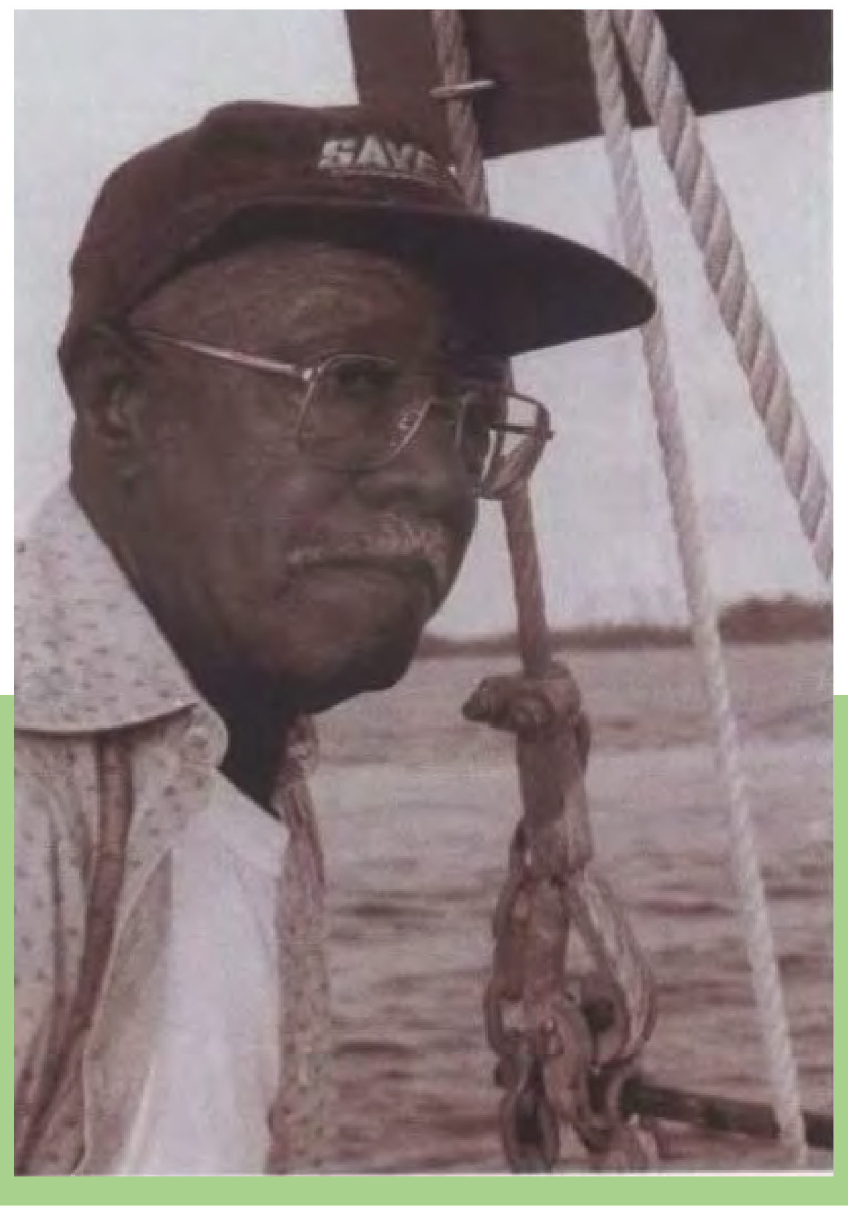
- ✓ Strengthen their connection to the natural world
- ✓ Explore, research and reflect on environmental topics
- ✓ Develop solutions
- ✓ Take action to address issues at school or in their local community
- ✓ Build life skills

Practice Inclusion

84% **of Latino voters polled in 2021 support Bay conservation**; an overwhelming majority support conserving 30% of lands and waters by 2030, and are concerned about climate change, water pollution, access to nature and historic sites.

Tell Their Stories

Preserve, celebrate and amplify the voices and actions of people not often recognized as having shaped our history. **Chesapeake Gateways** – a system of places to enjoy, learn about and help conserve the Chesapeake Bay and its watershed – is one example. This network of natural, cultural, historical and recreational sites, trails, museums, parks, refuges and more showcases ways to share inclusive stories and facilitate community engagement.



Traditionally excluded and underrepresented demographics care more about environmental issues than often is assumed, and are the most impacted by these issues. **Therefore, it is important that we are intentional about inclusion and representation.**

Save the Landscape

30% of the watershed protected by 2030 is a goal toward increased resilience to climate impacts, and for protecting our biodiversity and ecosystem services.

Building Resilient Communities & Landscapes

Conserving large landscapes throughout the region to benefit multiple values, including economic sustainability; scenic, historic and cultural heritage; working lands; important wildlife habitat; water quality and supply; and overall quality of life.

Our Land, Our Heritage, Our Future
Farms * Forests * Habitat * Heritage * Human Health
Chesapeake Conservation Partnership

Build Active Bay Stewards

24 out of 100 is the baseline stewardship score for watershed residents (2017) – a combined reflection of reported personal action, volunteerism, and attitudes about stewardship. Will the 2022 results show growth?

71% of residents surveyed want to do more to make their creeks, rivers and lakes healthier, and 65% agree polluted water affects them personally.

Spectrum of Community Engagement/ Public Participation

INFORM → CONSULT → INVOLVE → COLLABORATE → CO-LEAD/ EMPOWER

Using Social Science throughout CBP work will:

- Build support for Bay goals with the broader public
- Encourage pro-environmental behaviors
- Discourage environmentally harmful behaviors
- Involve watershed residents in lasting solutions

Chesapeake Bay Open Water Response to Geographic Nutrient Loads

Gary Shenk[1], Emily Trentacoste[2], Richard Tian[3], and John Wolf[4]

[1] USGS – Virginia/West Virginia Water Science Center, [2] USEPA – Chesapeake Bay Program Office, [3] University of Maryland Center for Environmental Science, [4] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Abstract

Geographic isolation runs are used to investigate the effects on Chesapeake Bay Chlorophyll concentration based on changes in nitrogen or phosphorus loads from both point and non-point sources. This poster demonstrates the use of a tool to visualize the source nutrient loads for each tidal water segment in Chesapeake Bay. The tool extends the approach used to assess relative effectiveness for the Chesapeake Bay Total Maximum Daily Load to all Open Water segments.

Key Factors

- ☐ Watershed Characteristics
- ☐ Travel time
- ☐ Existence of impoundments
- ☐ Position along mainstem bay
- ☐ Estuarine circulation

Methods

- ☐ Using the CBP's estuarine water quality model, run a separate scenario for each CB segment, nutrient, and source type (point or nonpoint)
- ☐ Add 5 million lbs of N or 0.5 Mlbs/yr P each year by an annual coefficient to the loads in each CBSEG
- ☐ Separate PS and NPS runs
- ☐ Model the change in June-September Chlorophyll concentration to the depth of the long-term surface mixed layer
- ☐ Multiply by watershed delivery
- ☐ **Calculation**
  - Watershed delivery:
    - ☐ Pound delivered per pound produced
  - Estuarine delivery
    - ☐ Chlorophyll increase per pound delivered
  - Overall Effectiveness
    - ☐ Chlorophyll increase per pound produced

Summary

- ☐ Visualization of Chlorophyll response - related to oxygen and clarity
- ☐ Visualization only – no nutrient exchanges based on these runs
- ☐ Shows primacy of local watersheds to small bays

Expanding TMDL Approach to Open Water Segments

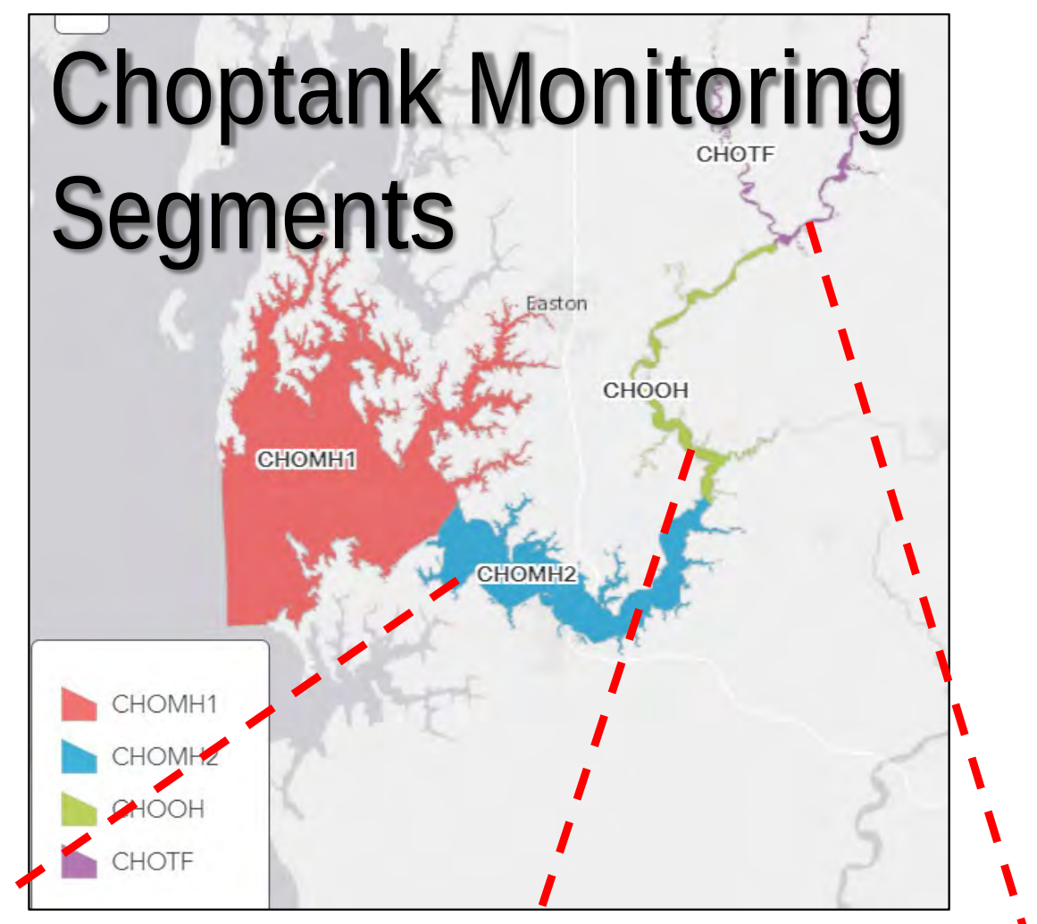
Existing relative effectiveness for used for nitrogen and phosphorus planning targets was based on sub-pycnocline dissolved oxygen in the mesohaline regions of the Bay and Potomac rivers

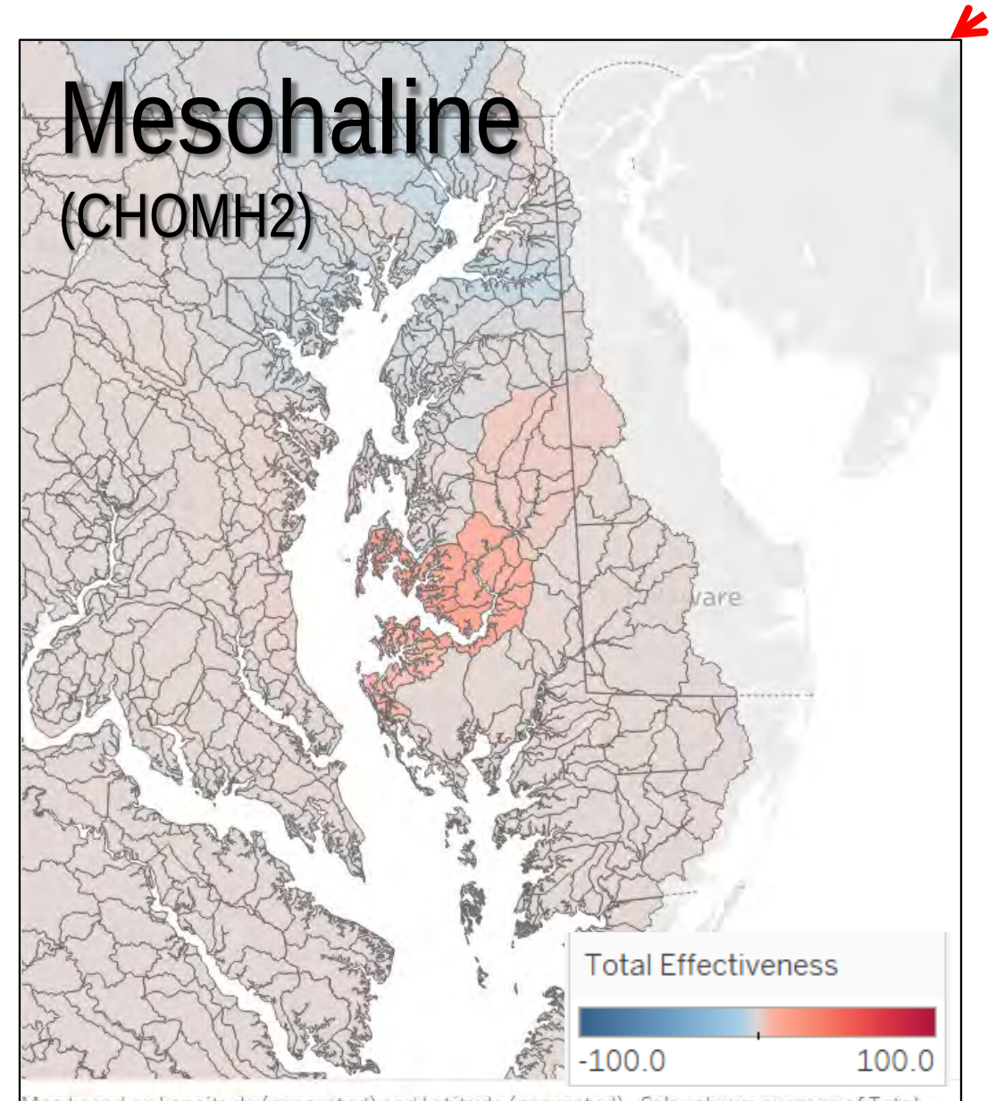
Goal is to provide a tool for the Partnership to visualize the source of load effecting the surface mixed layer for each Tidal Segment

Choptank River, Maryland Example

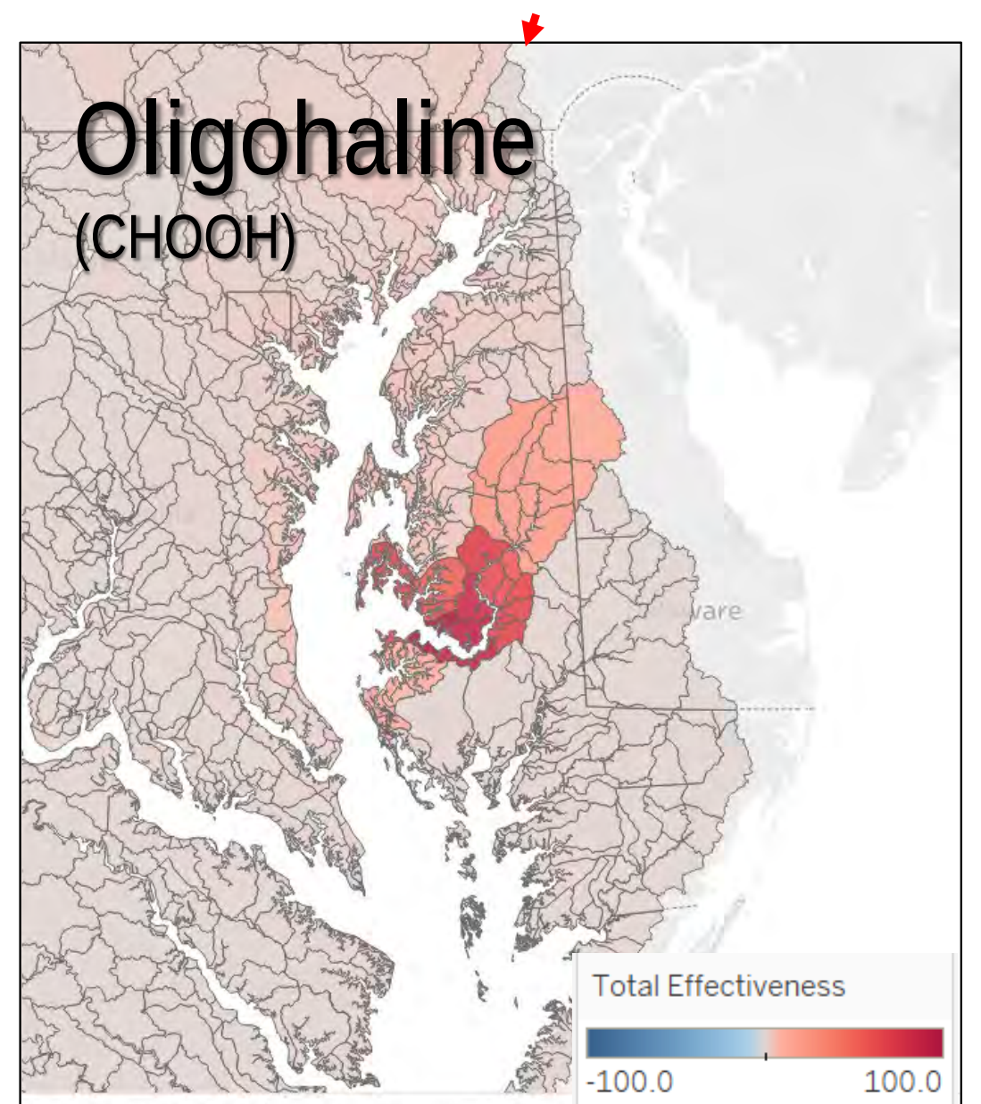
(Phosphorus – Non-Point Sources)

As you progress downstream from tidal fresh near Greensboro, Maryland to oligohaline to mesohaline conditions at the mouth of the river, the impact on Chlorophyll from phosphorus in the upstream watershed decreases relative to the influence of nitrogen and relative to nutrients from other basins. In some cases the total effectiveness becomes negative, indicating that a decrease in the upstream contribution of phosphorus would be expected to increase Chlorophyll a concentrations.





Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps CHOMH2. The Pollutant (N or P) filter keeps P. The Source (PS or NPS) filter keeps NPS.



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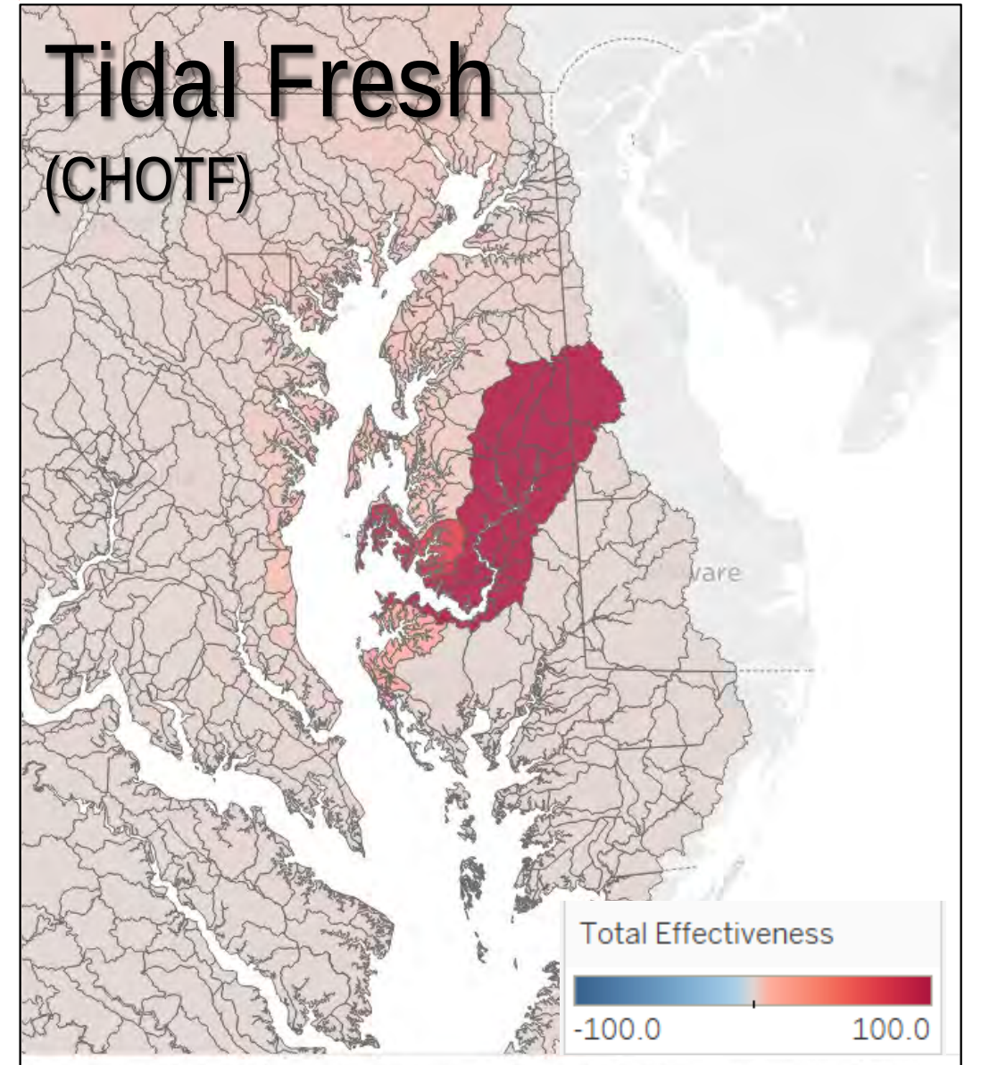

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Photo: Jane Thomas, UMCES IAN.

Photo: Wikipedia

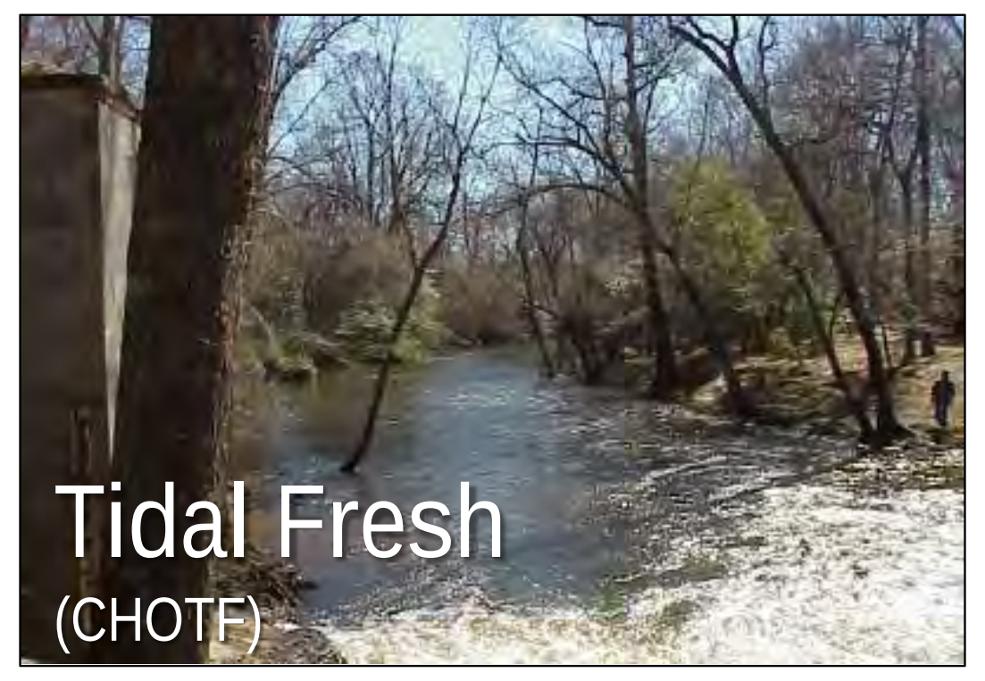


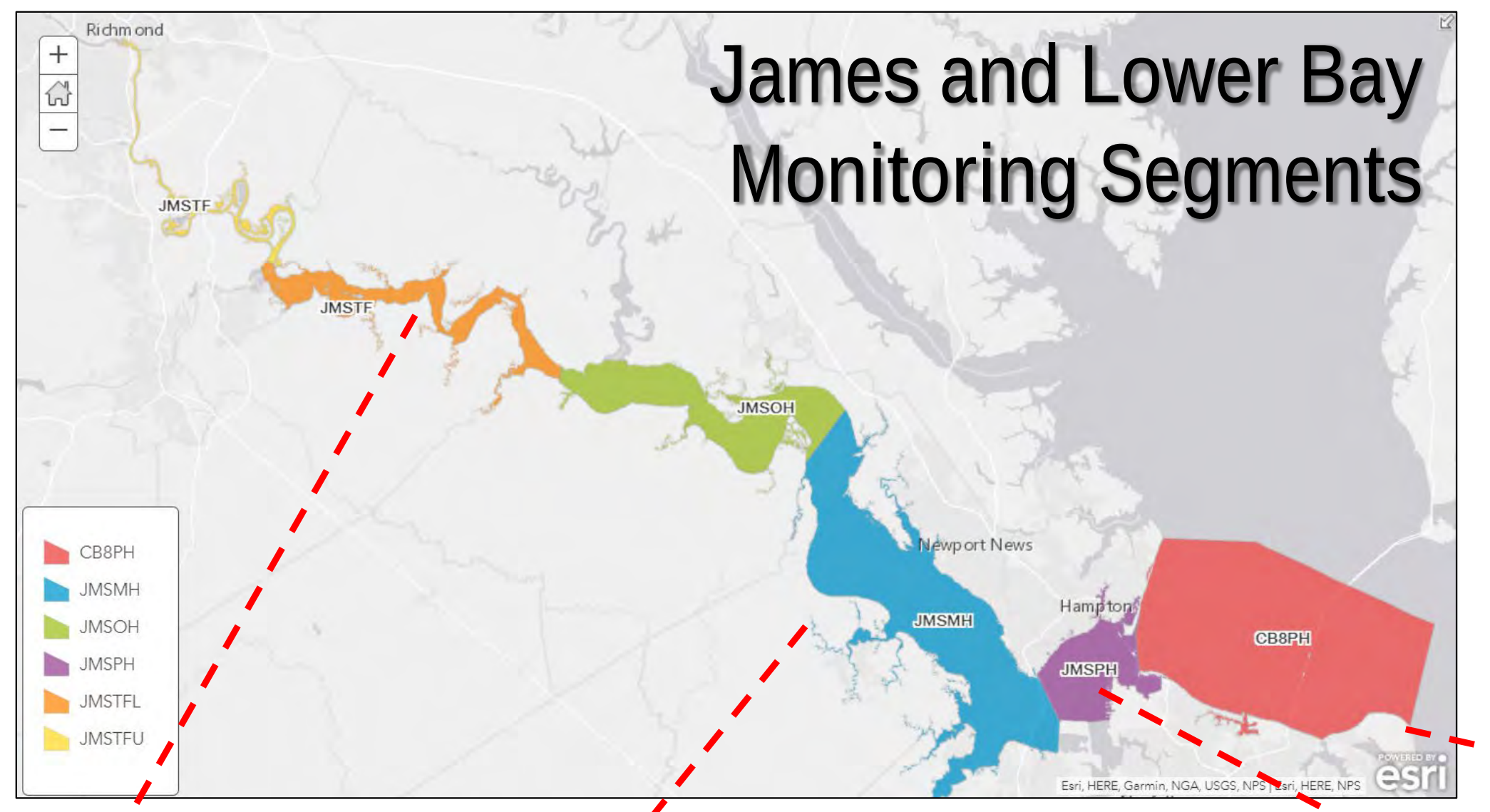
Photo: USGS Water Data for the Nation. CHOPTANK RIVER NEAR GREENSBORO, MD

James River, Virginia Example

(Nitrogen – Point Sources)

Tidal Fresh

- ☐ Nitrogen has relatively little influence in the generally phosphorus-limited tidal fresh
- ☐ Only the James watershed has any influence on the tidal fresh region

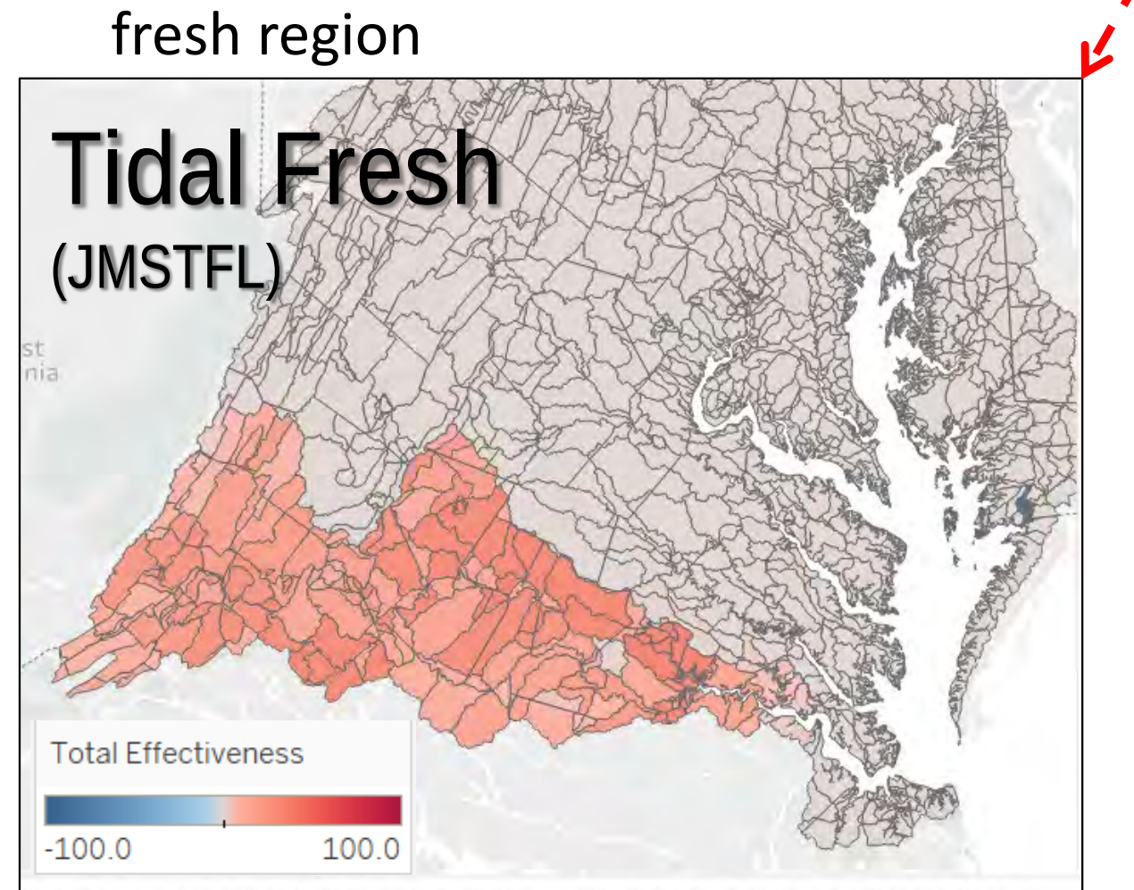


Mesohaline

- ☐ Nitrogen is much more effective at controlling chlorophyll in the mesohaline region compared to the tidal fresh. Mesohaline regions tend to be more nitrogen-limited that phosphorus-limited in the summer. The James is still the most important basin, but the influence of other basins starts to be seen.

Polyhaline

- ☐ Similar to the Mesohaline, nitrogen tends to be the more important nutrient for controlling chlorophyll in the summer
- ☐ The influence of other basins is increased relative to the James



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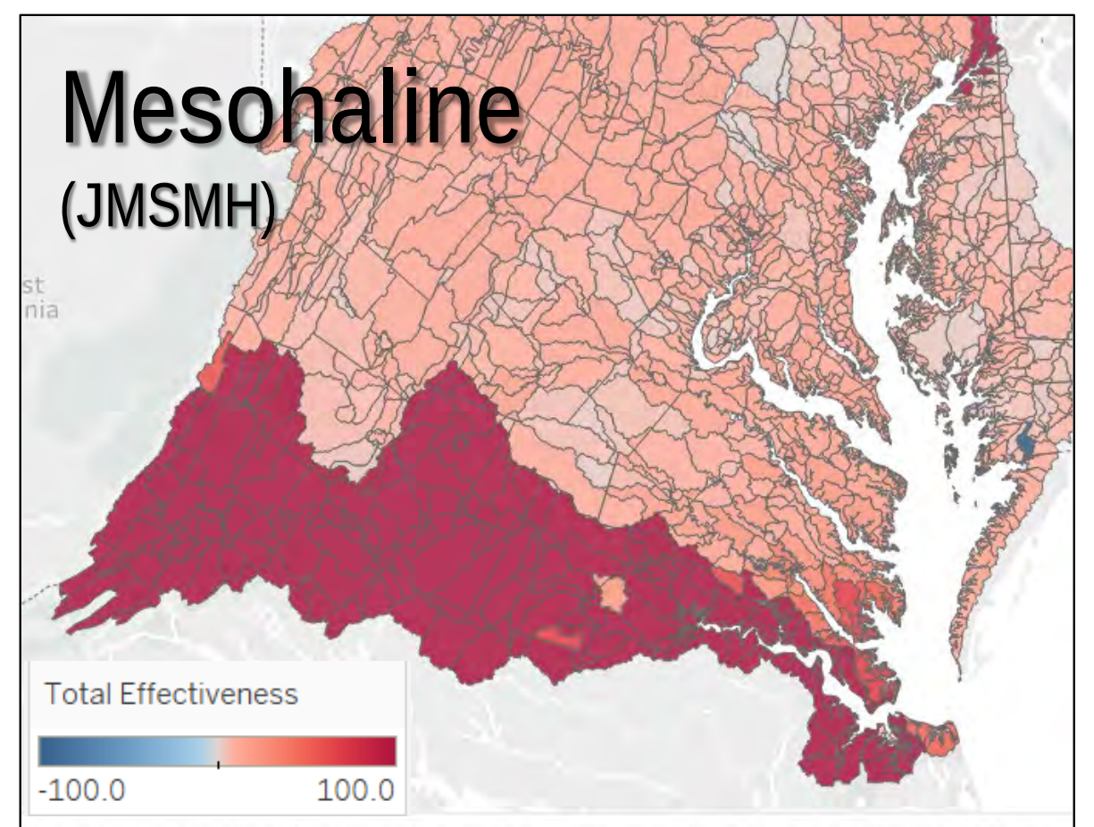

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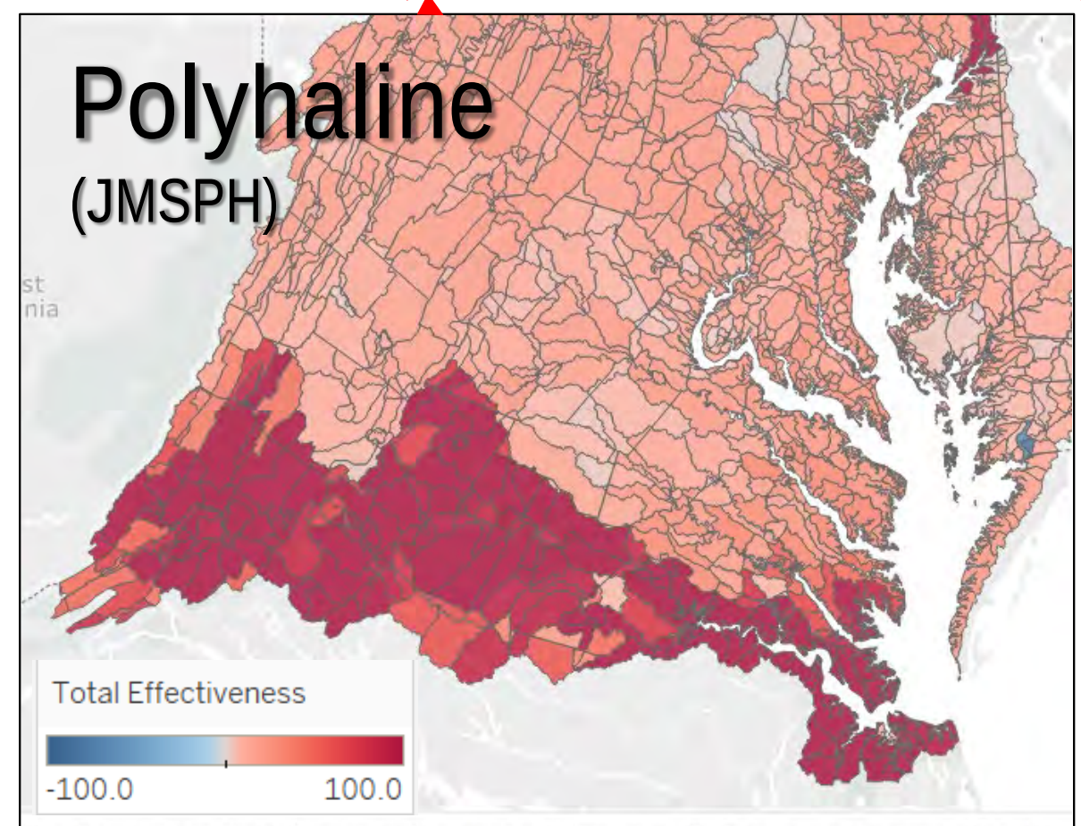

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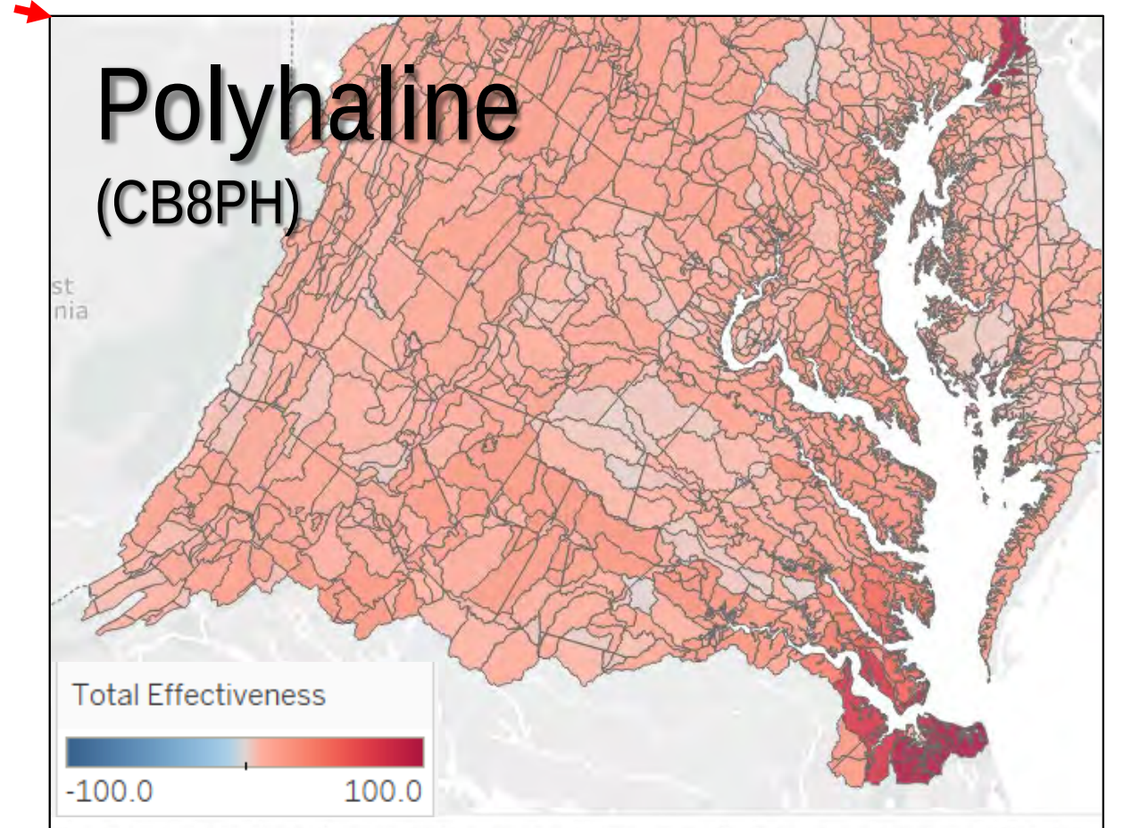

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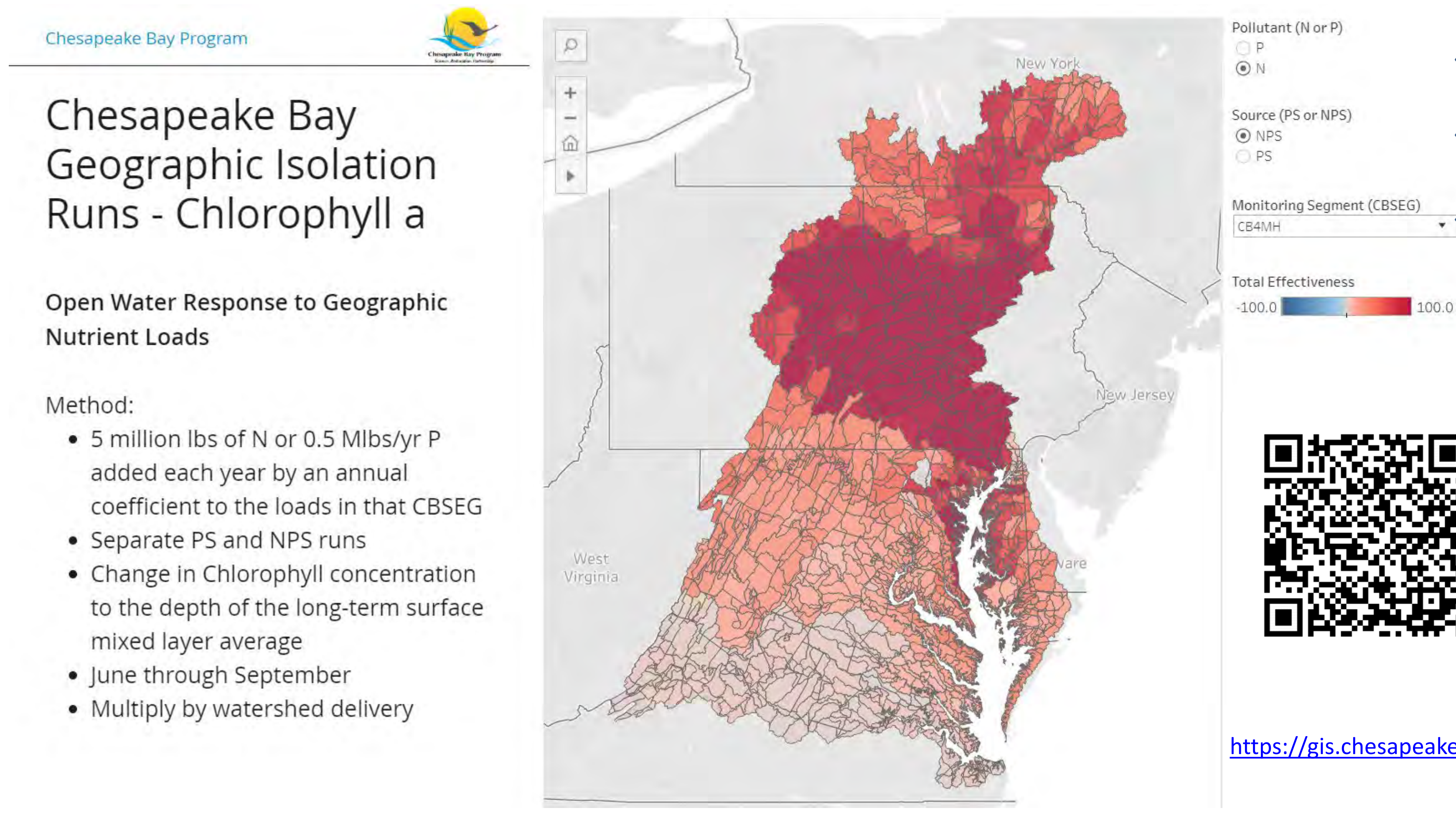
Photo: Chesapeake Bay Gateways Network

Photo: Hoffler Creek Wildlife Preserve

Photo: Envision the James (Chesapeake Conservancy)

Photo: Commonwealth of Virginia

Interactive Web Application



Chesapeake Bay Geographic Isolation Runs - Chlorophyll a

Open Water Response to Geographic Nutrient Loads

Method:

- 5 million lbs of N or 0.5 Mlbs/yr P added each year by an annual coefficient to the loads in that CBSEG
- Separate PS and NPS runs
- Change in Chlorophyll concentration to the depth of the long-term surface mixed layer average
- June through September
- Multiply by watershed delivery

Pollutant (N or P)
○ P
● N

Source (PS or NPS)
● NPS
○ PS

Monitoring Segment (CBSEG): CB4MH

Total Effectiveness
-100.0 100.0

User selects …

(1) Pollutant

(2) Source

(3) Segment

This QR Code will launch the Chesapeake Bay Geographic Isolation Runs - Chlorophyll a application.

https://gis.chesapeakebay.net/modeling/geoisoruns/

USGS Chesapeake Science Workshop
June 2019

USGS science for a changing world

Chesapeake Bay Program
40 years of science, restoration and partnership

Using Geomorphic Characteristics to Inform Reach-Scale Stream and Floodplain Restoration Opportunities

Labeeb Ahmed*, Marina Metes*, Peter Claggett*, Krissy Hopkins*, Michelle Katoski*, Sam Lamont, Tristan Mohs*, Greg Noe*

* U.S. Geological Survey

STREAM CONDITION

It is important to assess stream conditions because healthy vs. impaired streams can impact flooding in urban areas, sediment and nutrient exchange, groundwater connectivity and aquatic and riparian habitat.

STREAM RESTORATION

Stream restoration aims to mitigate impaired streams, but it is challenging:

- Difficult to quantify results of a stream restoration project
- Lack of consistent long-term monitoring
- Segmented restoration: site-specific and/or shifting problems downstream

WHAT IS FACET?

FACET (floodplain and channel evaluation tool) was developed to remotely evaluate geomorphic conditions at a stream-reach scale. It is an automated open-source tool that maps and measures geomorphic metrics such as channel width, bank height and active flood extent.

FACET derived geomorphometry for ~85% of Chesapeake Bay watershed (CBW) is published on USGS along with the code. In 2023, FACET's geomorphometry will be derived using 1-meter DEMs for complete CBW

APPLICATIONS

- Metrics are used to model sediment and nutrient fluxes in Chesapeake Bay and Delaware River watersheds (Greg Noe, USGS)
- Quantifying ecosystem services (sediment & nutrient retention, flood attenuation) provided by floodplains (Krissy Hopkins, USGS)
- CBP 30-meter riparian buffer

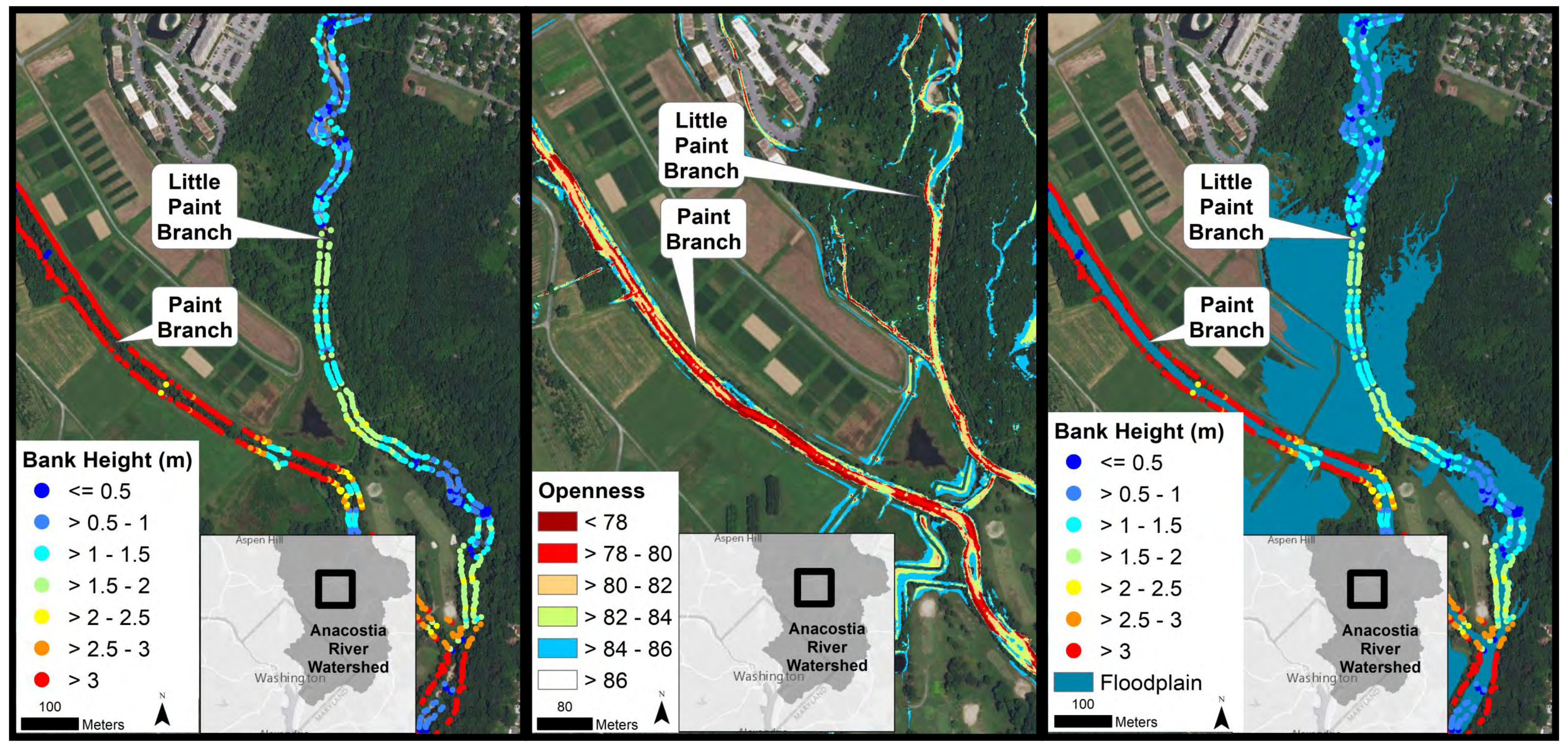
DATA

CODE

WEB APP

U.S. Department of the Interior
U.S. Geological Survey

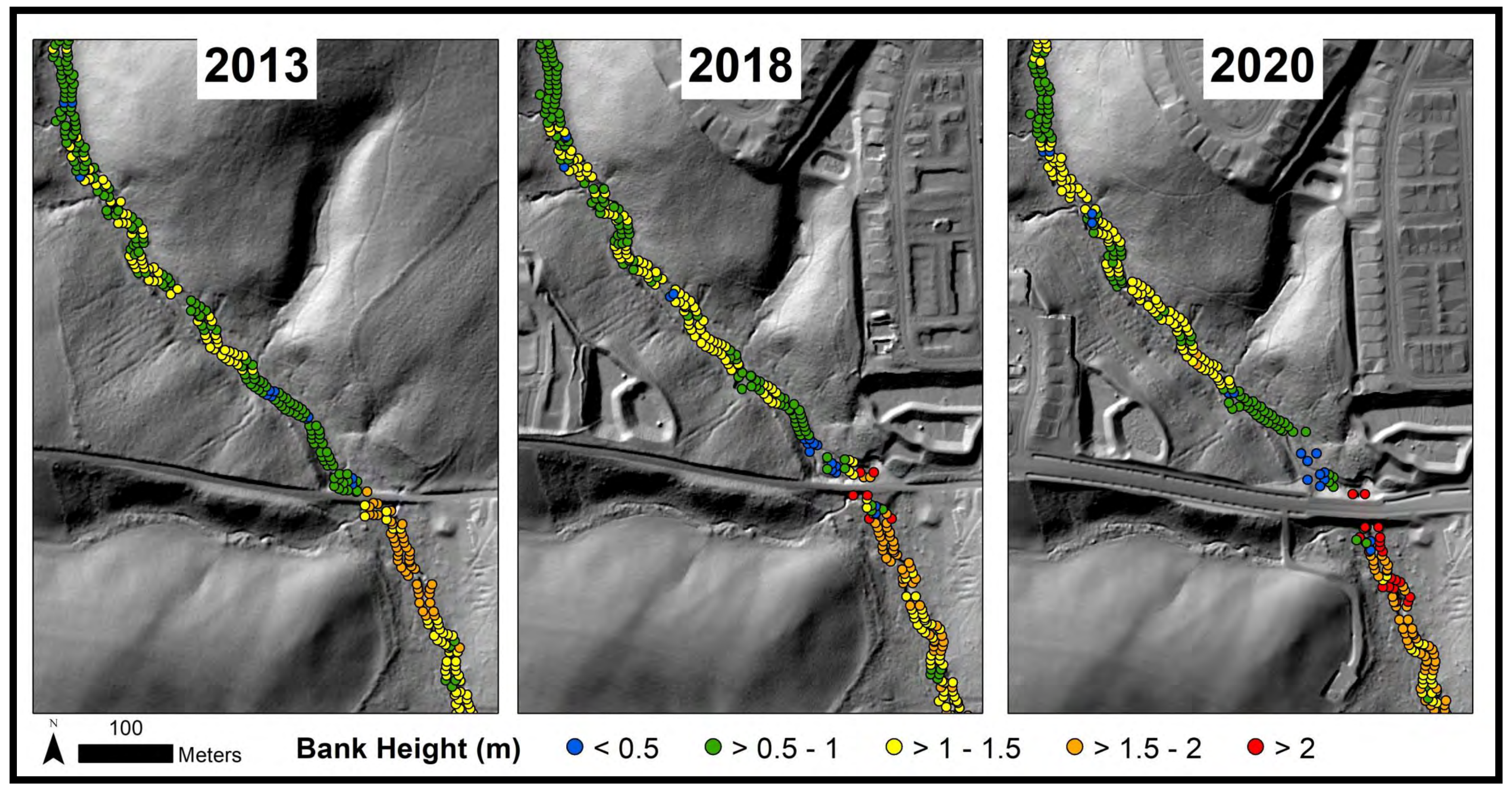
Evaluating Channel Conditions at Local Scale



Variations in bank height (A), incision (B), and floodplain extent (C) along two nearby tributaries

Source: Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1.

Evaluating Geomorphic Change with Repeat Lidar



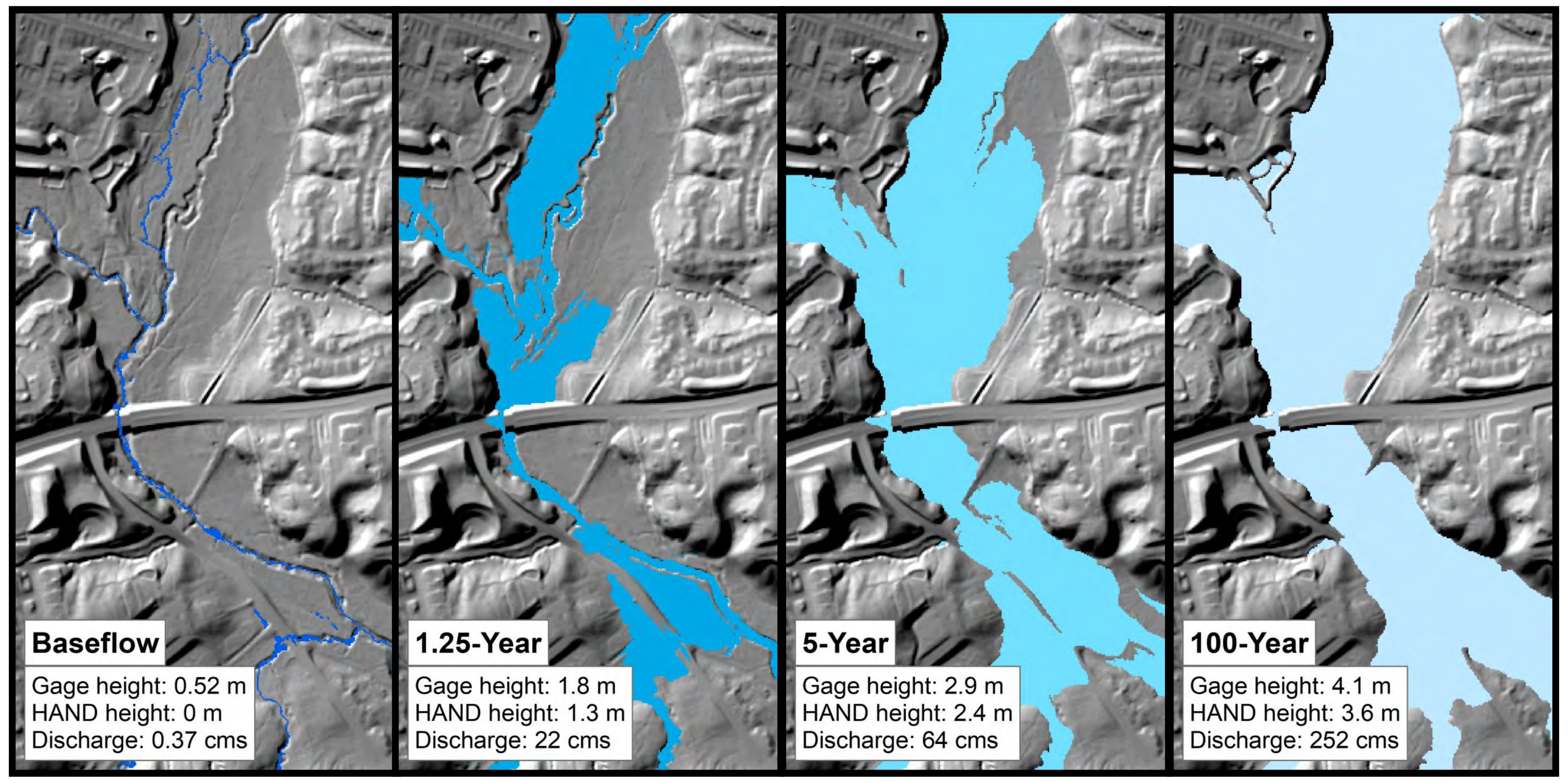
Site: Urbanizing **headwater** stream

Change: channel **deepening** between 2013 and 2020

Source(s) : Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1

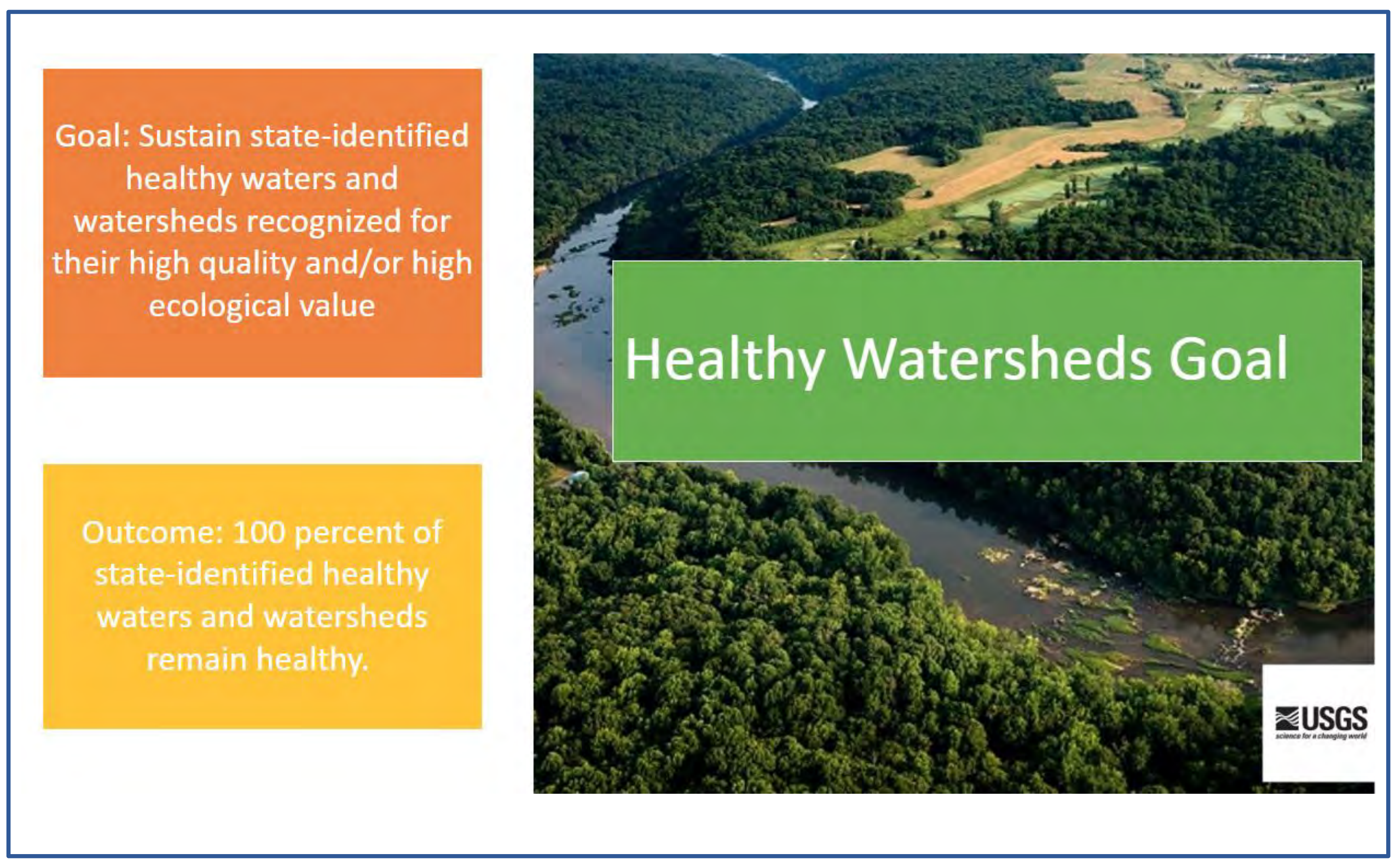
Metes, M.J. and Jones, D.K., 2021, Lidar-derived digital elevation models in Clarksburg, MD representing the years 2002, 2008, 2013, and 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P9YQFR17.

Current Focus: Calibrate Floodplain Extents to Various Flood Recurrence Intervals



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

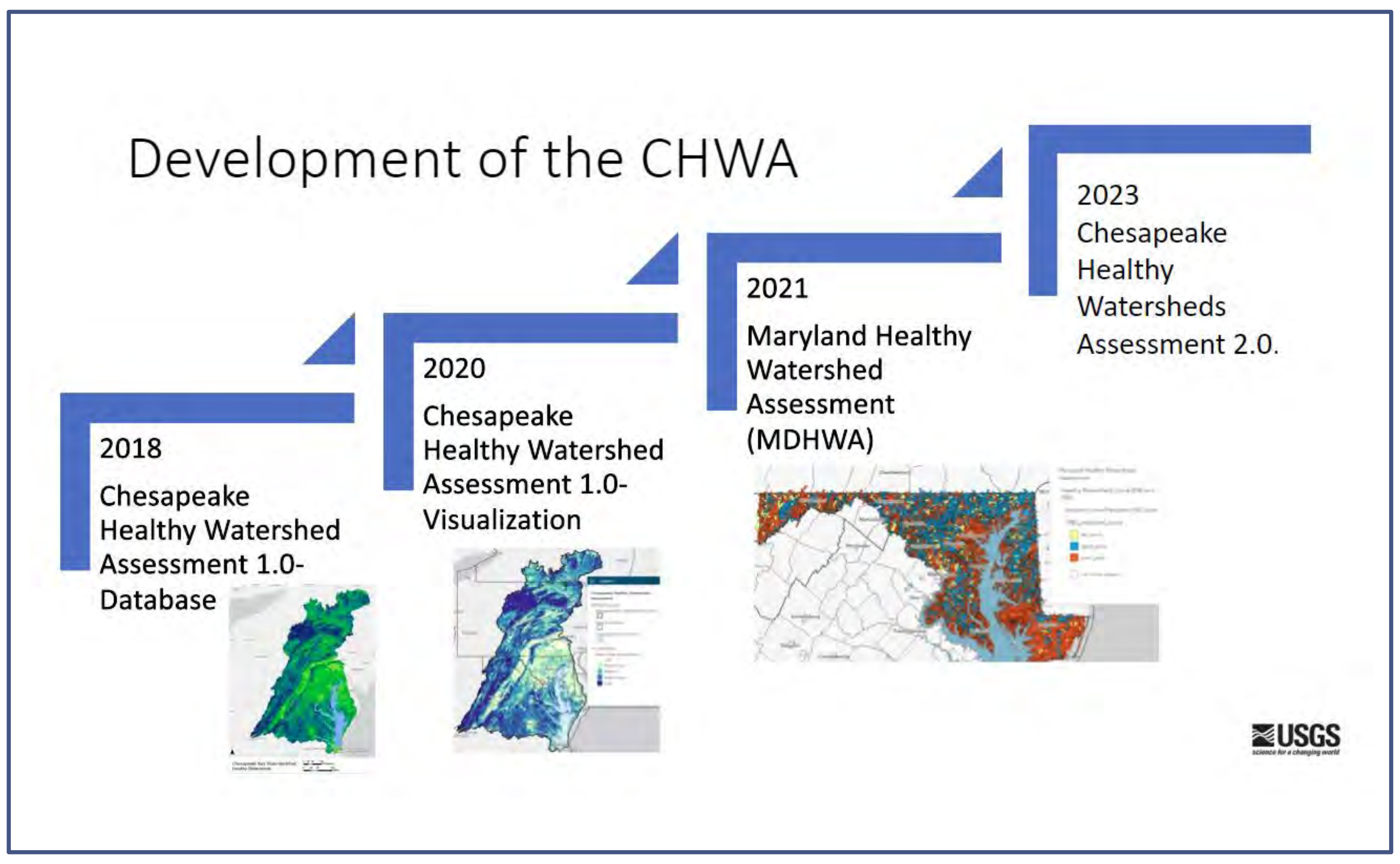
Development and Applications of the Chesapeake Healthy Watersheds Assessment



Goal: Sustain state-identified healthy waters and watersheds recognized for their high quality and/or high ecological value

Outcome: 100 percent of state-identified healthy waters and watersheds remain healthy.

Healthy Watersheds Goal



Development of the CHWA

2018
Chesapeake Healthy Watershed Assessment 1.0-Database

2020
Chesapeake Healthy Watershed Assessment 1.0-Visualization

2021
Maryland Healthy Watershed Assessment (MDHWA)

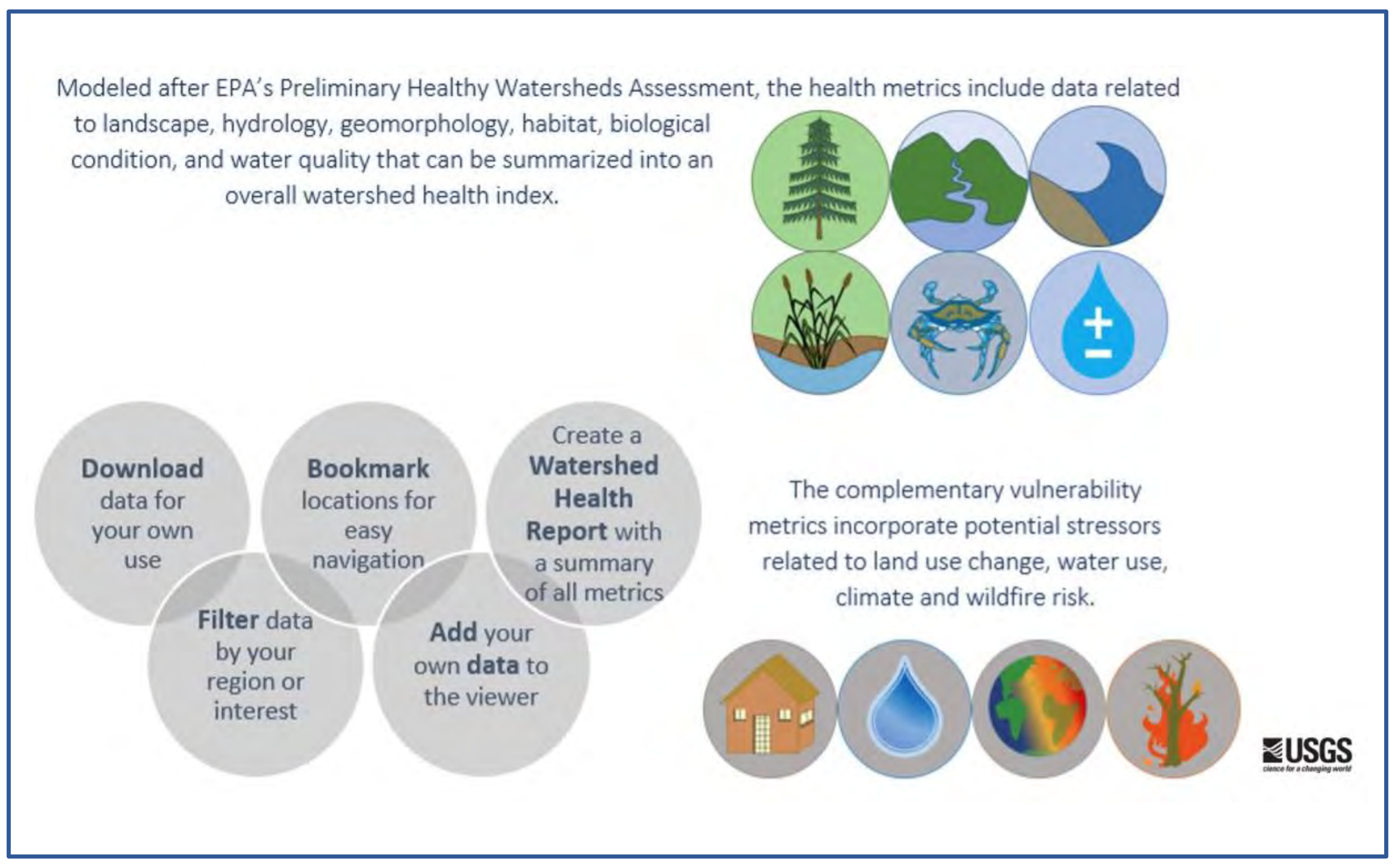
2023
Chesapeake Healthy Watersheds Assessment 2.0.

How healthy is your watershed?

https://gis.chesapeakebay.net/healthywatersheds/assessment/

Chesapeake Healthy Watersheds Assessment, an online, geospatial tool that summarizes the different landscape and water conditions in catchments across the entire watershed.

It was designed to help support and inform land use decisions that prioritize infrastructure resiliency, public health, and education while also protecting the environment in your community.



Modeled after EPA's Preliminary Healthy Watersheds Assessment, the health metrics include data related to landscape, hydrology, geomorphology, habitat, biological condition, and water quality that can be summarized into an overall watershed health index.

Download data for your own use

Bookmark locations for easy navigation

Create a **Watershed Health Report** with a summary of all metrics

Filter data by your region or interest

Add your own **data** to the viewer

The complementary vulnerability metrics incorporate potential stressors related to land use change, water use, climate and wildfire risk.

Management Applications for the CHWA

Examining/quantifying stressors affecting stream health (not just in healthy watersheds)

Assessing landscape factors affecting fish habitat in non-tidal and tidal watersheds

Identifying areas of Brook Trout populations susceptible to climate shifts

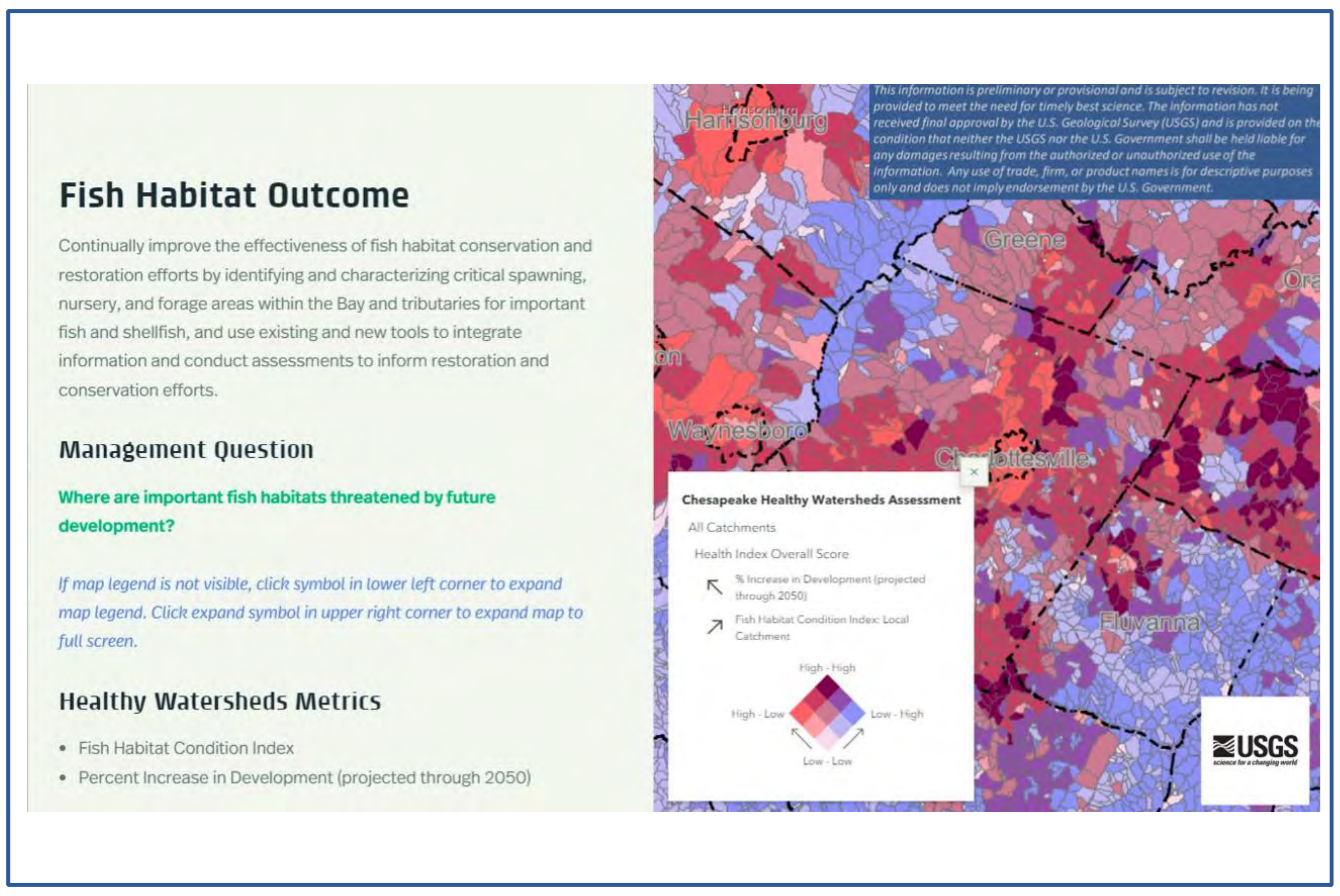
Coordination with Chesapeake Bay Program's fish habitat assessment

Engagement with local governments to inform land use decisions

Supporting land trusts and other organizations managing protected lands

Source water protection (drinking water)

Photos: Will Parson/Chesapeake Bay Program



Fish Habitat Outcome

Continually improve the effectiveness of fish habitat conservation and restoration efforts by identifying and characterizing critical spawning, nursery, and forage areas within the Bay and tributaries for important fish and shellfish, and use existing and new tools to integrate information and conduct assessments to inform restoration and conservation efforts.

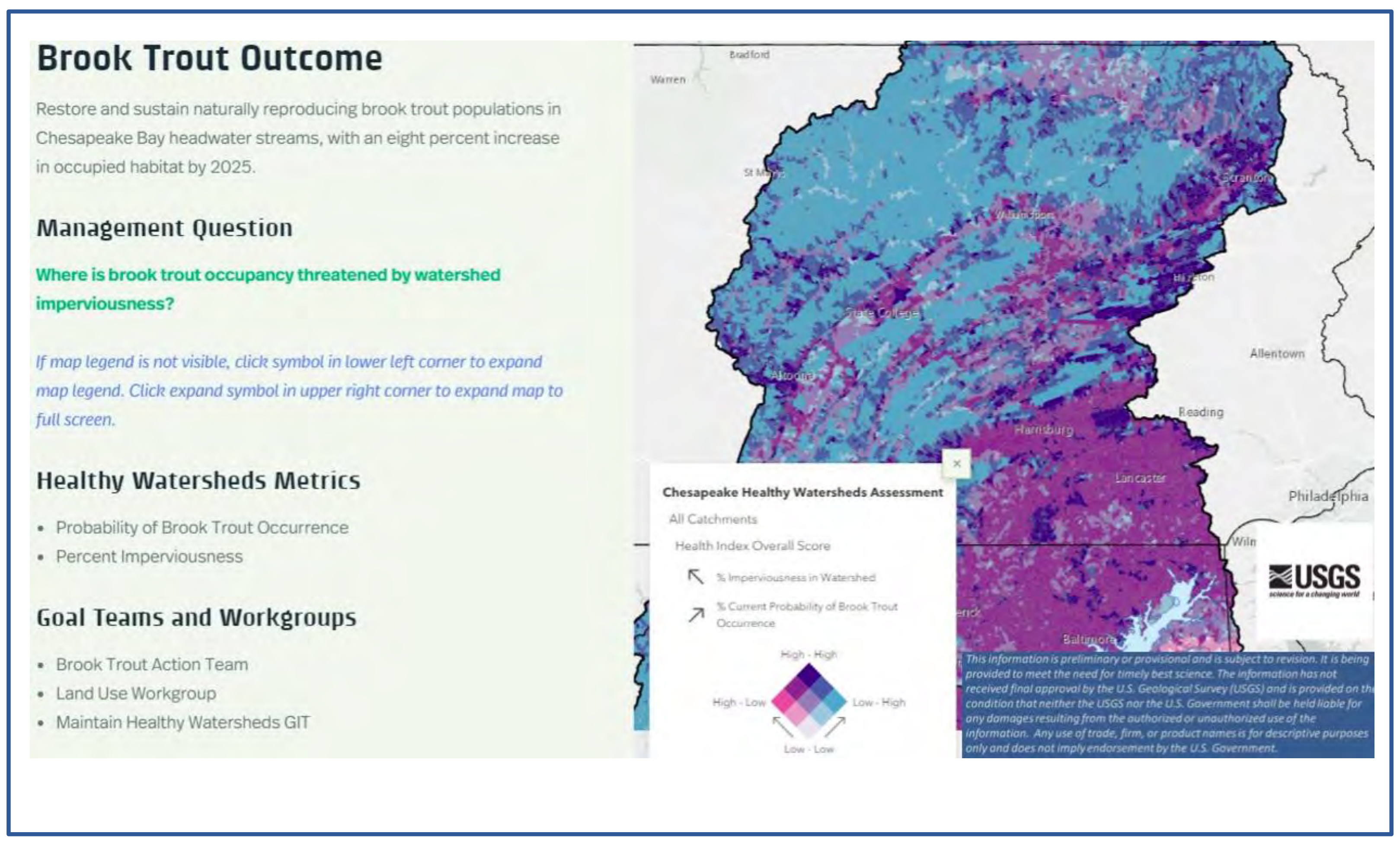
Management Question

Where are important fish habitats threatened by future development?

If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Fish Habitat Condition Index
- Percent Increase in Development (projected through 2050)



Brook Trout Outcome

Restore and sustain naturally reproducing brook trout populations in Chesapeake Bay headwater streams, with an eight percent increase in occupied habitat by 2025.

Management Question

Where is brook trout occupancy threatened by watershed imperviousness?

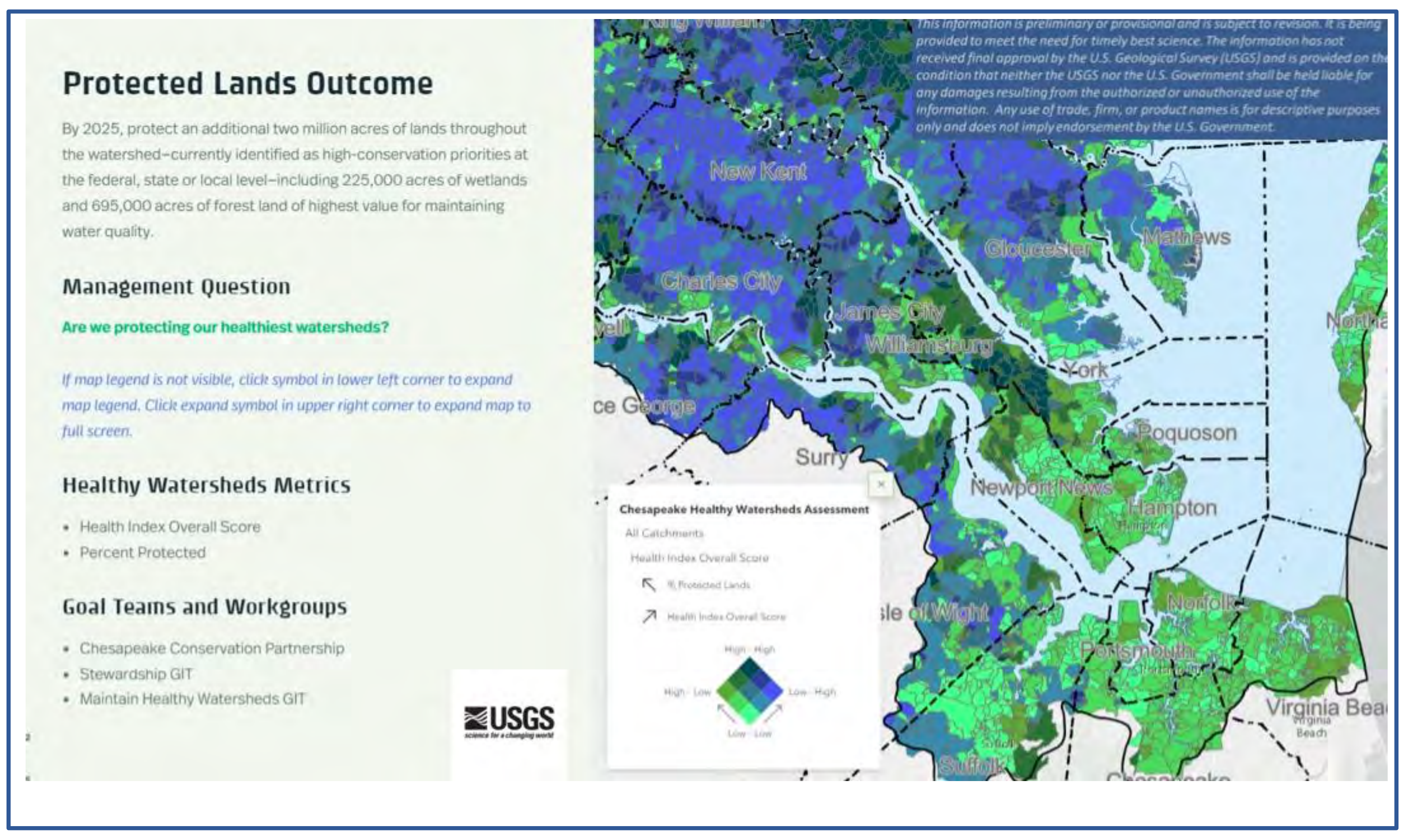
If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Probability of Brook Trout Occurrence
- Percent Imperviousness

Goal Teams and Workgroups

- Brook Trout Action Team
- Land Use Workgroup
- Maintain Healthy Watersheds GIT



Protected Lands Outcome

By 2025, protect an additional two million acres of lands throughout the watershed–currently identified as high-conservation priorities at the federal, state or local level–including 225,000 acres of wetlands and 695,000 acres of forest land of highest value for maintaining water quality.

Management Question

Are we protecting our healthiest watersheds?

If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Health Index Overall Score
- Percent Protected

Goal Teams and Workgroups

- Chesapeake Conservation Partnership
- Stewardship GIT
- Maintain Healthy Watersheds GIT

https://gis.chesapeakebay.net/healthywatersheds/assessment/

Chesapeake Bay Program

40 years of science, restoration and partnership

Renee Thompson
Coordinator, Maintain Healthy Watershed Goal Implementation Team,
Chesapeake Bay Program,
Annapolis, Maryland
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Geographer, USGS, Lower Mississippi Gulf Water Science Center
rthompson1@usgs.gov

The Chessie BIBI: An Index Twenty Years in the Making Now Supports CBP Stream Health Outcome Assessments

FAQs:

What is the Chessie BIBI?

It is the **Chesapeake Basin-wide Index of Biotic Integrity,** a multi-metric index of stream biological health applicable anywhere in the Chesapeake watershed.

What Data are Used?

Macroinvertebrate samples routinely collected in streams and small rivers by federal, state, local and citizen monitoring programs and **voluntarily shared** with the Chesapeake Bay Program.

Are the Data Available?

Yes, the raw data, calculated metrics, and R-programs used to calculate the index can be obtained from the Chesapeake Environmental Data Repository at www.chesapeakebay.net

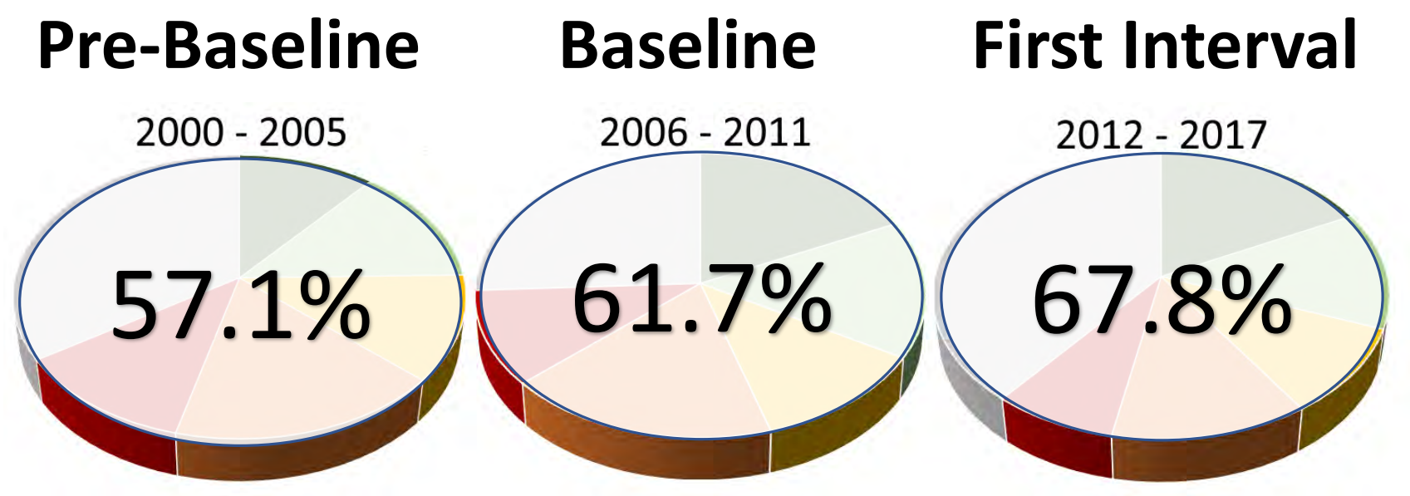
How Often Will the Index Be Updated?

About every six (6) years, to account for state rotational sampling schedules.

Any Progress?

The Chesapeake watershed is on track to meet the stream health outcomes in both the **Executive Order** (70% healthy streams) and **2014 Agreement** (10% improvement above Baseline).

% Healthy Stream Miles

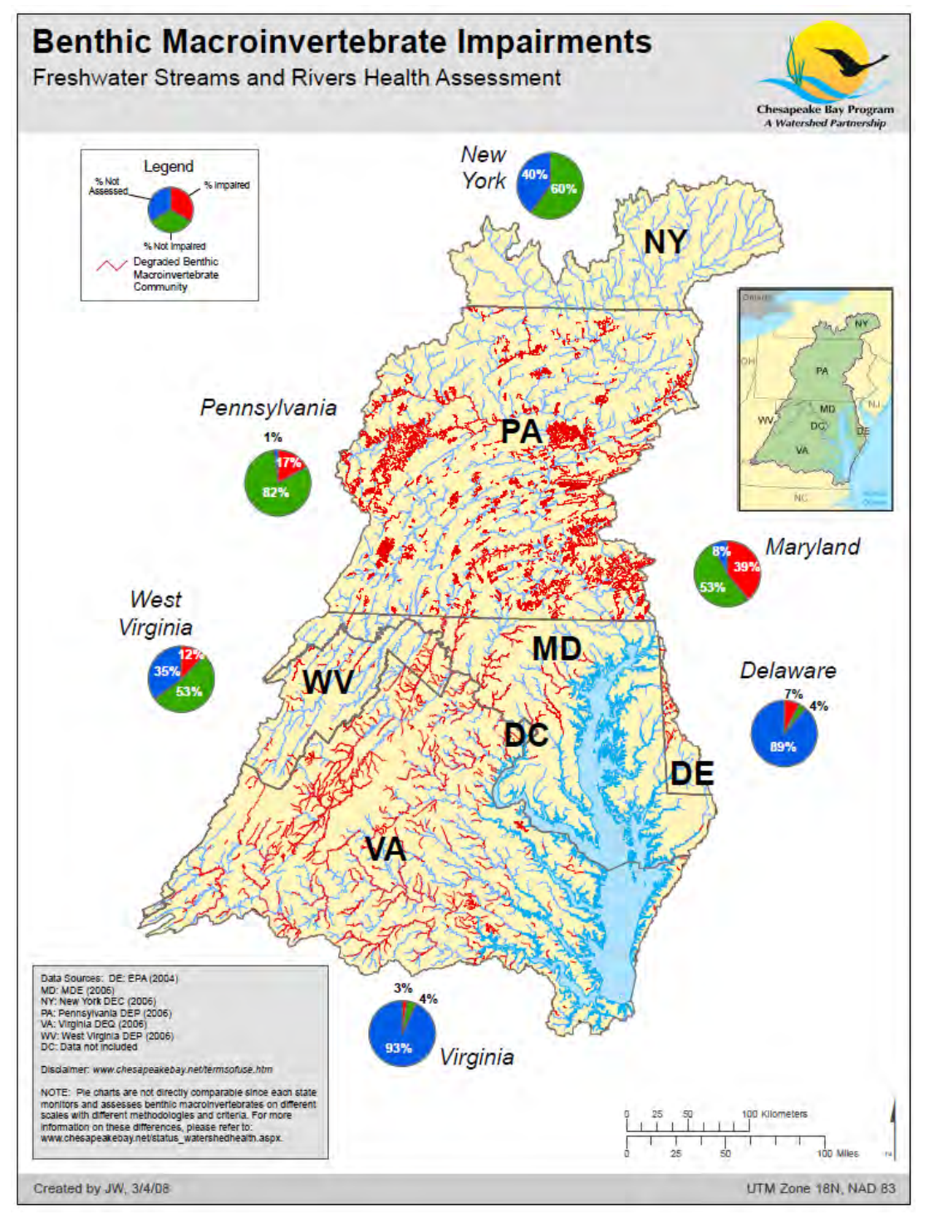


However, identifying which environmental factors are responsible for the net improvement would be speculative at this point … long-term efforts to conserve forests, preserve and restore riparian corridors and wetlands, mitigate acid rain and mine drainage, slow stormwater runoff and reduce nutrient and sediment loads have all likely contributed, and these efforts need to continue.

Chesapeake Bay Program

Gaps

Need for a Watershed-Wide Stream Health Indicator is Recognized



"State Assessments Are Not Comparable"

CBP Non-Tidal Workgroup

Outcomes

Chesapeake Bay Executive Order 13508

Improve the health of streams so that 70 percent of sampled streams throughout the Chesapeake watershed are in fair, good or excellent condition as measured by the Index of Biotic Integrity by 2025

2014 Chesapeake Agreement Signed

Improve health and function of ten percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed

Chessie BIBI Selected as CBP Stream Biological Health Indicator

CBP Stream Health Mgmt Strategy Team

2006 – 2011 Selected as "2008 Baseline"

[8, 9]

Cacapon WV 2018 Workshop

Models

Landscape Features Are Used to Predict Chessie BIBI & Model its Responses to Climate Change, Development, and Flow Alteration

[10, 11, 12, 13]

USGS Eastern Ecological Science Center

Progress Report Submitted to CBP

[14]

Potomac Benthic Index of Biotic Integrity is Created

[1, 2]

Proof of Concept for Chesapeake Completed

ICPRB Pilot Project

Development

Data Call

& ICPRB Database Built

Chessie BIBI 1.0

[3]

Index Sensitivity to Nutrients, Land Use & Flow Alteration Demonstrated

[4, 5, 6]

Data Call

& ICPRB Database Updated

Updates

Chessie BIBI 2.0 "Refinement"

[7]

Data Call

Data Updated, Analysis Tools Developed, Conversion to Chesapeake Environmental Data Repository

Chessie BIBI 3.0

[chesapeakebay.net/what/data]

Chessie BIBI Selected as an Indicator for Potomac Water Resources Comprehensive Plan

[15]

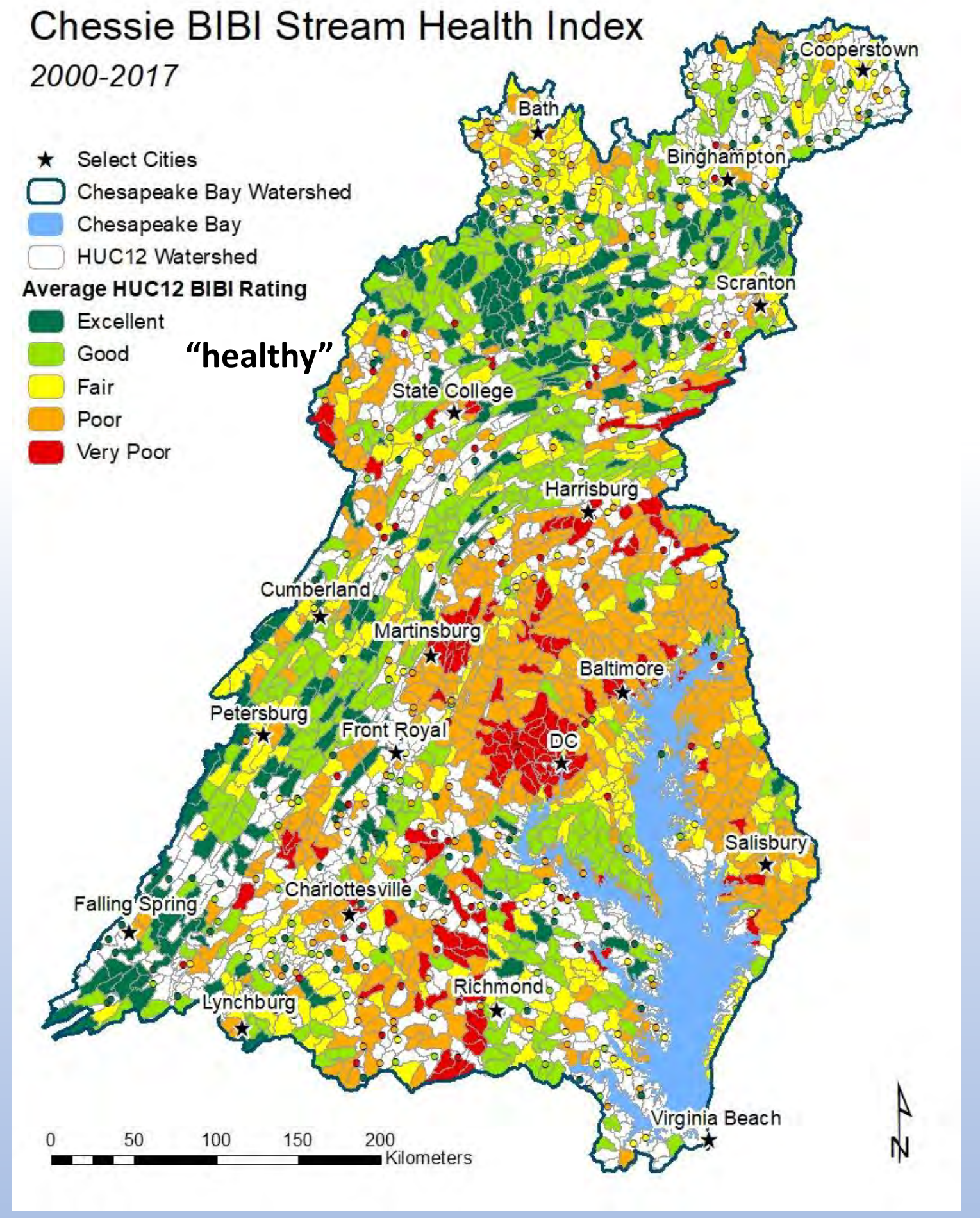
ICPRB Advisory Committee

Data Call

& Update CEDR Database

Progress Report to CBP

Assessments



Interstate Commission on the Potomac River Basin

Credits:

Chessie BIBI Development Team, Past & Present

Claire Buchanan (ICPRB)
Rikke Jepsen (ICPRB)
Michael Mallonee (ICPRB/CBPO)
Andrea Nagel (ICPRB)
Zachary Smith (formerly ICPRB)
Adam Griggs (formerly ICPRB)
Jacqueline Johnson (formerly ICPRB/CBPO)
Katherine Foreman (formerly UMCES/CBPO)

Stream Monitoring Programs that Answered the Data Call

Anne Arundel Co
Baltimore City
Baltimore Co
DC DOEE
Delaware NREC
Fairfax Co
Frederick Co
Howard Co
Loudoun Co
Maryland DNR
Montgomery Co
National Park Service
New York DEC
Pennsylvania DEP
Prince Georges Co
SRBC
USEPA
USFS
USGS NAWQA
Virginia DEQ
West Virginia DEP
Maryland SOS

Federal, State, County and Academic Representatives

who guided development of the Chessie BIBI index through their participation in our **Technical Advisory Groups** and **"2008 Baseline" Workshop**

Consultation and Collaboration

of key individuals who gave freely of their time and insights, including Kelly O. Maloney & John Young & Kevin Krause & Rich Walker (USGS, Leetown); Greg Pond (EPA3); Neely Law (formerly CWP and now Fairfax Co)

Chesapeake Bay Program

support was crucial in helping ICPRB expand the scope of the index from the Potomac to the Chesapeake. We thank

Peter Tango (USGS/CBPO)
Scott Phillips (USGS)
Jennifer Greiner (FWS)
and the members of the
Non-Tidal Workgroup,
Stream Health Mgmt. Strategy Team,
Stream Health Workgroup, and
CBPO Data Center Team

Citations

ICPRB Reports at potomacriver.org/publications/

1. doi.org/10.1016/j.ecolind.2005.08.030
2. doi.org/10.1016/j.ecolind.2006.09.004
3. ICPRB report 11-1
4. ICPRB Report 11-2
5. MPRWA_FINAL_April_2013.pdf
6. doi.org/10.1111/fwb.12240
7. ICPRB Report 17-5
8. ICPRB Report 18-6
9. ICPRB Report 19-7
10. doi.org/10.1086/700701
11. doi.org/10.1111/gcb.14961
12. doi.org/10.1007/s00267-021-01450-5
13. doi.org/10.1016/j.jenvman.2022.116068
14. ICPRB Report 23-1
15. ICPRB Report 18-1

More information:

http://bit.ly/Chessie_BIBI

Poster prepared April 2023 by Claire Buchanan with Renee Bourassa and Rikke Jepsen

CESR

Achieving Water Quality Goals in the Chesapeake Bay: A **C**omprehensive **E**valuation of **S**ystem **R**esponse

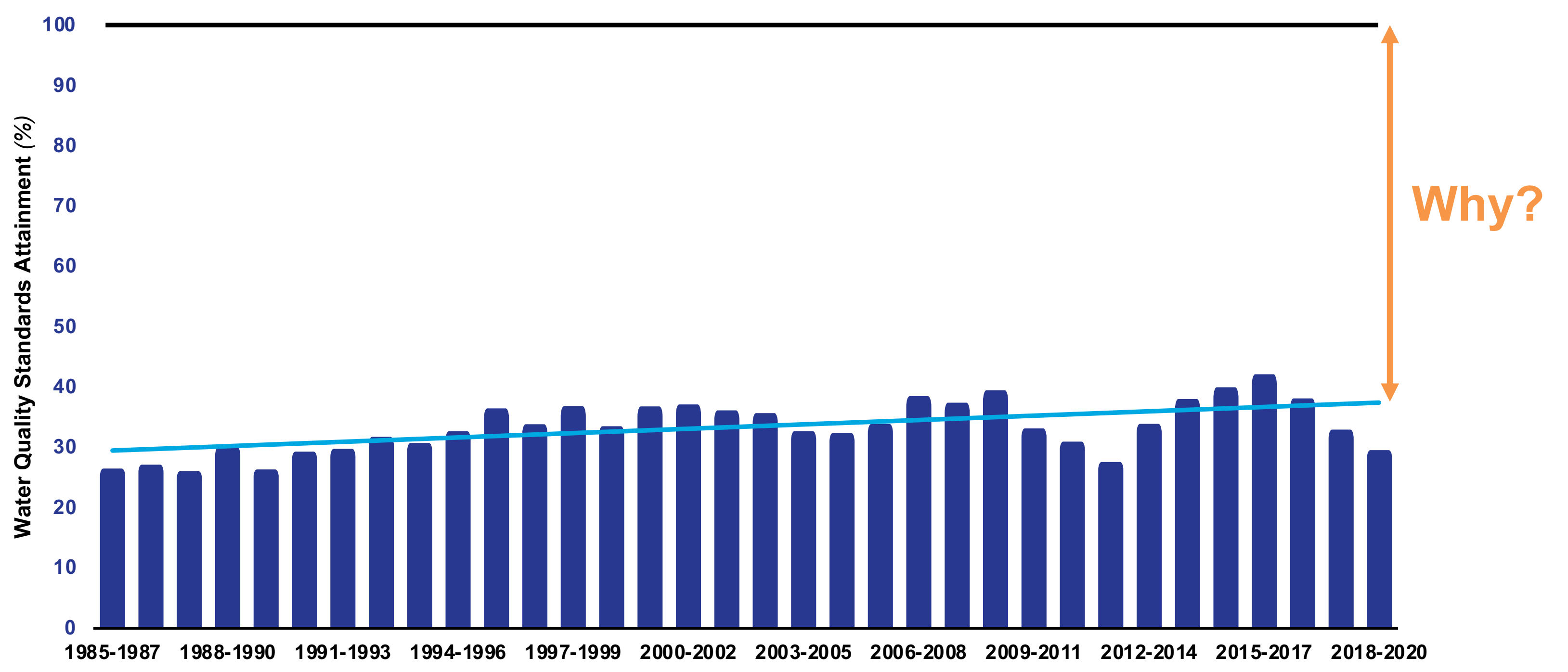
AN EXAMINATION OF HOW THE CHESAPEAKE BAY ECOSYSTEM HAS RESPONDED TO THE LAST FOUR DECADES OF MANAGEMENT EFFORTS

Introduction

Achieving Water Quality Goals in the Chesapeake Bay: A Comprehensive Evaluation of System Response (CESR) includes an evaluation of why progress toward meeting the TMDL and water quality standards has been slower than expected and offers options for how progress can be accelerated. The report evaluates the effectiveness of current policies and programs for reducing pollutants (nitrogen, phosphorus, and sediment) from wastewater treatment point sources and from farms and urban lands (nonpoint sources). Then, the evaluation turns to the water quality response in the estuary (dissolved oxygen, water clarity/submerged aquatic vegetation) to the realized nutrient and sediment reductions. Finally, the report summarizes what is known about the response of fish, shellfish, and other living organisms to changed water quality conditions. Decision-critical uncertainties at each stage of program implementation and assessment are identified and their implications for progress considered.

The Challenge

Achieving Chesapeake Bay Water Quality Standards

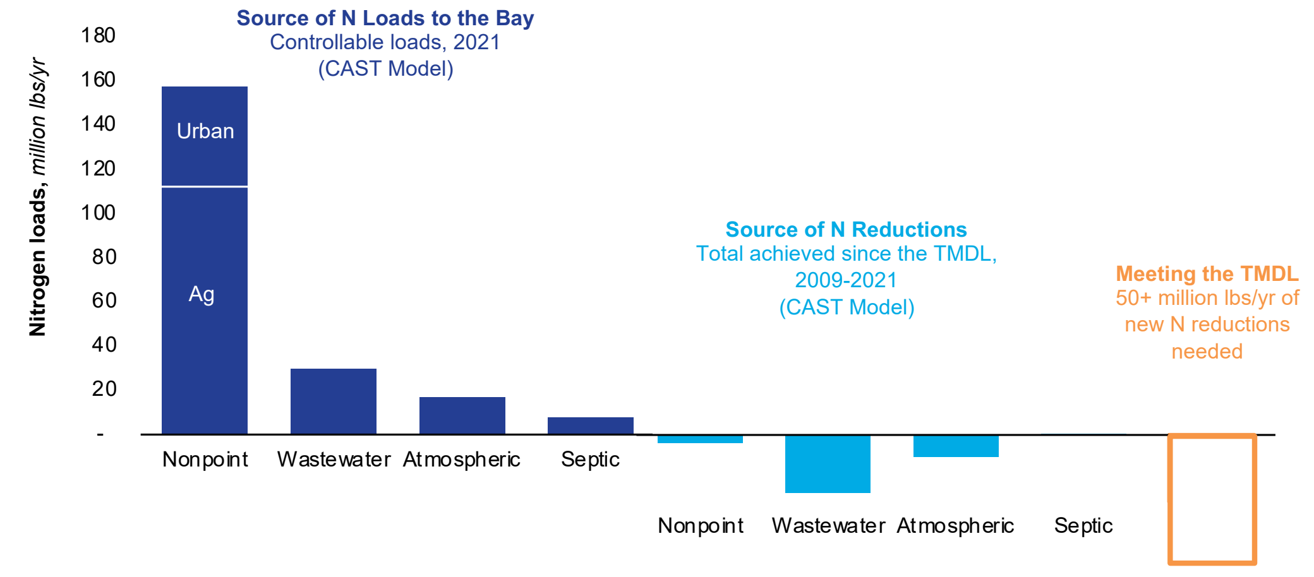


The light blue line in the graph above shows that there has been significant positive change in water quality attainment. This is especially true when you consider that, through the same time period shown, there have been significant increases in population, agriculture, development, and climate change. All other things equal, those factors would have caused water quality to get steadily worse.

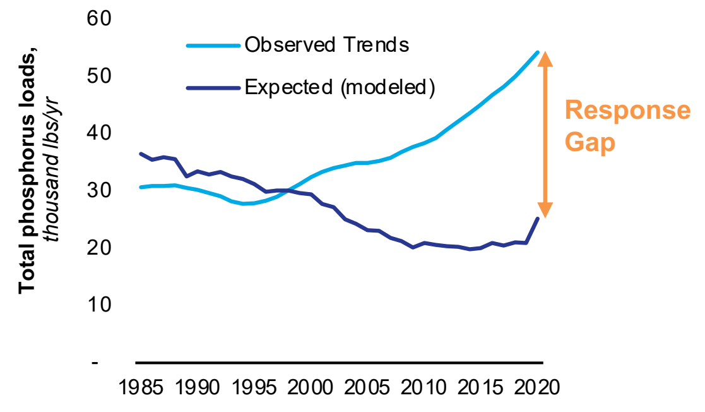
However, the black line representing 100% attainment is still far above our current attainment. CESR focused on the gap highlighted by the orange line and understanding why haven't we made more progress towards our water quality goals. Afterall, of the three main pollutants, the Chesapeake Bay Program (CBP) says we have achieved sediment goals, we are close on phosphorus (P), and we've made significant reductions in nitrogen (N), including reducing N loads by 100+ million pounds since 1985. What's going on?

Findings

1 Existing nonpoint source (NPS) water quality programs are insufficient to achieve the nutrient and sediment reductions called for under the TMDL.

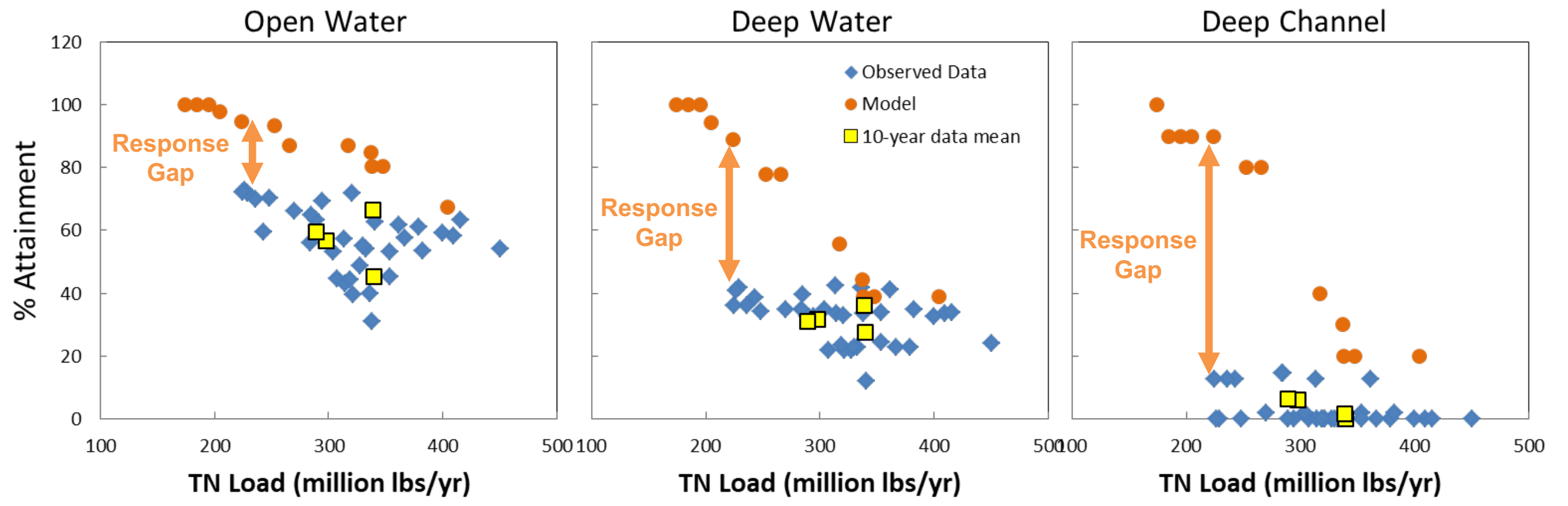


We have made the available reductions in wastewater, atmospheric, and septic. The new reductions needed will need to come from urban and agricultural NPS, but NPS programs have failed to generate reductions of this magnitude.



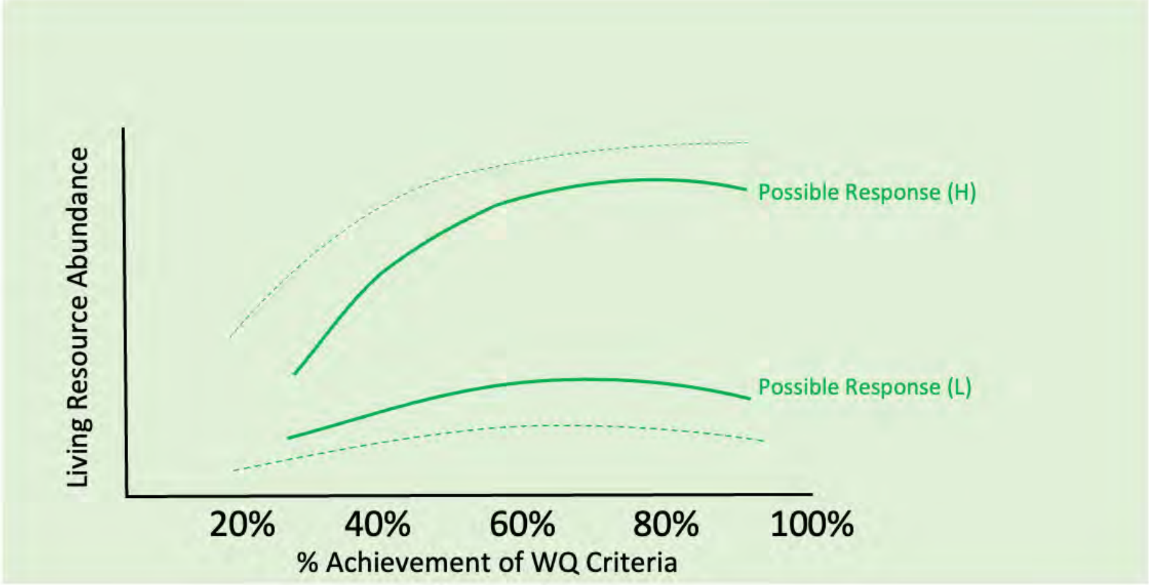
Predicted and observed P loads in a nonpoint source dominated watershed (Choptank)

2 Preliminary analyses suggest that nutrient load reductions have not produced the expected level of improvement in water quality, and this response gap is particularly pronounced in the Bay's deep channel.

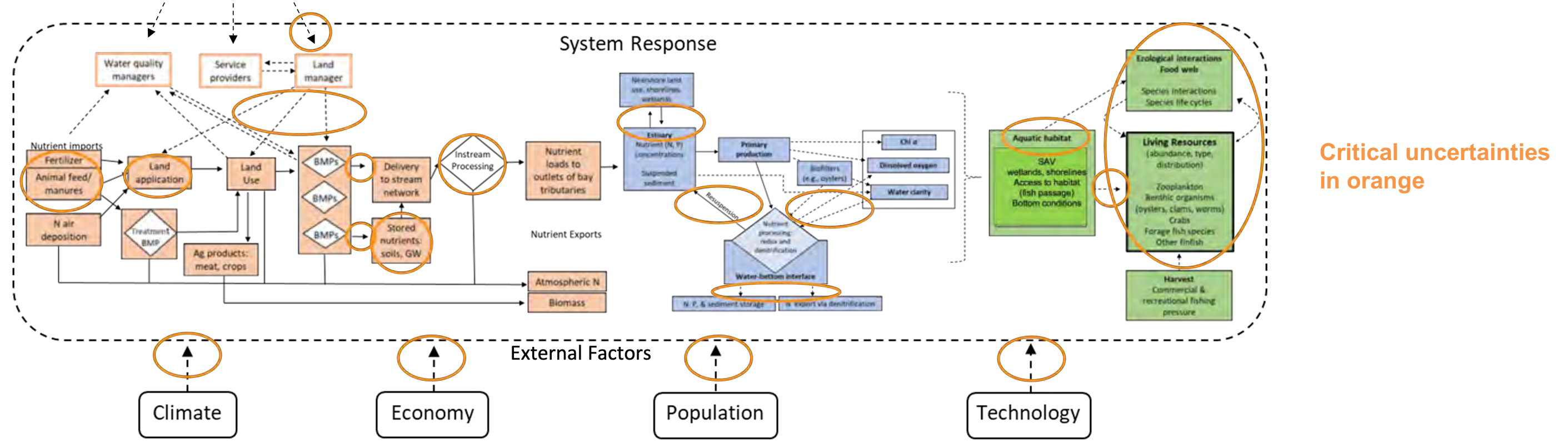


Nutrient reductions have led to improved water quality conditions, especially in areas with substantial localized reductions, but have not produced the expected levels of increased dissolved oxygen across the Bay's habitats. As shown in the series of graphs above, this shortfall (response gap) is especially pronounced in the Bay's deep channel.

3 Significant enhancement of living resources can be achieved through additional management actions without complete achievement of water quality standards across all habitats.

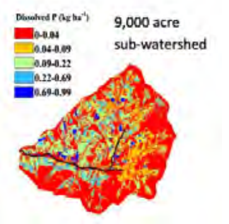


4 The Chesapeake Bay Program's current adaptive management process is not adequate to address the uncertainties and response gaps described in CESR.



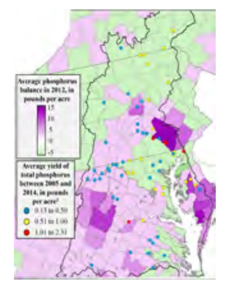
Implications

1 There are opportunities to improve nonpoint source program effectiveness, but policy changes are required.



$ = Effort

$ = Outcomes



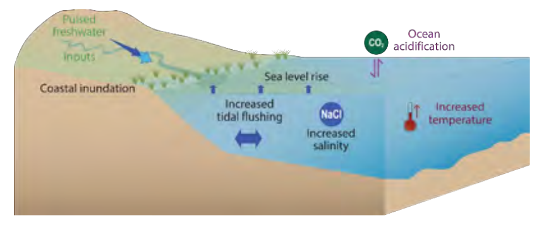
Targeting
- Nonpoint source loads are distributed highly unevenly across the landscape
- Who does what where matters
- Finer scale modeling and monitoring and changes to TMDL crediting increase potential to target high loss regions

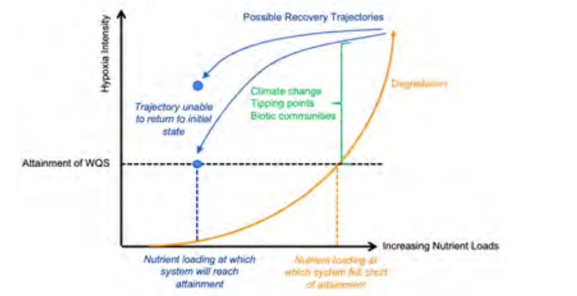
Outcome-based Incentives/Requirements
- Conventional voluntary cost share rewards low effort practices and limits adoption of practices with upfront costs but high public benefits
- Pay for performance programs directly reward those who produce pollutant reduction outcomes

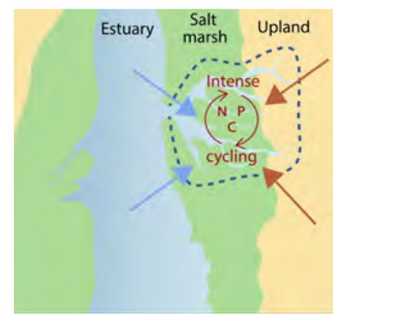
Mass Balance
- Areas with nutrient mass imbalances (nutrient inputs exceed crop needs) produce high nutrient loads
- Frequently associated with intensive livestock regions
- Policies that address mass imbalances have high chance of success in reducing loads

Sandboxing
- Encourage the development and testing of institutional innovations

2 Additional nutrient reductions will improve water quality, but water quality criteria may be unattainable in some regions of the bay under existing technologies.





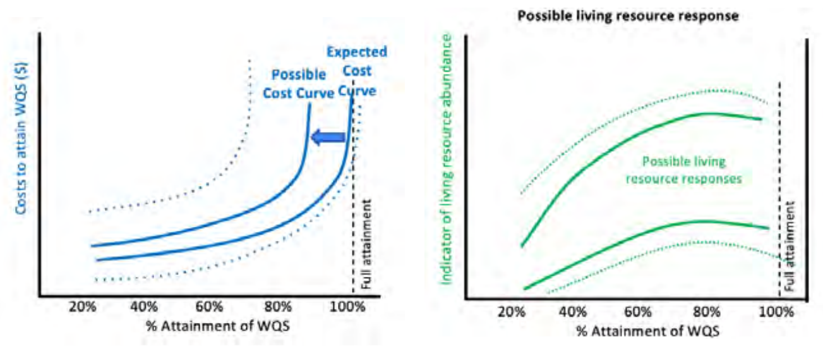


Construct future visions
- The Bay of the future is not the Bay of the past
- Changing conditions mean that there is no historical precedent

Trajectories of response
- The trajectory of recovery may be different than the original trajectory of degradation
- Take advantage of biotic communities that can accelerate recovery

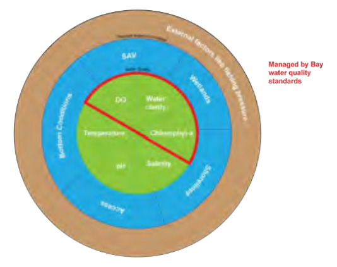
Tiered approach to attainment
- Focus resources to shallow water areas that can take advantage of tipping points and high rates of nutrient cycling and where pollutant reduction limits can be achieved first

3 The legal requirements of the Clean Water Act (the water quality goal) divert attention away from considering multiple means of improving living resources (support of aquatic life as the designated use) as articulated in the Chesapeake Bay Watershed Agreement.

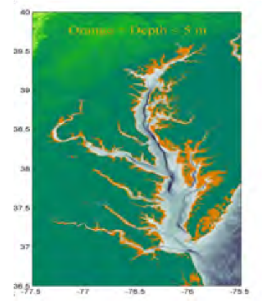


Refocusing on living resources
- Express benefits of actions in terms of living resources as well as water quality
- Allocate funds and efforts to generate largest living resource impacts for the most stakeholders

4 Opportunities exist to adjust water quality goals to prioritize management actions that improve living resource response.

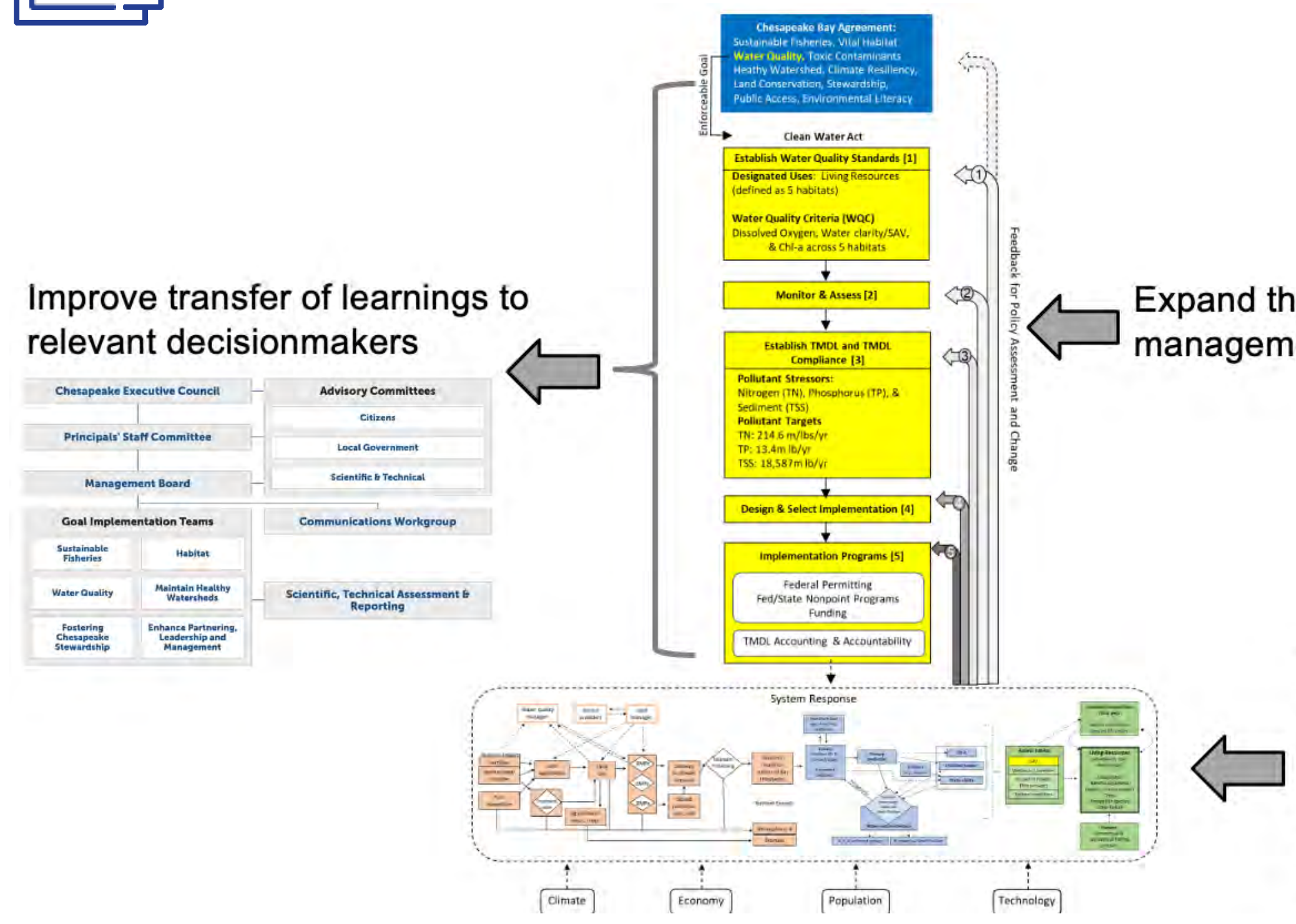


WQS are necessary but not sufficient
- Actions in shallow waters (Living Shorelines, benthic habitat) could boost LR response



Identify areas with opportunity to elevate LR response
- 17 of 31 outcomes of Watershed Agreement are in shallow waters
- Critical habitat for LR
- High stakeholder engagement

5 Expanding the scope of adaptive management could address critical uncertainties and response gaps.



Improve transfer of learnings to relevant decisionmakers

Expand the scope of adaptive management

Improve capacity to identify and evaluate uncertainties and gaps in system response

Scan to read the full report, find resources related to the report, and more.

Devereux Consulting
Data+Research+Analysis+Strategy

Chesapeake Assessment Scenario Tool

Olivia Devereux & Helen Golimowski, Devereux Consulting, Inc.

Partnership Planning with CAST

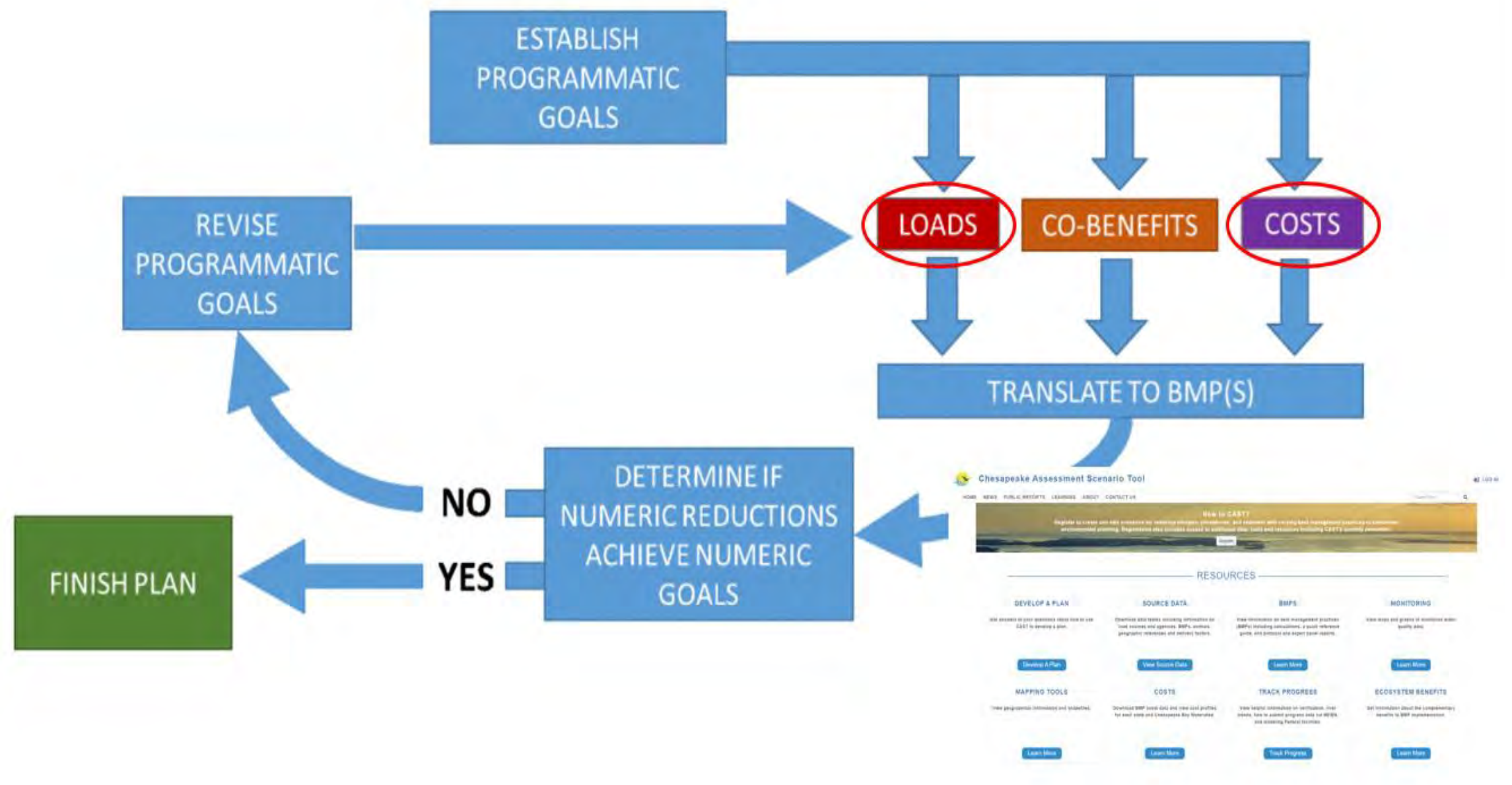
Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning. Users specify a geographical area and apply Best Management Practices (BMPs) on that area. CAST builds the scenario and estimates nitrogen, phosphorus, and sediment load reductions. CAST also estimates the cost of a scenario so that users may select the most cost-effective practices to reduce pollutant loads.

The following diagram summarizes a sequence of steps for developing a water quality improvement plan.

1. Establish programmatic goals that include quantifiable loads for nitrogen, phosphorus and sediment; ecosystem benefits from implementing BMPs; and the costs of implementation.
2. Translate a combination of programmatic goals into specific BMPs, and then use those BMPs in a CAST scenario to estimate nitrogen, phosphorus and sediment loads.
3. Determine if the loads are achieving the programmatic goals. If not, revise programmatic goals, perhaps changing ecosystem benefits and/or costs, and then revising the scenario to estimate loads again.
4. Once the estimated loads meet programmatic goals, finish the plan and send it to the next level of the planning process.

https://cast.chesapeakebay.net/Documentation/DevelopPlans

Steps to Developing a Plan and Assessing Progress Using CAST

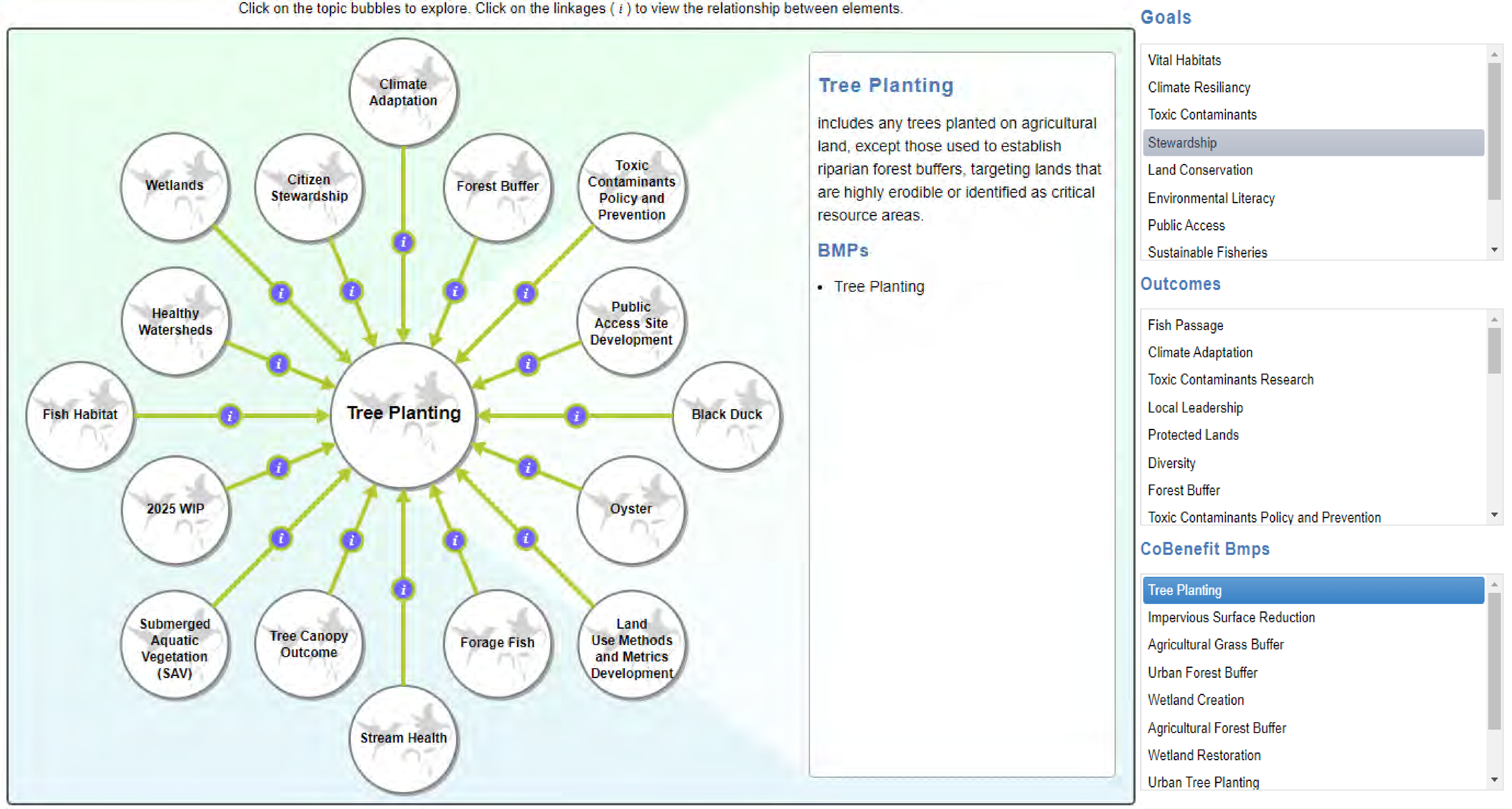

ESTABLISH PROGRAMMATIC GOALS
REVISE PROGRAMMATIC GOALS
LOADS
CO-BENEFITS
COSTS
TRANSLATE TO BMP(S)
NO
YES
DETERMINE IF NUMERIC REDUCTIONS ACHIEVE NUMERIC GOALS
FINISH PLAN

1. **Science:** Data on watershed land uses, loads, and BMPs to be used for targeting and planning purposes.
2. **Restoration:** Information on BMP ecosystem benefits available, including which BMPs support Chesapeake Bay Goals and Outcomes.
3. **Partnership:** Assists the Chesapeake Bay partners with assessing the achievements of their commitments and goals under the 2014 Chesapeake Bay Watershed Agreement and TMDL.

Restoration: Ecosystem Benefits

In addition to nitrogen, phosphorus and sediment goals, there may be additional, complementary objectives to BMP implementation called ecosystem benefits (often referred to as co-benefits). Examples of ecosystem benefits include: improve stream health, increase fish habitat, and reduce toxic contaminants. Identifying these additional objectives early in the planning process allows for selection of BMPs that meet the load reduction goals as well as achieve these complementary objectives.

Ecosystem Benefits Browser


Click on the topic bubbles to explore. Click on the linkages (*i*) to view the relationship between elements.

Tree Planting

Includes any trees planted on agricultural land, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.

BMPs

- Tree Planting

Goals

Vital Habitats
Climate Resiliency
Toxic Contaminants
Stewardship
Land Conservation
Environmental Literacy
Public Access
Sustainable Fisheries

Outcomes

Fish Passage
Climate Adaptation
Toxic Contaminants Research
Local Leadership
Protected Lands
Diversity
Forest Buffer
Toxic Contaminants Policy and Prevention

CoBenefit Bmps

Tree Planting
Impervious Surface Reduction
Agricultural Grass Buffer
Urban Forest Buffer
Wetland Creation
Agricultural Forest Buffer
Wetland Restoration
Urban Tree Planting

The Chesapeake Bay Program developed the Ecosystem Benefits Browser, in interactive tool that visualizes and summarizes the Goals, Outcomes, and Ecosystem Benefits associated with CAST BMPs. When using the browser online, click on the topic bubbles to explore the relationships between the Chesapeake Bay Program Goals and Outcomes, and CAST BMPs. Alternatively, select a Goal, Outcome, or BMP from the lists to update the browser chart and learn more.

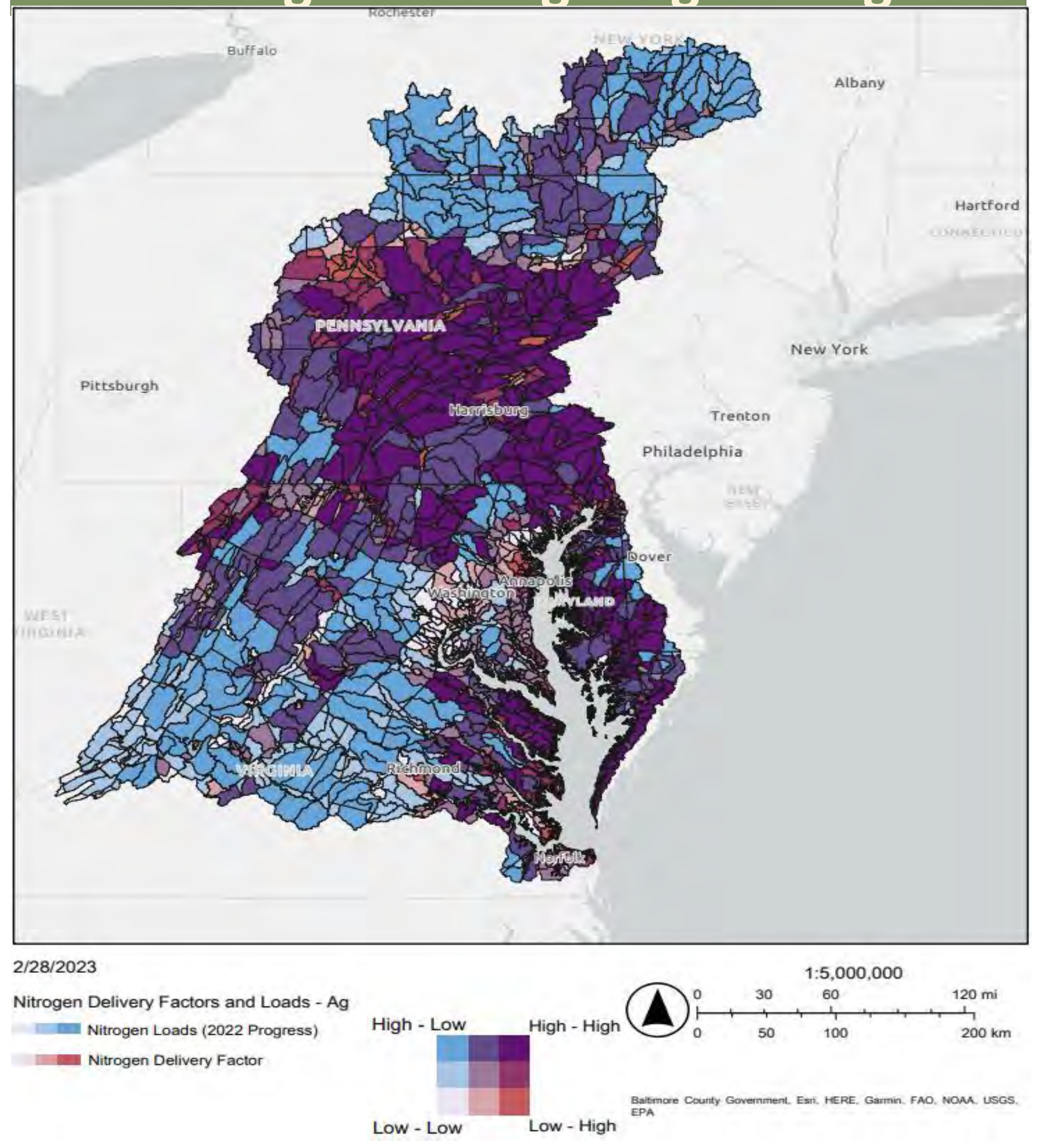
https://cast.chesapeakebay.net/ecohealth/index

Science: BMP Targeting Maps

Devereux Consulting used data in CAST to produce BMP targeting maps. By using delivery factors and 2022 annual progress loads, these maps communicate which land-river segments in the watershed would be most effective for BMP targeting. Delivery factors represent the fate and transport of nutrients and sediment from the land to the water. The higher the delivery factor, the higher the amount of nutrients and sediment are likely to run off from that area. There are six bivariate targeting maps posted on the CAST site, one for each nutrient and sector. The legend on each map has a box with 9 colors representing the variation of loads and delivery factors in each land-river segment from low to high. The lightest, bottom-left square in the legend correlates to the land-river segments on the map that have the lowest loads and delivery factors. The square in the top-right of the legend with the darkest coloring corresponds to the areas that have the highest loads, and the highest delivery factors. These are the areas that would be most effective for BMP targeting.

https://cast.chesapeakebay.net/Documentation/MapToolSpatialData

CBWS Ag BMP Targeting: Nitrogen



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40 years of monitoring and analysis in the Chesapeake Bay Program partnership : Insights on ecosystem change and new monitoring investments for improved decision support

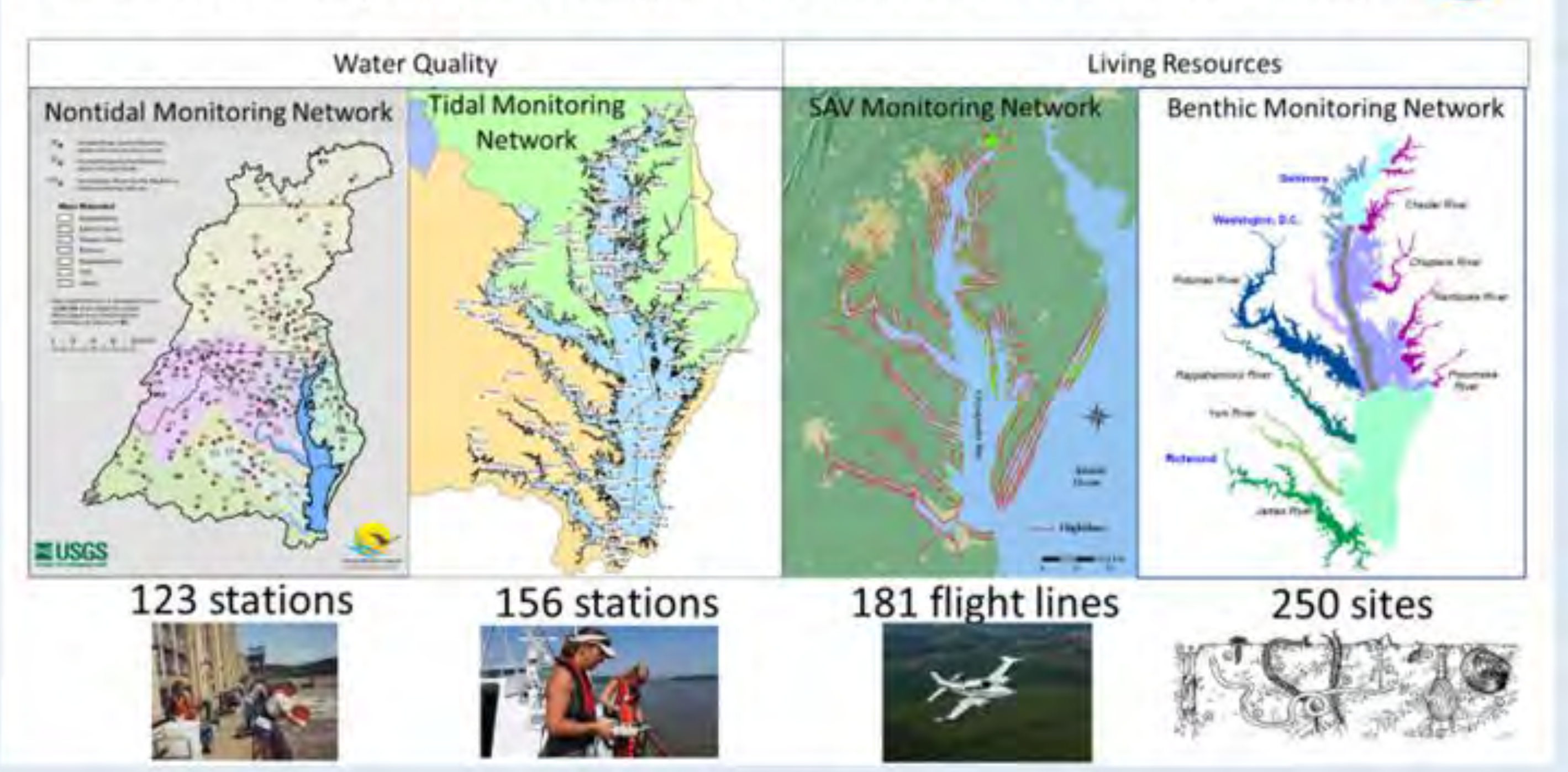
Peter Tango USGS@CBPO Biennial SRS Meeting 2023, Charlottesville, VA

Credits: STAR and its workgroups, CBP Monitoring Team, CBP partnership contributions over many decades

Chesapeake Bay Program
40 years of science, restoration and partnership

Abstract: The Chesapeake Bay Program Monitoring Programming had its first full year of operation in 1985. Water quality and living resource monitoring programs are valued for providing 1) decision-support on progress toward management goals and outcomes, 2) research insight, 3) development-calibration- verification of models, 4) education, 5) management targeting activities, 6) regulatory endpoint assessments, and 7) forecasting change over time. **Watershed monitoring results show improvements** across time though progress can vary by location and estimated results are generally greater than measured results as lag time for some effects are yet to be realized. The **Stream Health Benthic Index of Biotic Integrity analysis shows improvement** of watershed health in the last 20 years. **Various bay indicators demonstrate progress with Bay response**, however, the partnership expresses interest in accelerating the pace change. **Monitoring data have provided insight into climate change affects on the pace of progress. New monitoring approaches** are being incorporated into our assessment efforts. **Additional support is needed** for effectively monitoring of progress towards addressing all 2014 Chesapeake Watershed Agreement outcomes.

Core Monitoring Networks



Community Science

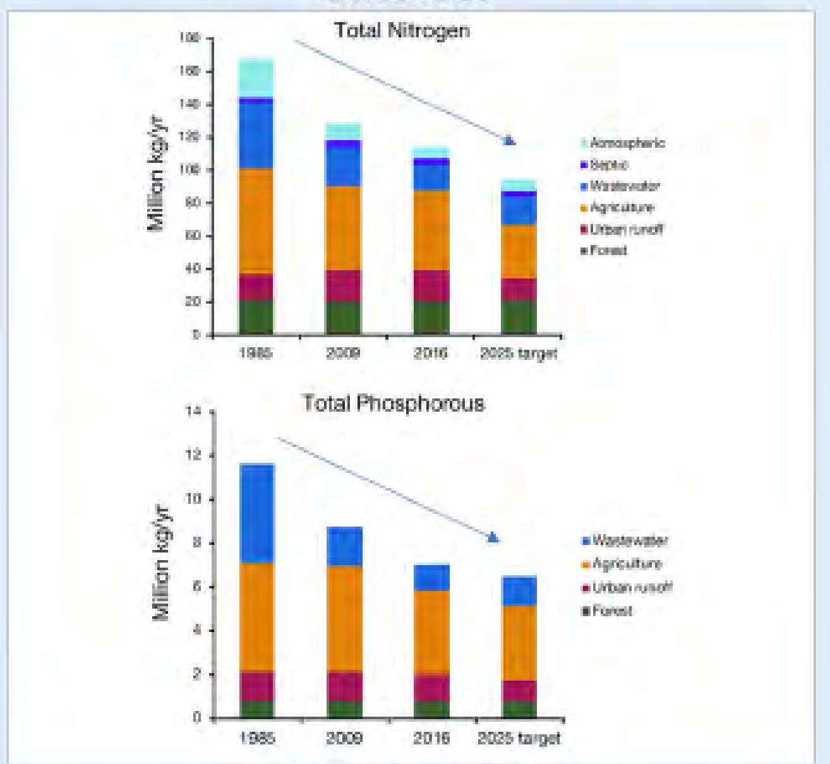
Sources/Usage: Public Domain. Visit Media to see details.

Land Use Land Cover

1. Core Chesapeake Bay Program Monitoring Program Elements include nontidal and tidal water quality, submerged aquatic vegetation, tidal benthic macroinvertebrates, Community Science, and Land Use Land Cover change

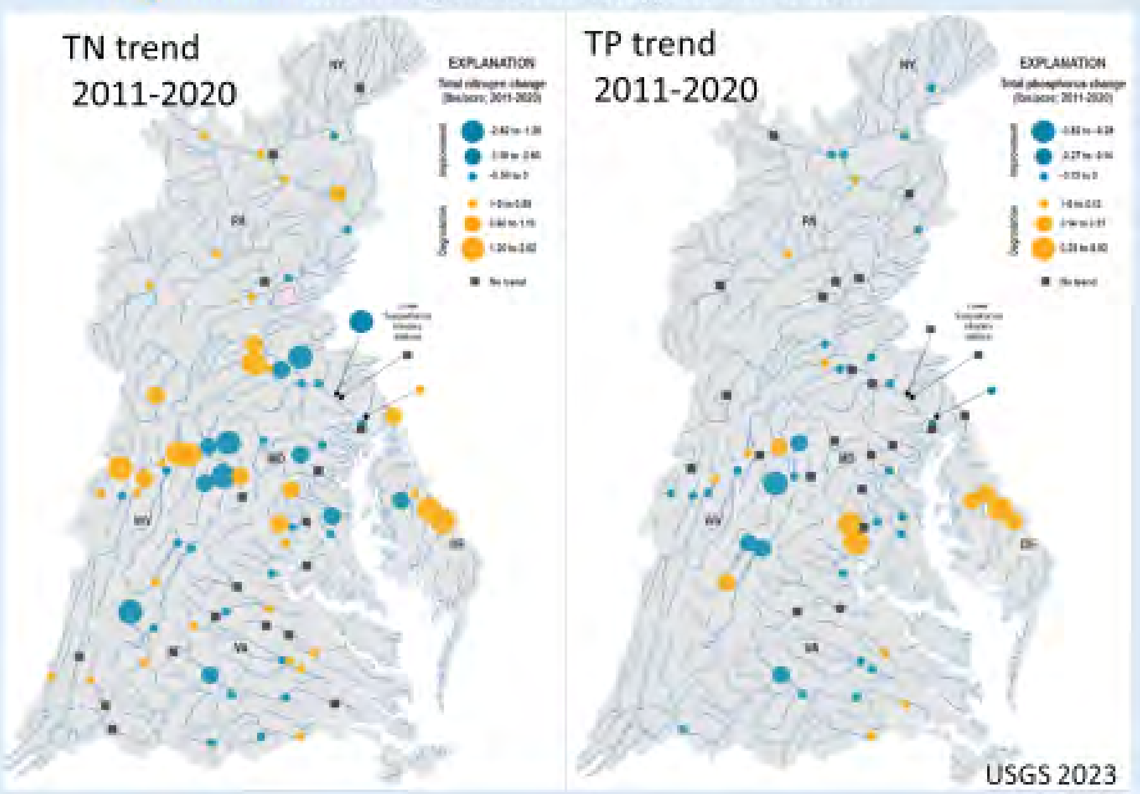
Watershed nutrient management shows cumulative progress but mixed local results

Estimated cumulative load reductions to the bay since 1985



D. Boesch 2019 Frontiers in Marine Science

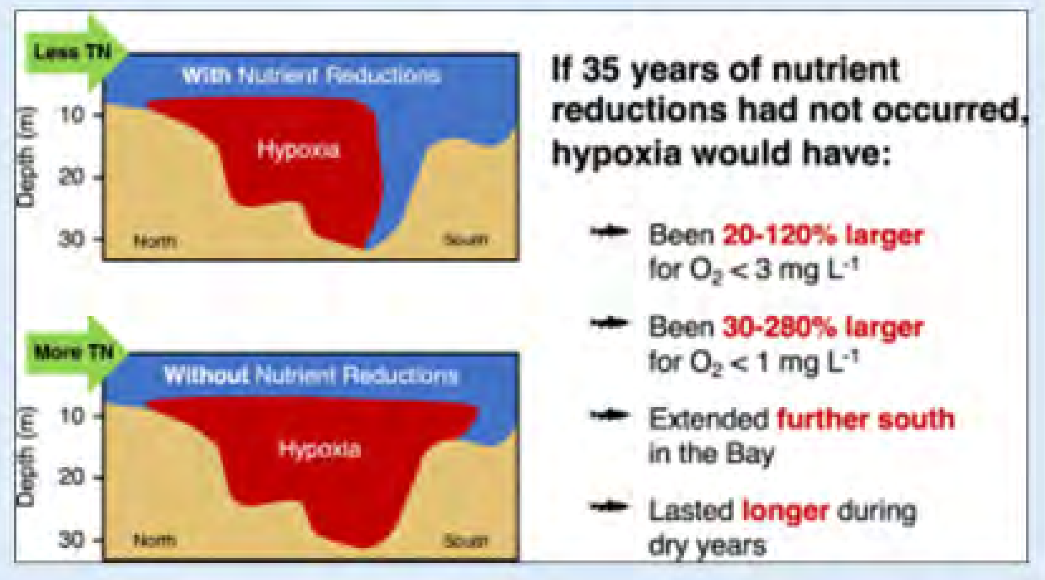
Spatially diverse patterns in trends for improvement and degradation offer targets for management action



USGS 2023

2. Watershed conditions improve though unevenly across the watershed

Are we seeing progress in the Bay response to management? Yes.



If 35 years of nutrient reductions had not occurred, hypoxia would have:

- Been 20-120% larger for $O_2 < 3$ mg L^{-1}
- Been 30-280% larger for $O_2 < 1$ mg L^{-1}
- Extended further south in the Bay
- Lasted longer during dry years

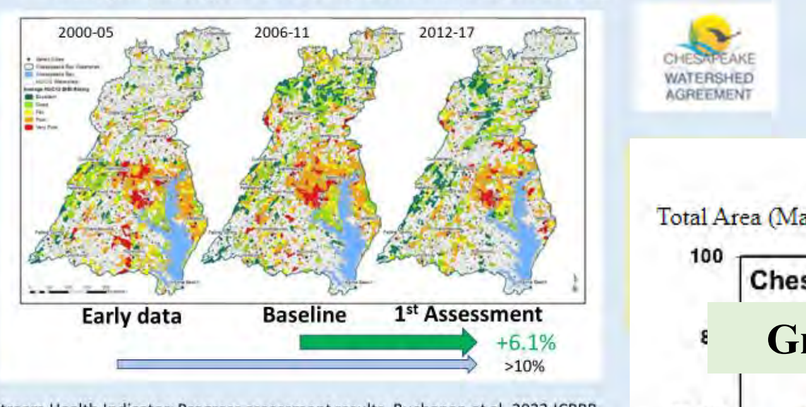
Frankel, L.T., M.A.M. Friedrichs, P. St-Laurent, A.J. Bever, R.N. Lipcius, G. Bhatt, G.W. Shenk, 2022. **Nitrogen reductions have** decreased hypoxia **in the Chesapeake Bay**: Evidence from empirical and numerical modeling, Science of the Total Environment, accepted for publication in December 2021

Science supporting improving water quality for the Bay

- Murphy, R. R., J. Keisman, J. Harcum, R.R. Karrh, M. Lane, E.S. Perry, and Q. Zhang. 2022. **Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management.** Environ. Sci. Technol. 56:260-270.
- Fisher, T. R.; Fox, R. J.; Gustafson, A. B.; Koontz, E.; Lepori-Bui, M.; Lewis, J. 2021. **Localized Water Quality Improvement in the Choptank Estuary, a Tributary of Chesapeake Bay.** Estuar. Coast. 44, 1274-1293.
- Jones, C. 2020. **Recovery of a tidal freshwater embayment from eutrophication**: a multidecadal study. Estuaries and Coasts. 43:1318-1334.
- Lefcheck, J. S.; Orth, R. J.; Dennison, W. C.; Wilcox, D. J.; Murphy, R. R.; Keisman, J.; Gurbisz, C.; Hannam, M.; Landry, J. B.; Moore, K. A.; Patrick, C. J.; Testa, J.; Weller, D. E.; Batiuk, R. A. 2018. **Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region.** Proc. Natl. Acad. Sci. U.S.A. 115, 3658-3662.
- Zhang, Q.; Murphy, R. R.; Tian, R.; Forsyth, M. K.; Trentacoste, E. M.; Keisman, J.; Tango, P. J. 2018. **Chesapeake Bay's water quality condition has been recovering: Insights from a multimetric indicator assessment of thirty years of tidal monitoring data.** Sci. Total Environ. 637-638. 1617-1625.
- Ruhl, H. A.; Rybicki, N. B. 2010. **Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat.** Proc. Natl. Acad. Sci. U.S.A. 107, 16566.

Stream Health Outcome – Assessment impact

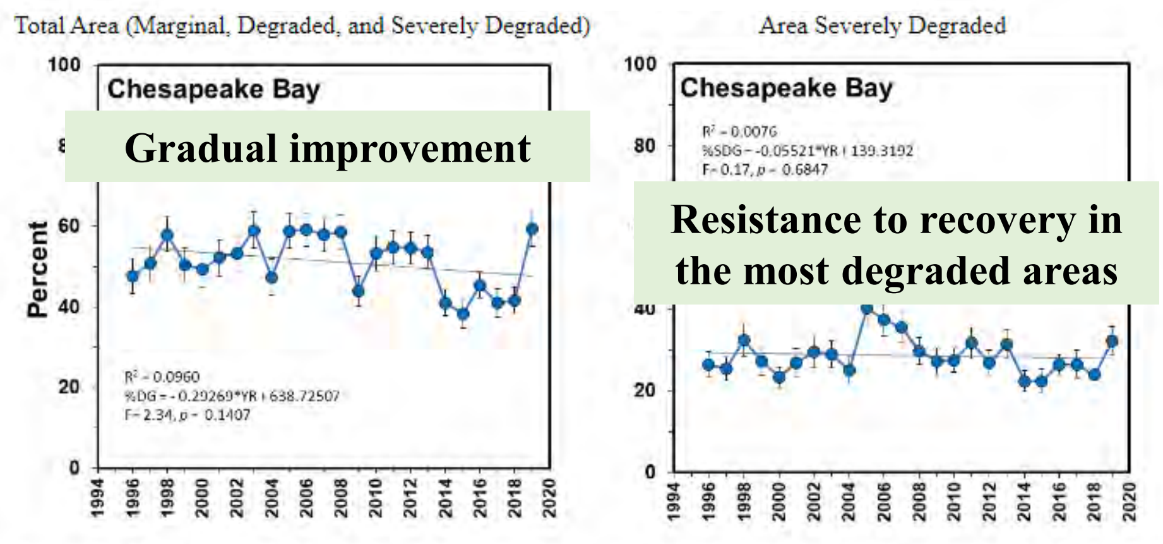
Management target of a 10% improvement for the watershed



Stream Health Indicator: Progress assessment results, Buchanan et al. 2023 ICPRB

Watershed macroinvertebrates: Chessie BIBI results improving 2000-2017

Tidal Bay IBI Baywide Results



Proportion of the Chesapeake Bay (+/- 1 Standard Error) with degraded (total area failing Restoration Goals, left panel) and severely degraded (right panel) benthic community condition. Trends of temporal changes tested by ANOVA.

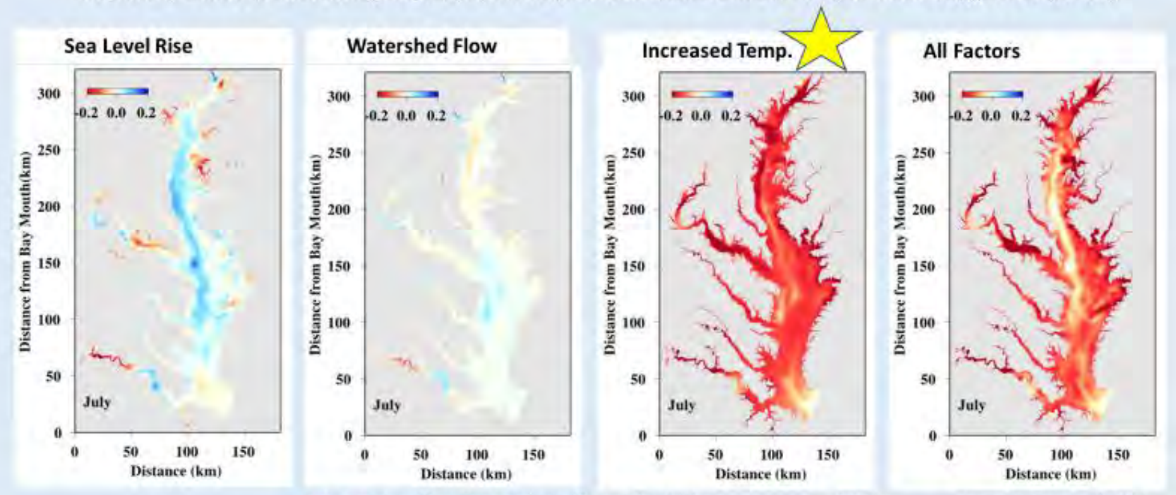
1994-2019

3. Bay and watershed indicators showing improvement, however, local to bay and watershed-wide measures vary in their pace of recovery

Signals of Change: Climate Influence on the Chesapeake Bay

Climate and Bottom Dissolved Oxygen Change: 1995 to 2025

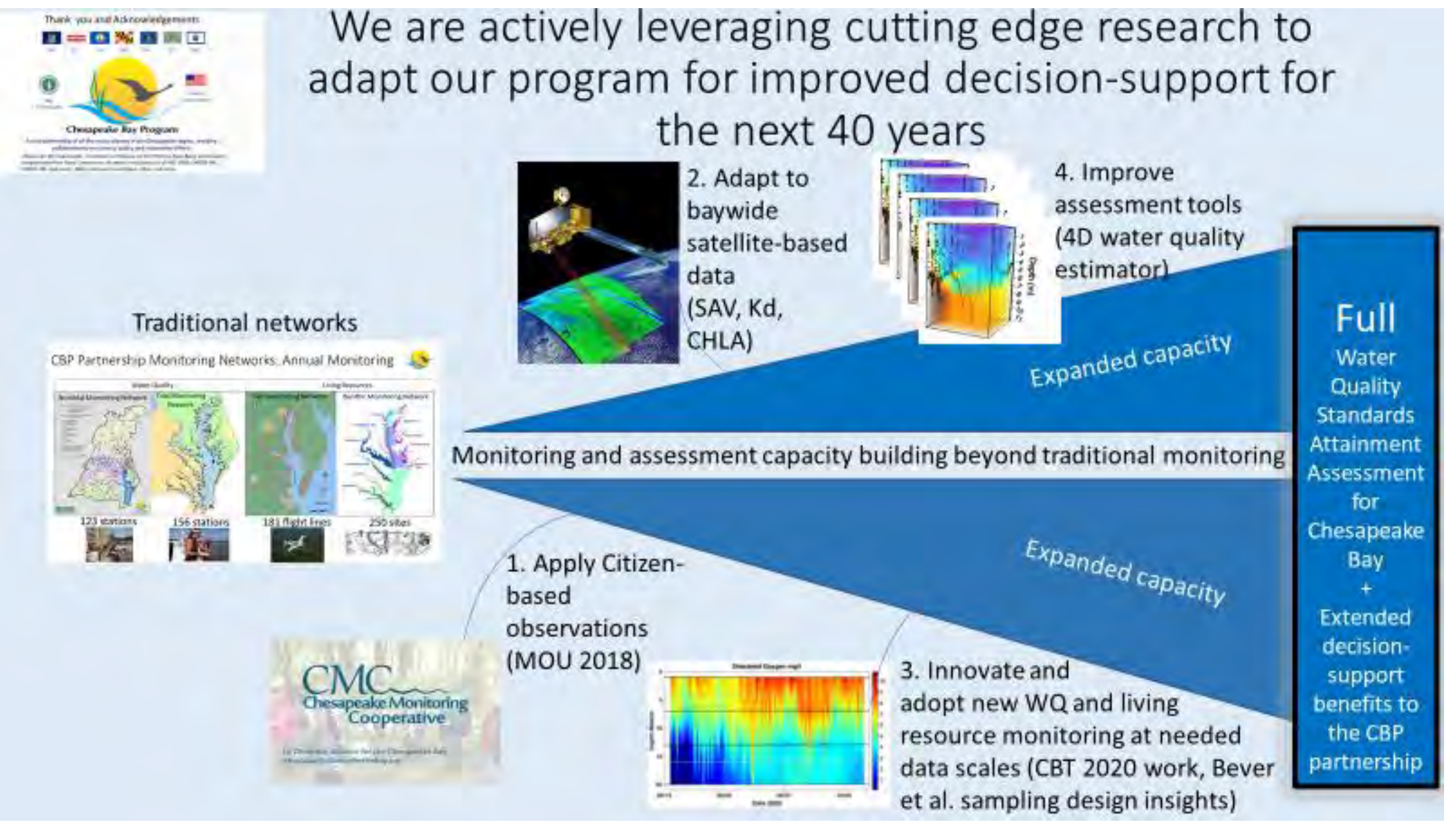
Hinson et al. (2021) Negative effects on bay recovery:
Increased water column temperatures are the predominant influence on dissolved oxygen conditions



Red = negative effect, Blue = positive effect on dissolved oxygen resources of the bay. Source: Hinson et al. 2021

4. Climate change effects are evident; temperature rise is widespread and important in negatively affecting the pace of ecosystem recovery

We are actively leveraging cutting edge research to adapt our program for improved decision-support for the next 40 years



2. Adapt to baywide satellite-based data (SAV, Kd, CHLA)

4. Improve assessment tools (4D water quality estimator)

Monitoring and assessment capacity building beyond traditional monitoring

1. Apply Citizen-based observations (MOU 2018)

3. Innovate and adopt new WQ and living resource monitoring at needed data scales (CBT 2020 work, Bever et al. sampling design insights)

Full Water Quality Standards Attainment Assessment for Chesapeake Bay + Extended decision-support benefits to the CBP partnership

5. Investments continue to support maintaining core networks while leveraging an expanded set of tools for improved assessments and enhanced decision support

Current policy:
2014 Agreement

5 themes
10 goals
31 outcomes

- Abundant Life
  - Sustainable Fisheries
  - Vital Habitats
- Clean Water
  - Healthy Watersheds
  - Toxic Contaminants
  - Water Quality
- Climate Change
  - Climate Resiliency
- Conserved Lands
  - Land Conservation
- Engaged Communities
  - Environmental Literacy
  - Public Access
  - Stewardship

6. The recent Principal Staff Committee Monitoring Review highlighted additional support needed to improve monitoring to assess progress toward achieving all outcomes of the 2014 Chesapeake Watershed Agreement

A LOCAL GOVERNMENT GUIDE TO THE CHESAPEAKE BAY

PROJECT OVERVIEW

- *A Local Government Guide to the Chesapeake Bay* is a series of educational modules created to support decision making by local officials

- Modules include a customizable presentation, one page handout, a PDF and a video
- Icons highlight how the information aligns with local government priorities
- Highly visual and succinct information

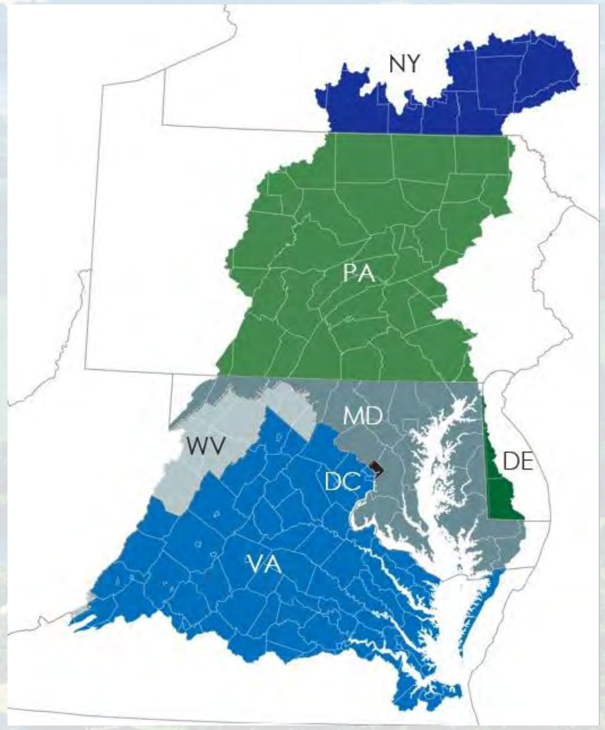
Check out the modules at this QR code:

LOCAL GOVERNMENT PRIORITIES

- Economic Development
- Public Safety and Health
- Infrastructure Maintenance & Finance
- Education

MODULES

- How the Watershed Works
- Foundations of Clean Water
- Preserving Local Character and Landscapes



- Preparing Your Community for Water Extremes
- Capitalizing on the Benefits of Trees
- Building the Workforce of Today and Tomorrow
- Protecting Community Infrastructure Through Stormwater Resilience
- Clean Water for the Economy
- Understanding and Supporting Your Agricultural Allies
- Keys to Building Community Buy-in for the Environment
- Your Health and the Environment

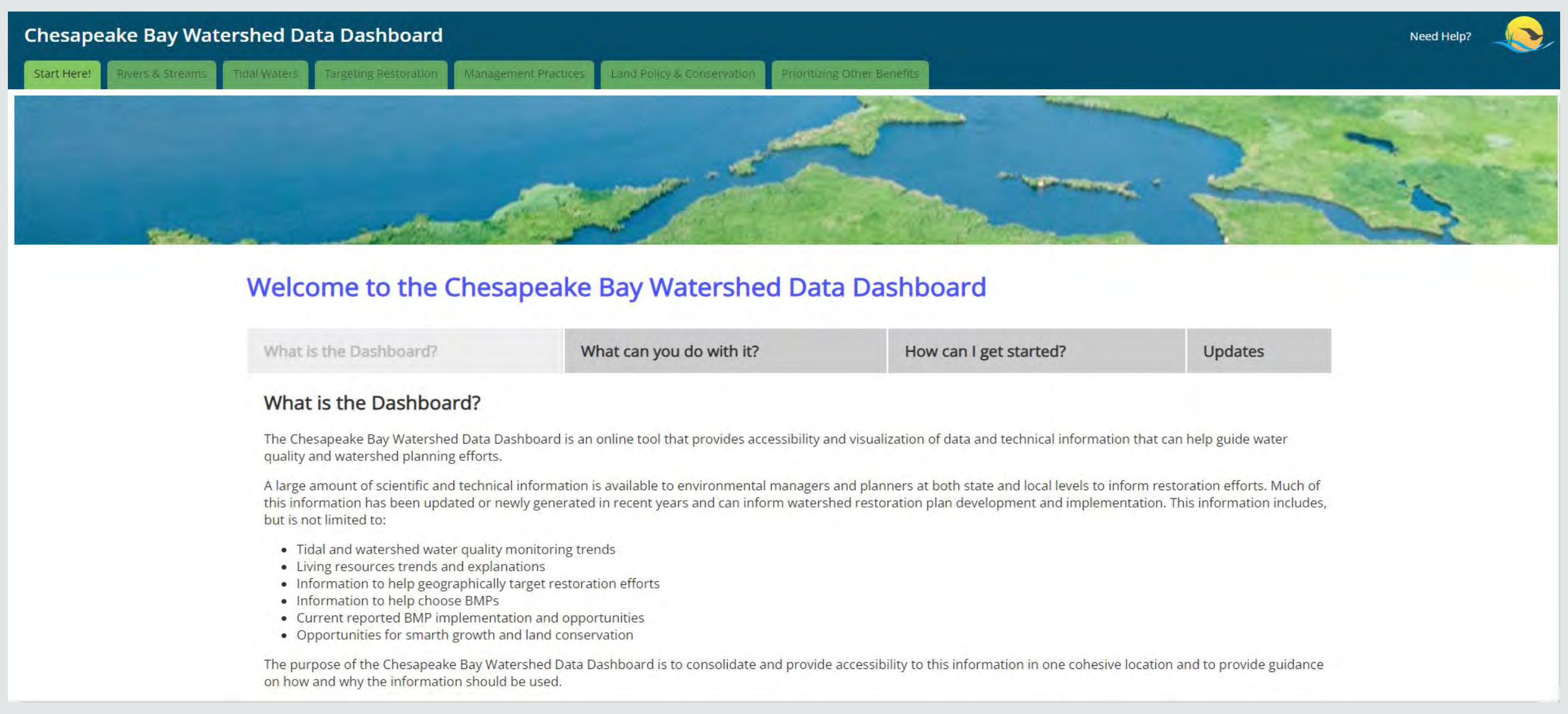
PROJECT ENGAGEMENT

- 400+ people have accessed the modules
- 1,500+ local officials directly engaged
- Shared with 10,000+ local officials
- 4 states have tailored the modules

HOW TO USE THE MODULES

- Modules are easily customized and shared
- Example uses: one-pager as handout, ppt as the basis for a presentation, one slide as an infographic, pdf version as a handbook etc.
- NEW WEBSITE for modules→ Summer 2023
- "Train the trainer" → Fall 2023

Tools and Resources for planning in the Chesapeake



Welcome to the Chesapeake Bay Watershed Data Dashboard

What is the Dashboard?

The Chesapeake Bay Watershed Data Dashboard is an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

A large amount of scientific and technical information is available to environmental managers and planners at both state and local levels to inform restoration efforts. Much of this information has been updated or newly generated in recent years and can inform watershed restoration plan development and implementation. This information includes, but is not limited to:

- Tidal and watershed water quality monitoring trends
- Living resources trends and explanations
- Information to help geographically target restoration efforts
- Information to help choose BMPs
- Current reported BMP implementation and opportunities
- Opportunities for smarth growth and land conservation

The purpose of the Chesapeake Bay Watershed Data Dashboard is to consolidate and provide accessibility to this information in one cohesive location and to provide guidance on how and why the information should be used.

Chesapeake Bay Watershed Data Dashboard

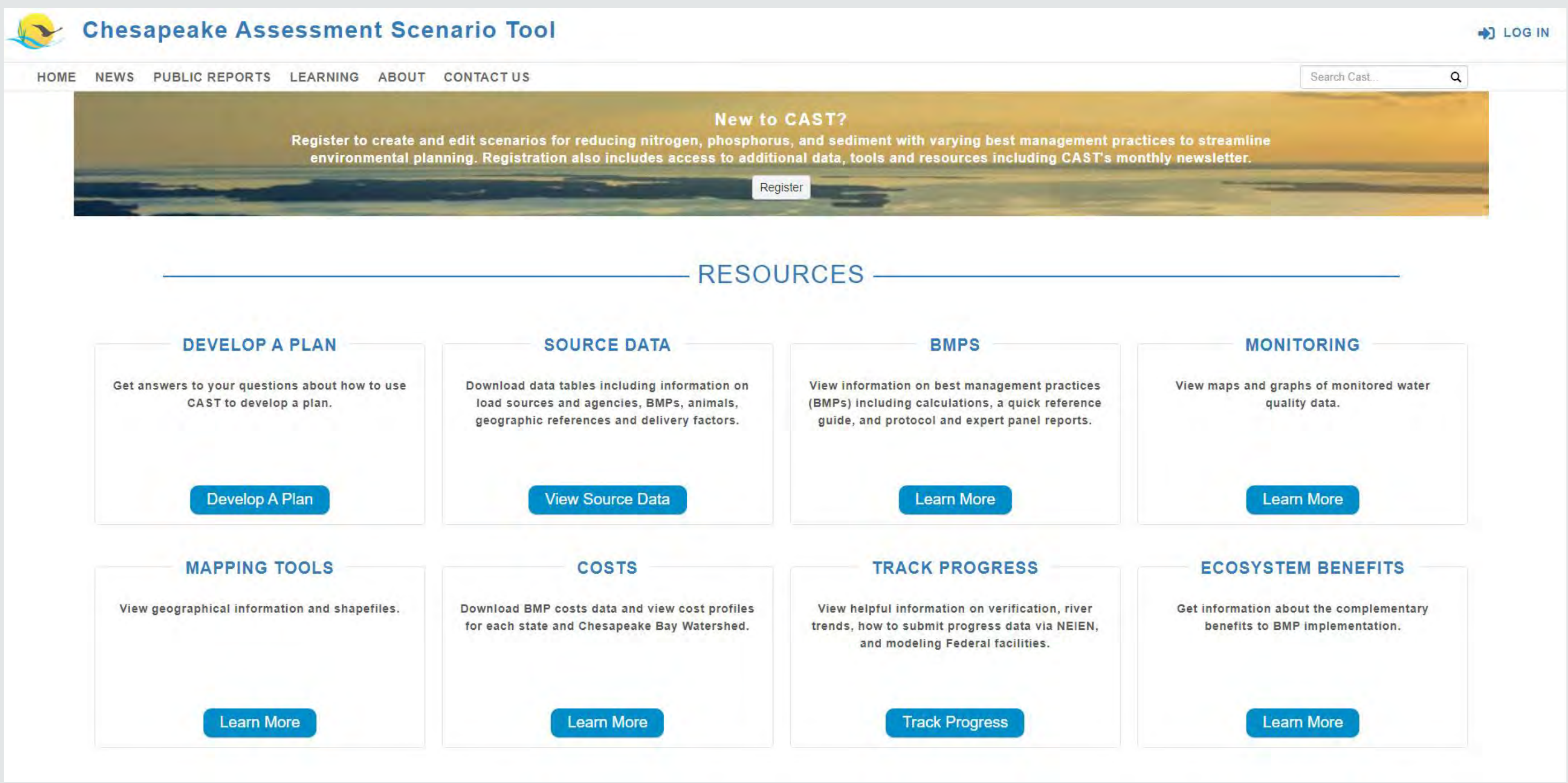
The Chesapeake Bay Watershed Data Dashboard is an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

The Chesapeake Executive Council's Diversity, Equity, Inclusion and Justice (DEIJ) Statement commits to including DEIJ in all areas of Chesapeake Bay restoration and conservation. To help workgroup leaders identify opportunities to implement DEIJ into their work, we have developed the Chesapeake Environmental Justice and Equity Dashboard, a web application that integrates data from multiple sources to convey demographic, socioeconomic, environmental, and programmatic topics connected to the Chesapeake Bay Watershed Agreement and Chesapeake specific DEIJ initiatives.

The dashboard is currently accessible in this draft or beta release as we collect information from users on content and usability. Please send comments or suggestions to diversitydashboard@chesapeakebay.net.

Chesapeake Bay Environmental Justice and Equity Dashboard

Provides access to a variety of spatial data layers pertinent to addressing environmental issues in areas with underrepresented populations, which include communities of color, low income, and linguistically isolated communities.

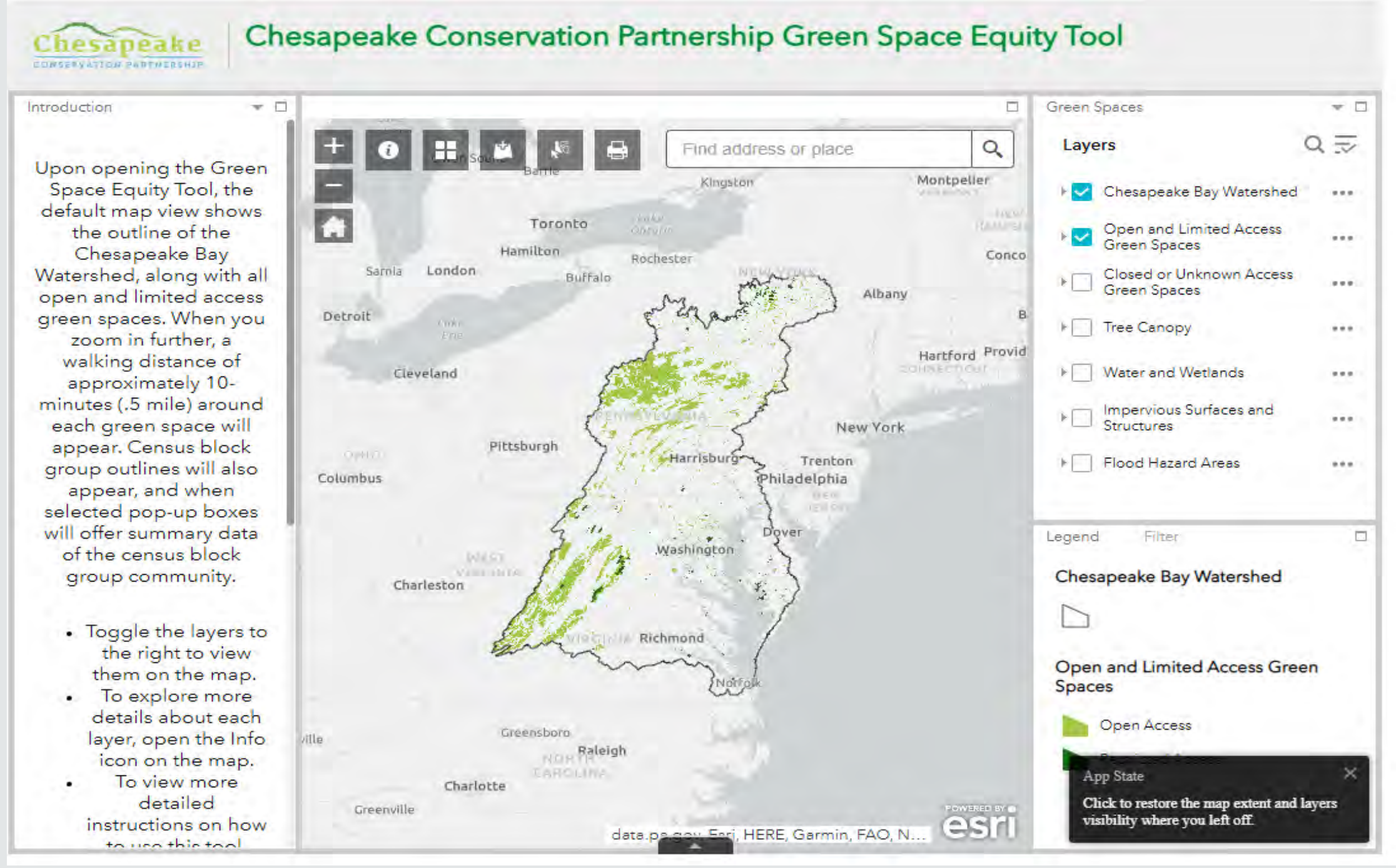


Register to create and edit scenarios for reducing nitrogen, phosphorus, and sediment with varying best management practices to streamline environmental planning. Registration also includes access to additional data, tools and resources including CAST's monthly newsletter.

DEVELOP A PLAN	Get answers to your questions about how to use CAST to develop a plan.
SOURCE DATA	Download data tables including information on load sources and agencies, BMPs, animals, geographic references and delivery factors.
BMPS	View information on best management practices (BMPs) including calculations, a quick reference guide, and protocol and expert panel reports.
MONITORING	View maps and graphs of monitored water quality data.
MAPPING TOOLS	View geographical information and shapefiles.
COSTS	Download BMP costs data and view cost profiles for each state and Chesapeake Bay Watershed.
TRACK PROGRESS	View helpful information on verification, river trends, how to submit progress data via NEIEN, and modeling Federal facilities.
ECOSYSTEM BENEFITS	Get information about the complementary benefits to BMP implementation.

Chesapeake Assessment Scenario Tool (CAST)

Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.



Upon opening the Green Space Equity Tool, the default map view shows the outline of the Chesapeake Bay Watershed, along with all open and limited access green spaces. When you zoom in further, a walking distance of approximately 10-minutes (.5 mile) around each green space will appear. Census block group outlines will also appear, and when selected pop-up boxes will offer summary data of the census block group community.

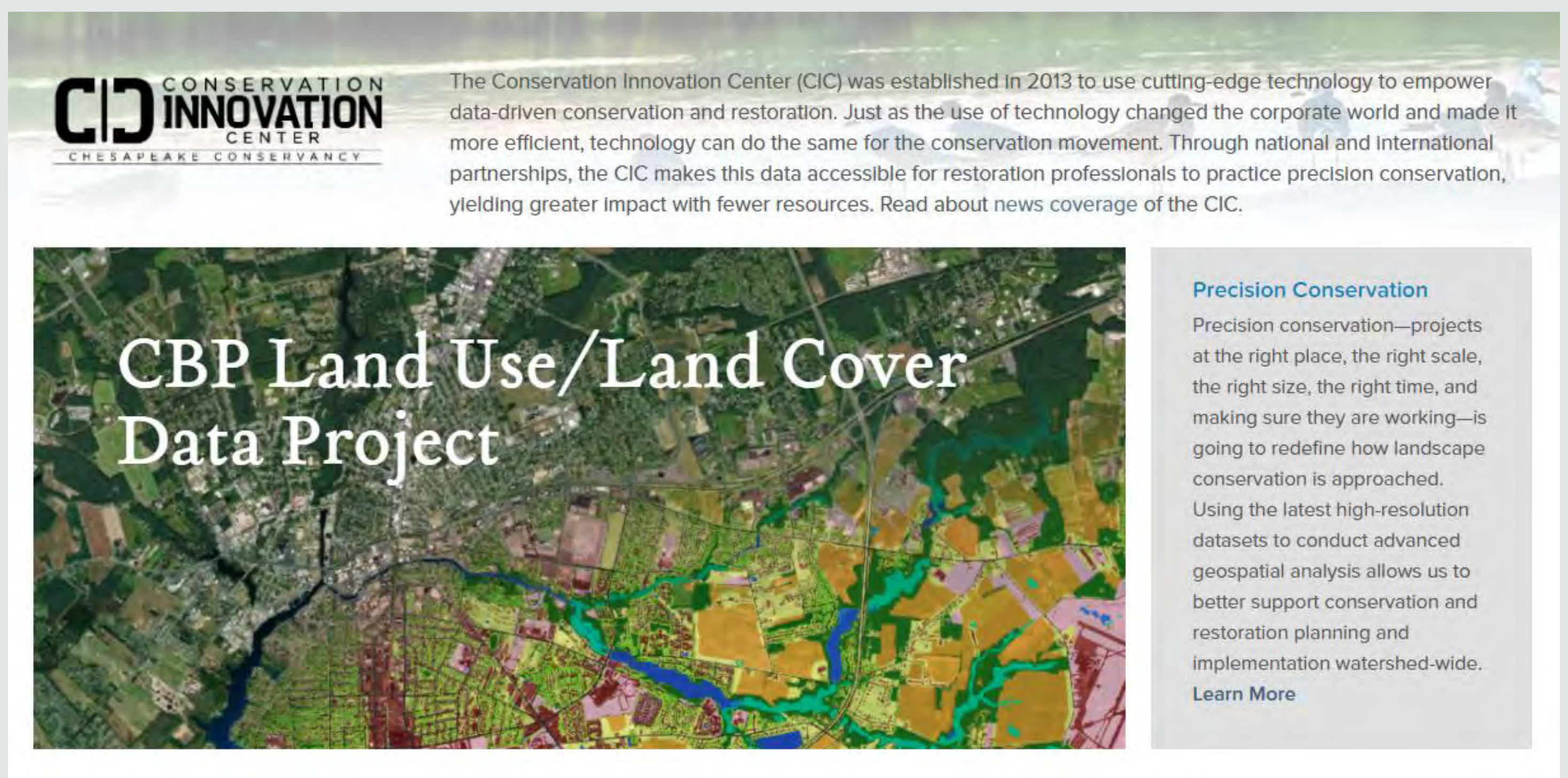
- Toggle the layers to the right to view them on the map.
- To explore more details about each layer, open the Info icon on the map.
- To view more detailed instructions on how to use this tool

App State

Click to restore the map extent and layers visibility where you left off.

Chesapeake Conservation Partnership Green Space Equity Mapping Tool

Assists in identifying and prioritizing conservation opportunities in low-income communities and communities of color throughout the watershed with limited or no access to open space.



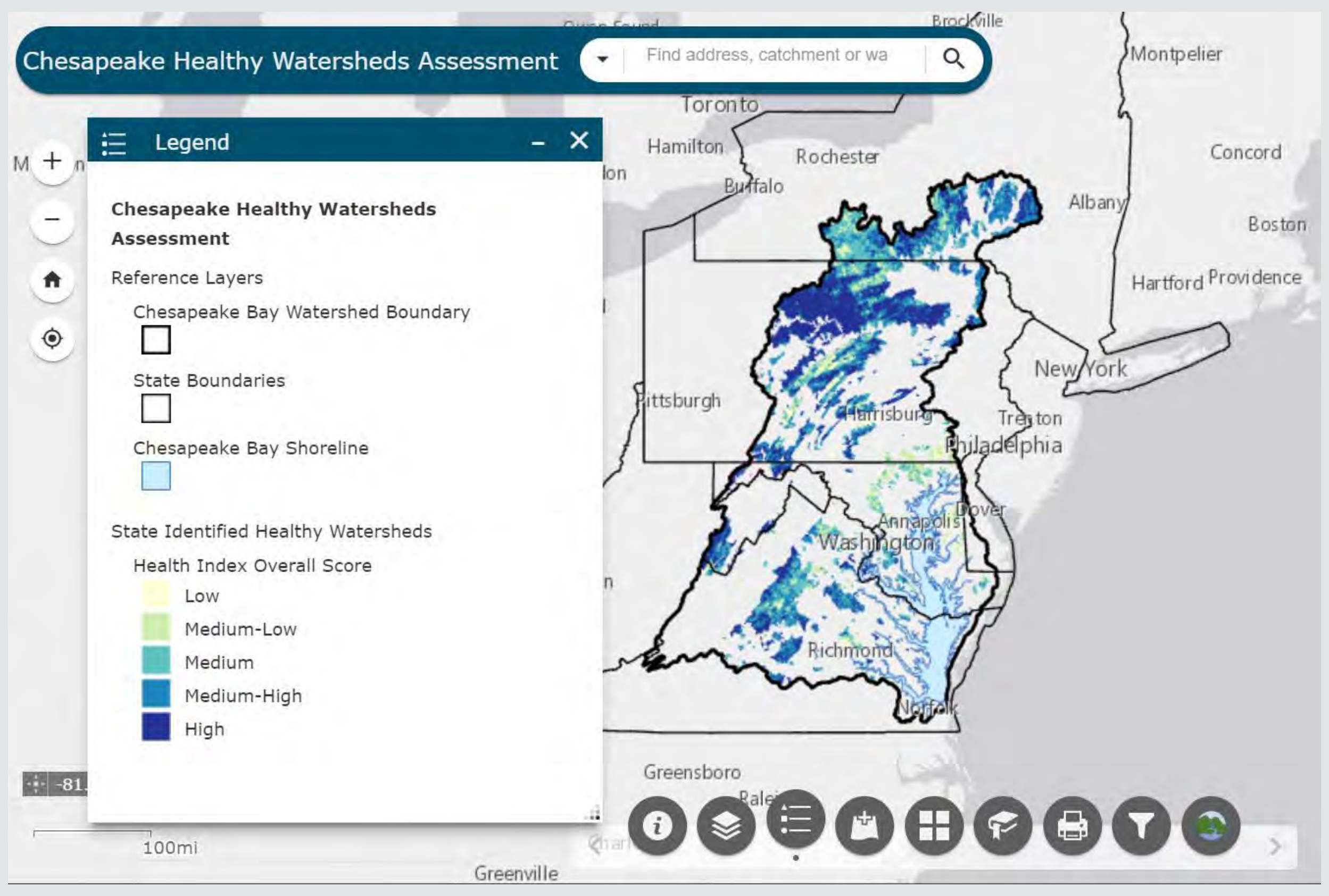
The Conservation Innovation Center (CIC) was established in 2013 to use cutting-edge technology to empower data-driven conservation and restoration. Just as the use of technology changed the corporate world and made it more efficient, technology can do the same for the conservation movement. Through national and international partnerships, the CIC makes this data accessible for restoration professionals to practice precision conservation, yielding greater impact with fewer resources. Read about news coverage of the CIC.

Precision Conservation

Precision conservation—projects at the right place, the right scale, the right size, the right time, and making sure they are working—is going to redefine how landscape conservation is approached. Using the latest high-resolution datasets to conduct advanced geospatial analysis allows us to better support conservation and restoration planning and implementation watershed-wide. Learn More

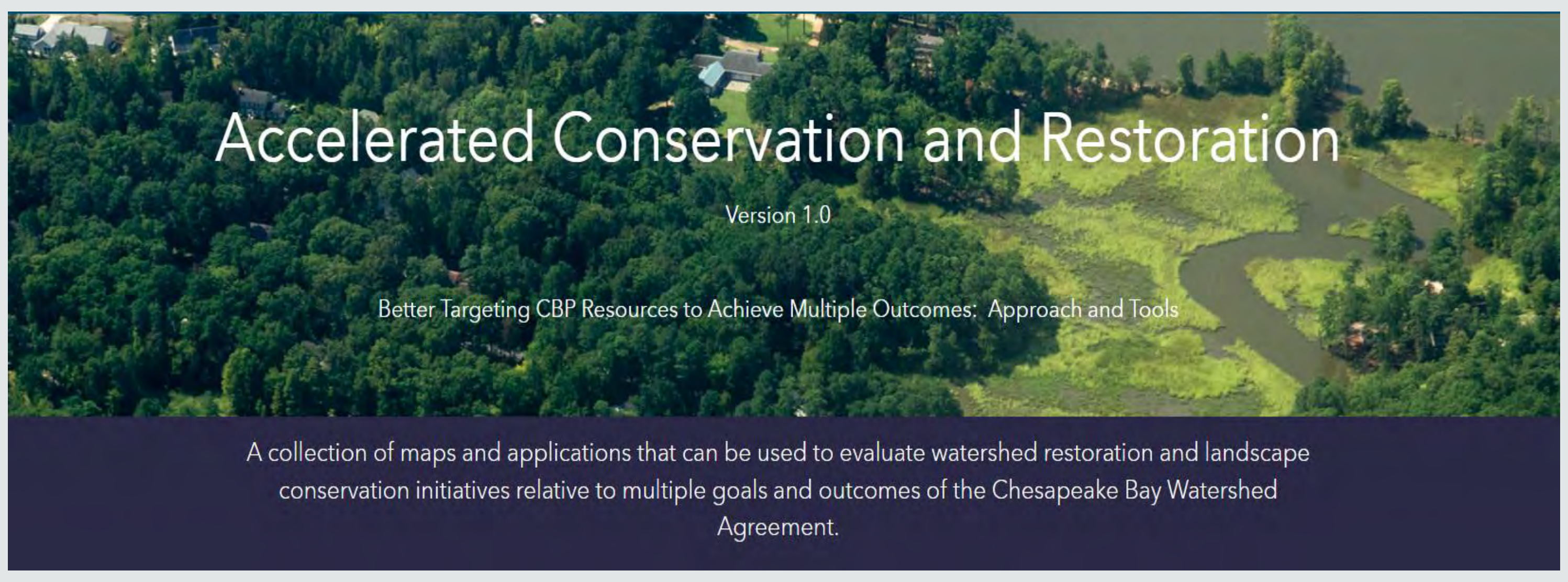
Chesapeake Bay High Resolution Land Use Land Cover Data

1-meter resolution land cover and land use/land cover datasets of the Chesapeake Bay watershed regional area (206 counties, over 250,000 km2). These data are foundational, authoritative, and transformative looks at the landscape and its management throughout the region.



Chesapeake Healthy Watersheds Assessment

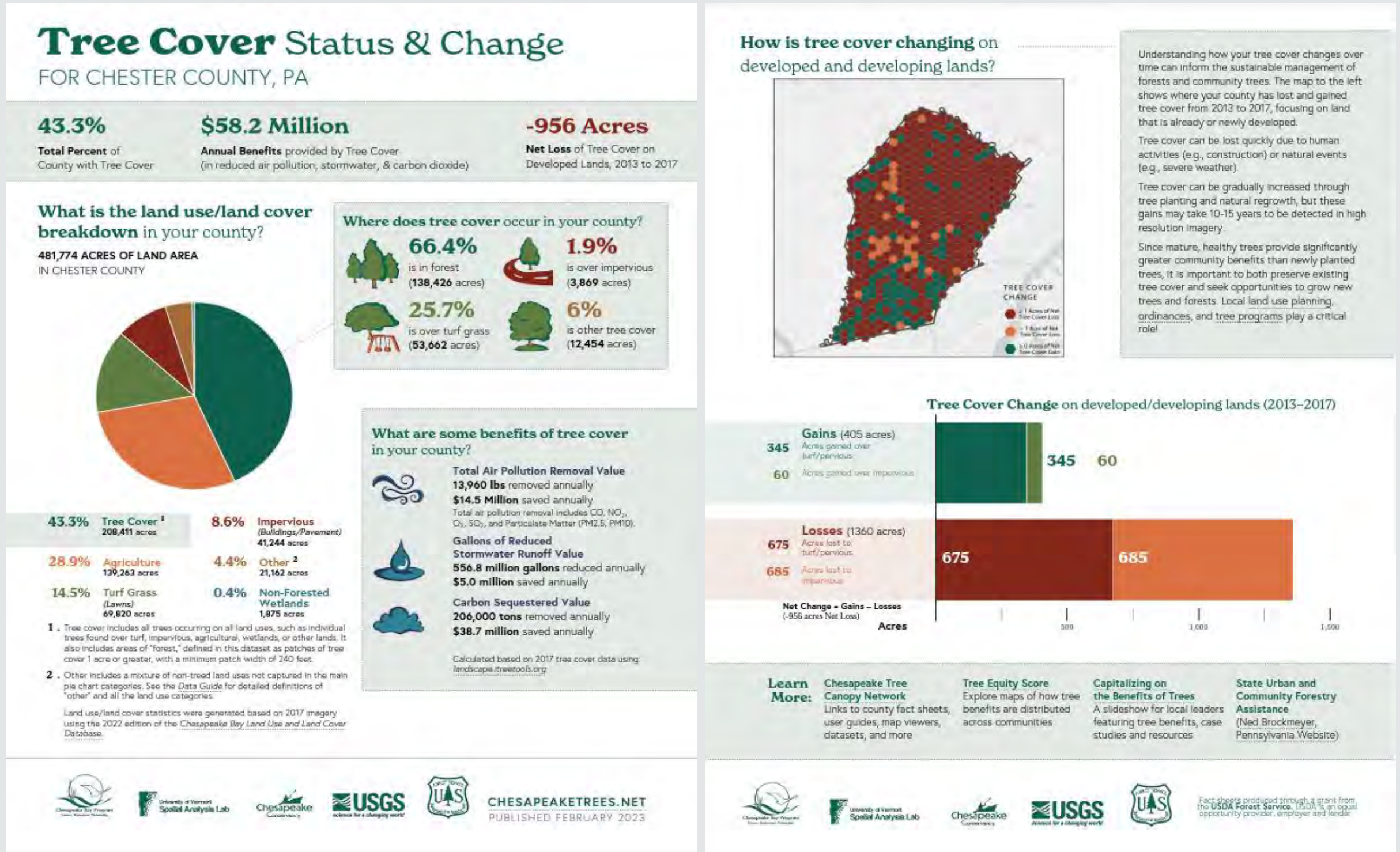
Assessing the Healthy and Vulnerability of Healthy Watersheds within the Chesapeake Bay Watershed Catchment data at NHD Plus Version 2 scale



A collection of maps and applications that can be used to evaluate watershed restoration and landscape conservation initiatives relative to multiple goals and outcomes of the Chesapeake Bay Watershed Agreement.

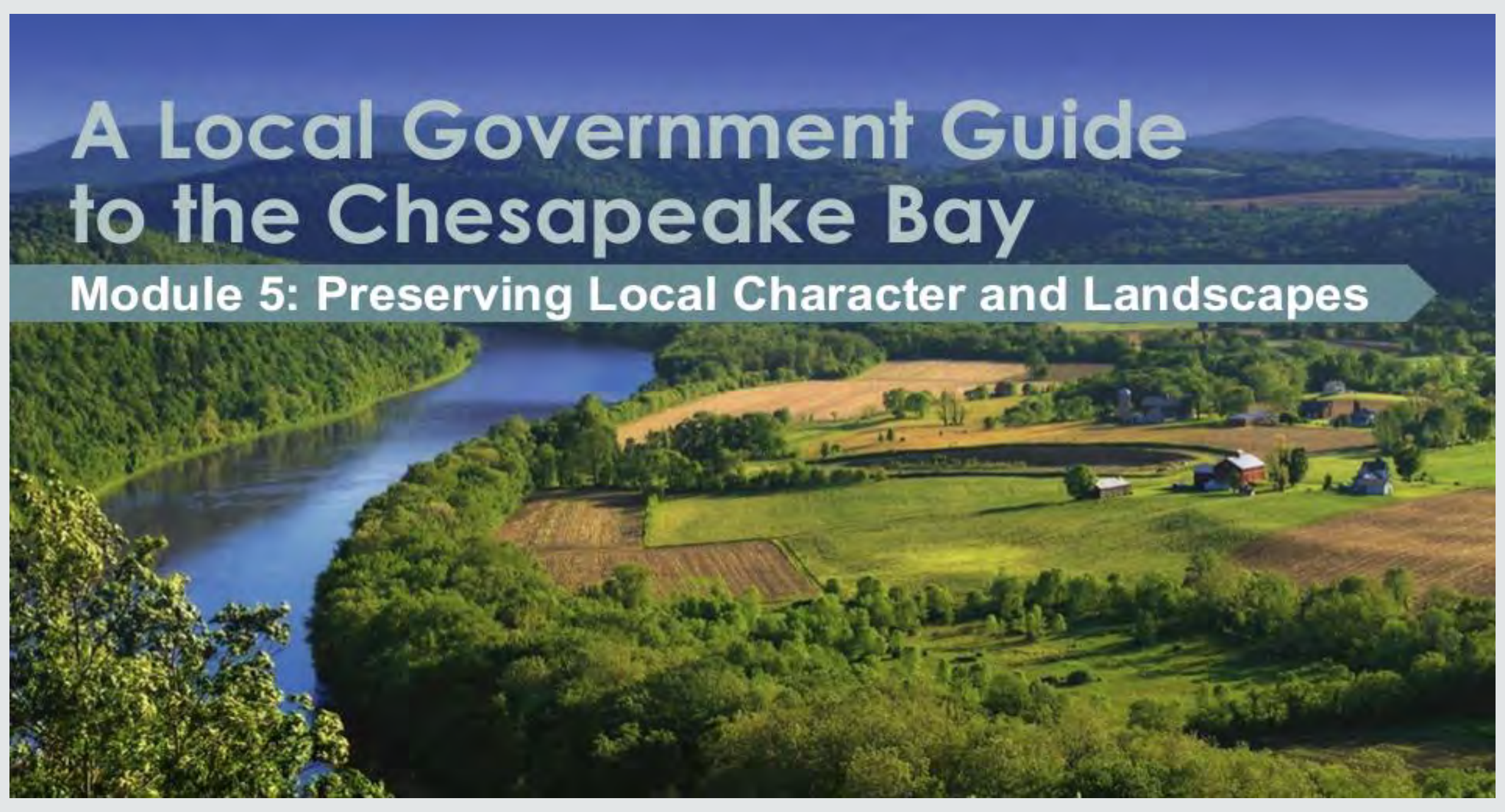
Accelerated Conservation and Restoration Targeting Portal

A collection of maps and applications that can be used to evaluate watershed restoration and landscape conservation initiatives relative to multiple goals and outcomes of the Chesapeake Bay Watershed Agreement.



County Tree Cover Fact Sheet

County Tree Cover Fact Sheets are for all Chesapeake watershed counties sharing tree cover status, benefits (from i-Tree) and change information over the 2013/14 to 2017/18 time periods



A Local Government Guide to the Chesapeake Bay Module 5

highlights the economic, ecological, cultural, and recreational value of the conserved landscapes around the Chesapeake Bay watershed to the people and communities of the region

For links to all the listed tools please scan the QR code!

40 Chesapeake Bay Program

40 years of science, restoration and partnership

Chesapeake Bay Program
40 years of science, restoration and partnership.

Enhancing the Chesapeake Bay Program Monitoring Networks:
CBP enters a new phase of monitoring thanks to partnership investment

August Goldfischer (CRC); Breck Sullivan, Peter Tango, and Scott Phillips (USGS); Denice Wardrop (Penn State); Lee McDonnell, Kaylyn Gootman (EPA)

Timeline of Monitoring Review Process ①

March 2021
Principals' Staff Committee requested a study and recommendations on how to improve CBP monitoring networks.

2021-2022
STAR- and STAC-led team conducted a review with input from all GITs and outcome leads, summarizing findings in a report.

2022
Communicated findings and developed sampling designs to address data collection needs.

2022
The team worked with scientists and managers to develop cost estimates based on proposed sampling designs.

2022-2023
CBP partners collaborate to maintain existing monitoring networks, with help from Infrastructure, Investment and Jobs Act (IIJA).

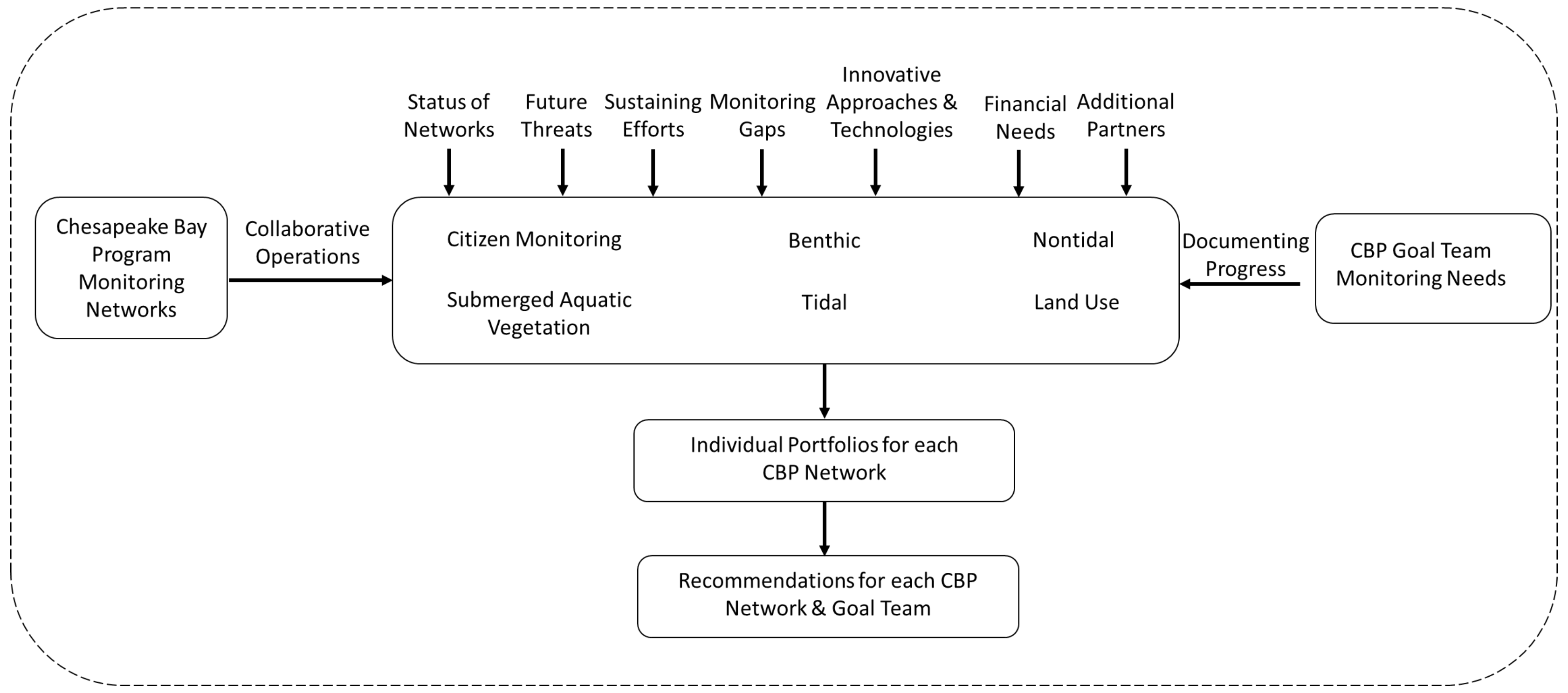
2023-onward
CBP partners enhance existing networks, establish new monitoring, and sustain monitoring long-term.

Key Findings ②

! Monitoring is critical to assess progress towards meeting goals and outcomes of the 2014 Watershed Agreement.

Monitoring is insufficient for many CBP Outcomes.

$ Opportunities for enhancing the networks exist but funding is a challenge.



Chesapeake Bay Program Monitoring Networks
Collaborative Operations
Status of Networks
Future Threats
Sustaining Efforts
Monitoring Gaps
Innovative Approaches & Technologies
Financial Needs
Additional Partners
Citizen Monitoring
Benthic
Nontidal
Submerged Aquatic Vegetation
Tidal
Land Use
Documenting Progress
CBP Goal Team Monitoring Needs
Individual Portfolios for each CBP Network
Recommendations for each CBP Network & Goal Team

Monitoring Networks Overview ③

Monitoring Networks
- Nontidal
- Tidal
- Submerged Aquatic Vegetation (SAV)
- Benthic
- Community Monitoring
- Land Use

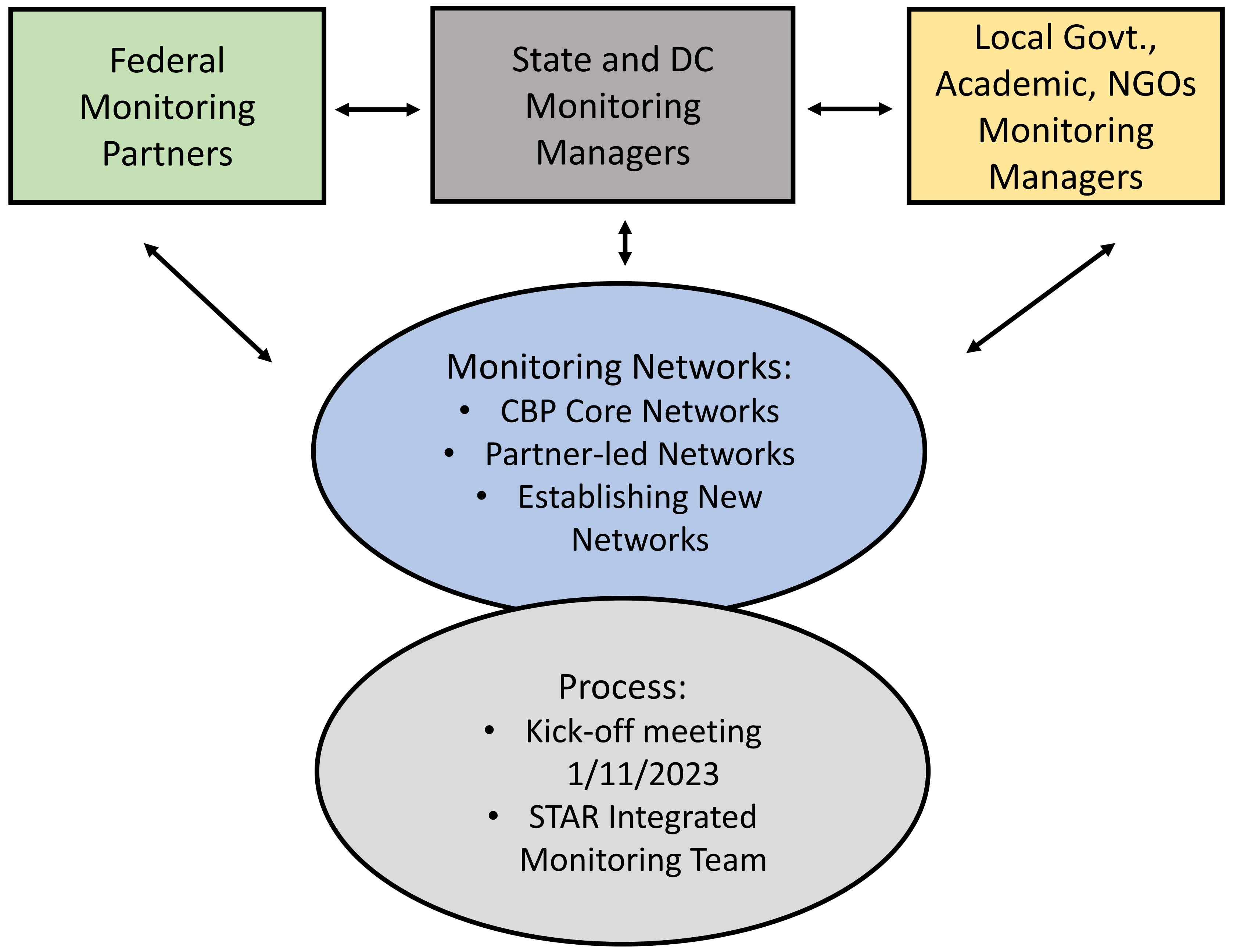
Available Data
- Continuous Monitoring
- Long-term fixed stations
- Dataflow
- SAV Watchers Program
- Aerial SAV
- Macroinvertebrate
- High resolution ($1m^2$) land cover and land use

Data Uses
- Status & Trends
- Model Development, Calibration, & Verification
- BMP Effectiveness assessment
- Climate Impact Assessment
- Research/hypothesis testing
- Leveraging for Proposals
- Policy Making
- Management Decision Support
- Communication
- Outreach & Education
- Indicator Development & Reporting
- Forecasting
- Scientific Discovery

		Maintain	Enhance	Establish
Goal	**Outcome**			
Sustainable Fisheries	Forage Fish		x	x
	Fish Habitat		x	x
	Oysters	x	x	
	Blue Crab Abundance	x	x	
	Blue Crab Management	Outcome is complete		
Vital Habitats	Wetland		x	
	Black Duck		x	
	Stream Health		x	
	Brook Trout		x	
	Fish Passage	x		
	Forest Buffers	x	x	
	Tree Canopy	x	x	
	Submerged Aquatic Vegetation		x	
Water Quality	WIP 2017	Outcome is complete		
	WIP 2025		x	
	WQSAM	x	x	x
Toxic Contaminants	Toxic Contaminants Research			x
	Toxic Contaminants Policy & Prevention			x
Healthy Watersheds	Healthy Watersheds	x		

		Maintain	Enhance	Establish
Goal	**Outcome**			
Climate Resiliency	Climate Monitoring and Assessment	x	x	x
	Climate Adaptation			x
Land Conservation	Protected Lands	x	x	x
	Land Use Methods and Metrics	x	x	
	Land Use Options Evaluation	x		
Stewardship	Citizen Stewardship	x		
	Local Leadership			x
	Diversity		x	x
Public Access	Public Access Site Development	x		
Environmental Literacy	Student	x		
	Sustainable	x		
	Environmental Literacy Planning	x		

Building Capacity ④



Federal Monitoring Partners

State and DC Monitoring Managers

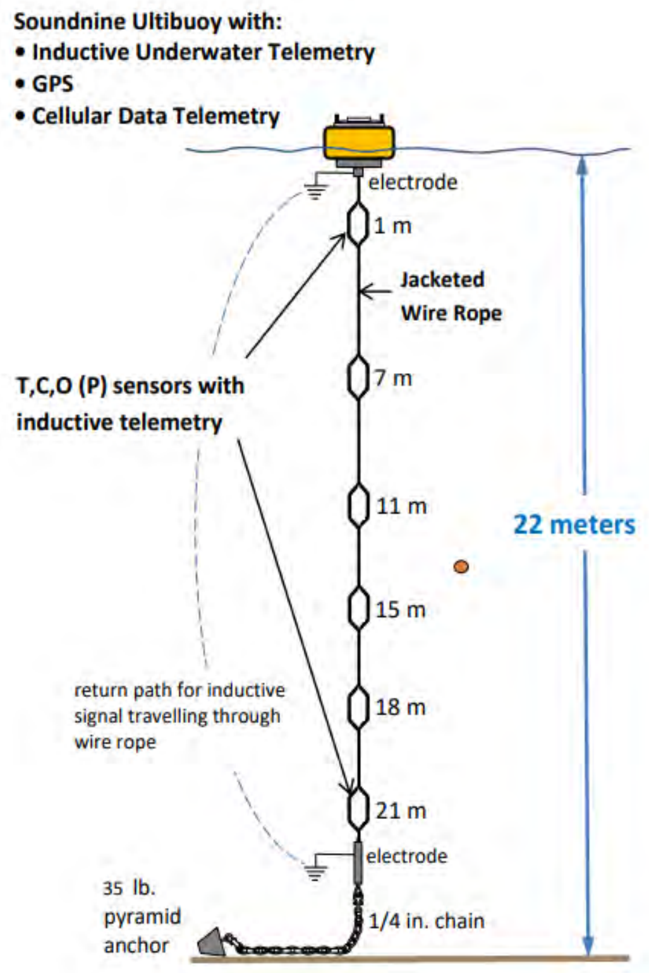
Local Govt., Academic, NGOs Monitoring Managers

Monitoring Networks:
- CBP Core Networks
- Partner-led Networks
- Establishing New Networks

Process:
- Kick-off meeting 1/11/2023
- STAR Integrated Monitoring Team

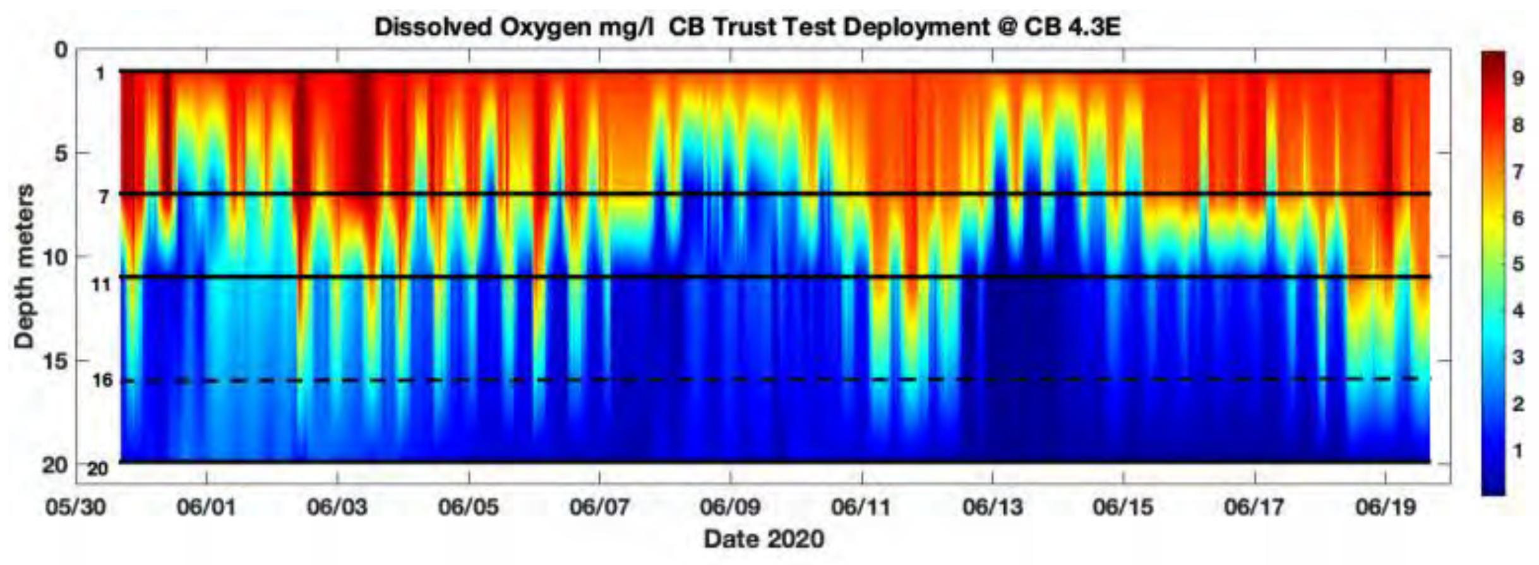
Partnership in Action 1: Hypoxia Monitoring Network ⑤

Hypoxia Monitoring Pilot Project Team:
(L-R) Doug Wilson, C.J. Pellerin, Max Ruehrmund, Jay Lazar



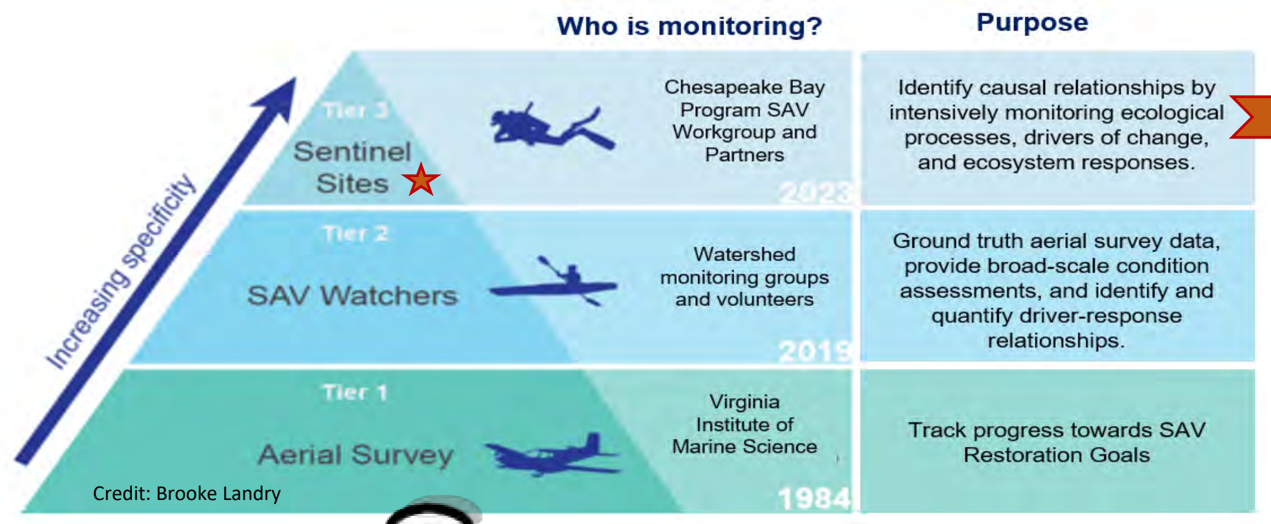
- *Schematic of Buoy with Sensors and Mooring System. Image credit: Doug Wilson, Caribbean Wind LLC.*

- *Top of Buoy. Image credit: NOAA Chesapeake Bay Office*



Example data set for approximately 1 month in 2020, 20-meter water column depth, deployed near the mouth of the Choptank River, MD.
Image credit: NOAA Chesapeake Bay Office

Partnership in Action 2: SAV Sentinel Sites ⑥



	Who is monitoring?	Purpose
Tier 3 Sentinel Sites ★ 2023	Chesapeake Bay Program SAV Workgroup and Partners	Identify causal relationships by intensively monitoring ecological processes, drivers of change, and ecosystem responses.
Tier 2 SAV Watchers 2019	Watershed monitoring groups and volunteers	Ground truth aerial survey data, provide broad-scale condition assessments, and identify and quantify driver-response relationships.
Tier 1 Aerial Survey 1984	Virginia Institute of Marine Science	Track progress towards SAV Restoration Goals

Credit: Brooke Landry

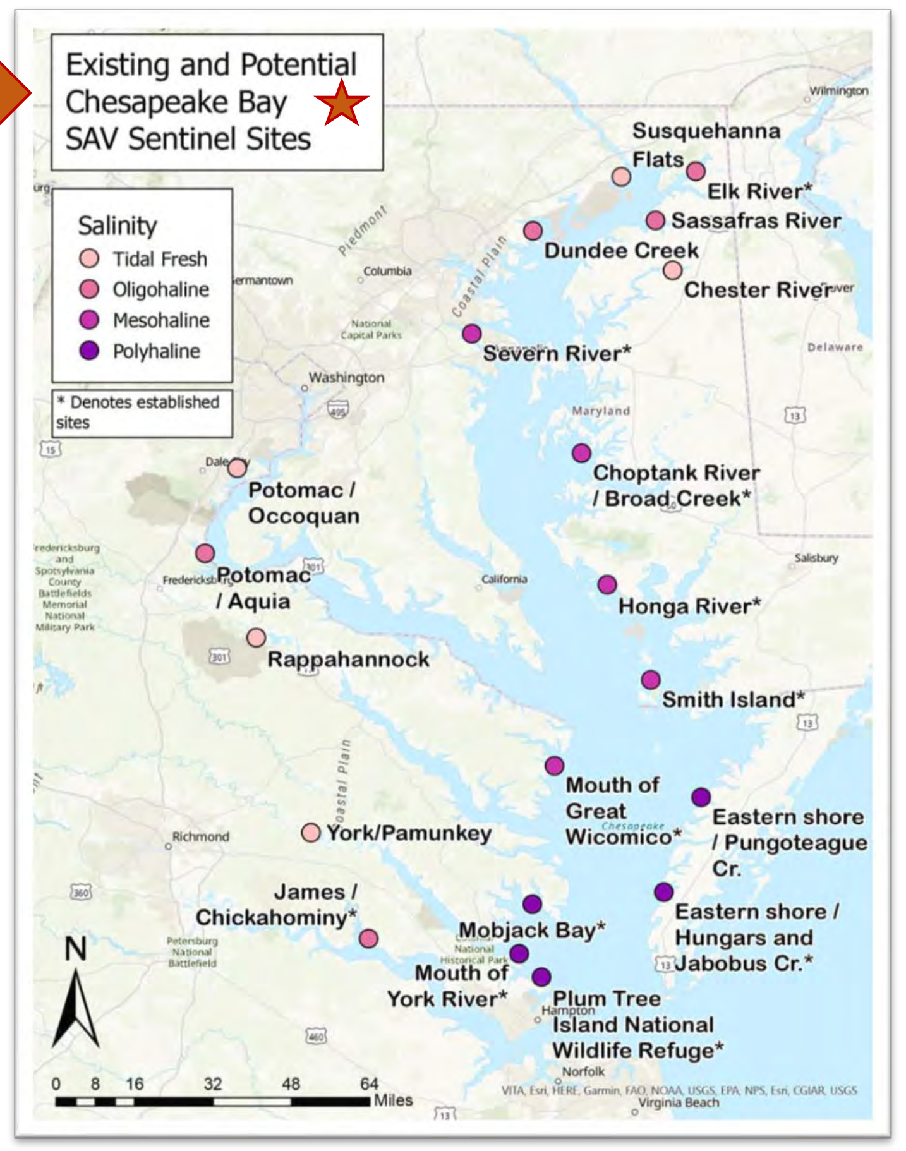


Photo credit: Michael Norman

SAV Biologist Brooke Landry collects SAV plants.

SAV Biologist Becky Golden collects SAV data.

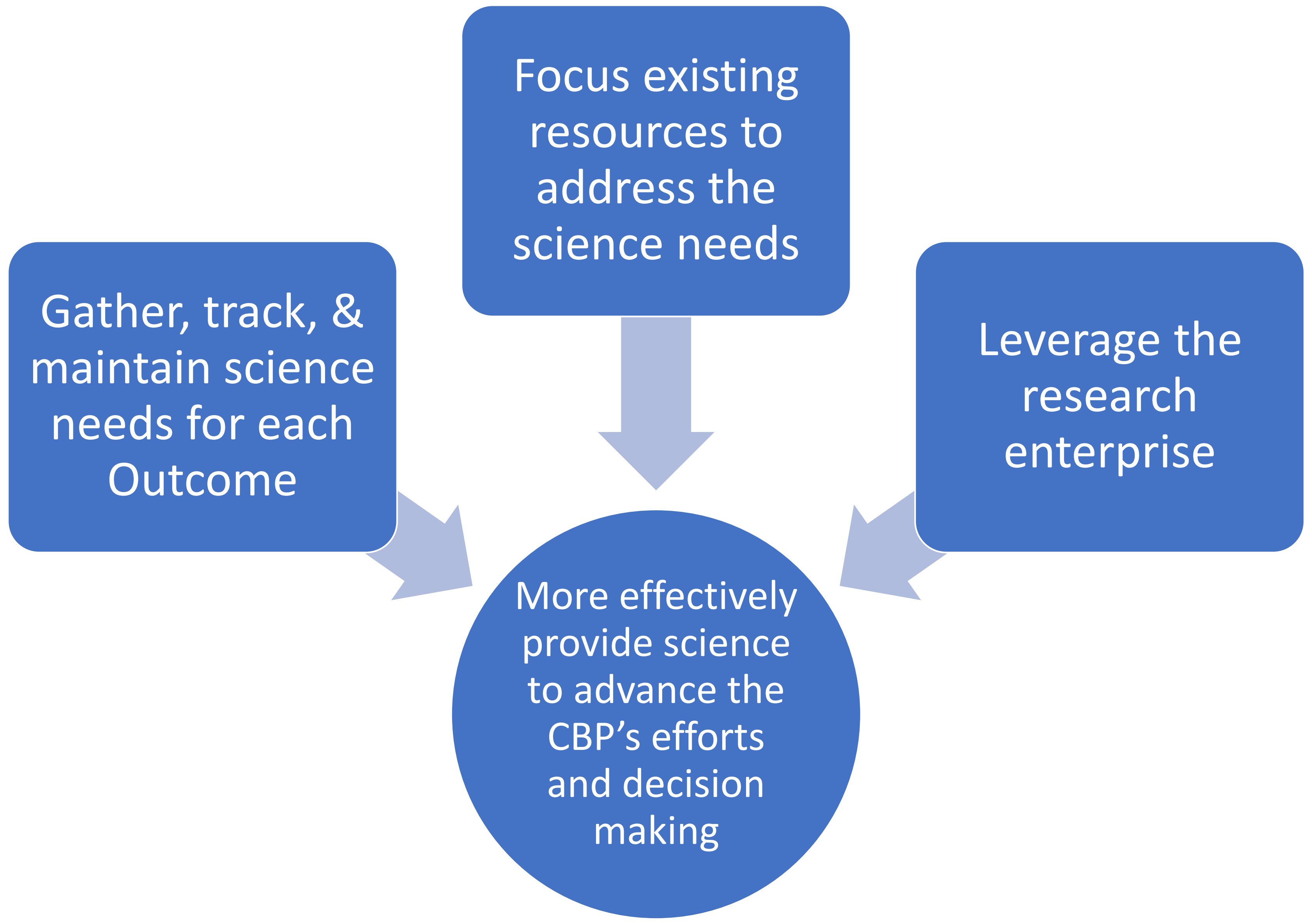
Photo credit: Maryland Department of Natural Resources

More partnership and collaboration to come!

Strategic Science and Research Framework (SSRF): Leveraging Science to Progress Chesapeake Bay Restoration

Alexander Gunnerson (CRC), August Goldfischer (CRC), Breck Sullivan (USGS)

Purpose - The SSRF Provides a Strategic Approach to:



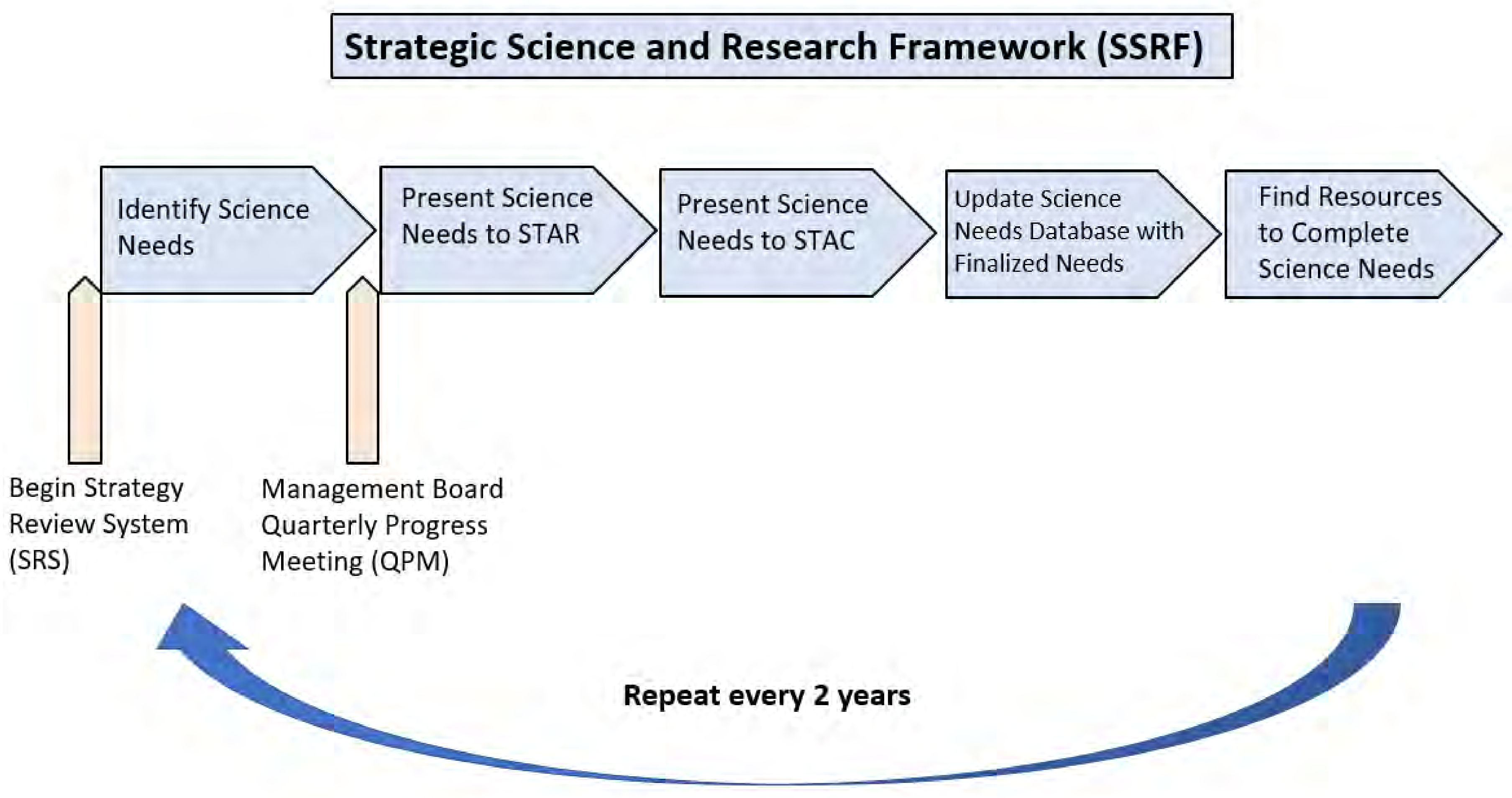
Focus existing resources to address the science needs

Gather, track, & maintain science needs for each Outcome

Leverage the research enterprise

More effectively provide science to advance the CBP's efforts and decision making

STAR Coordinates the SSRF to Support CBP Science



Strategic Science and Research Framework (SSRF)

Identify Science Needs

Present Science Needs to STAR

Present Science Needs to STAC

Update Science Needs Database with Finalized Needs

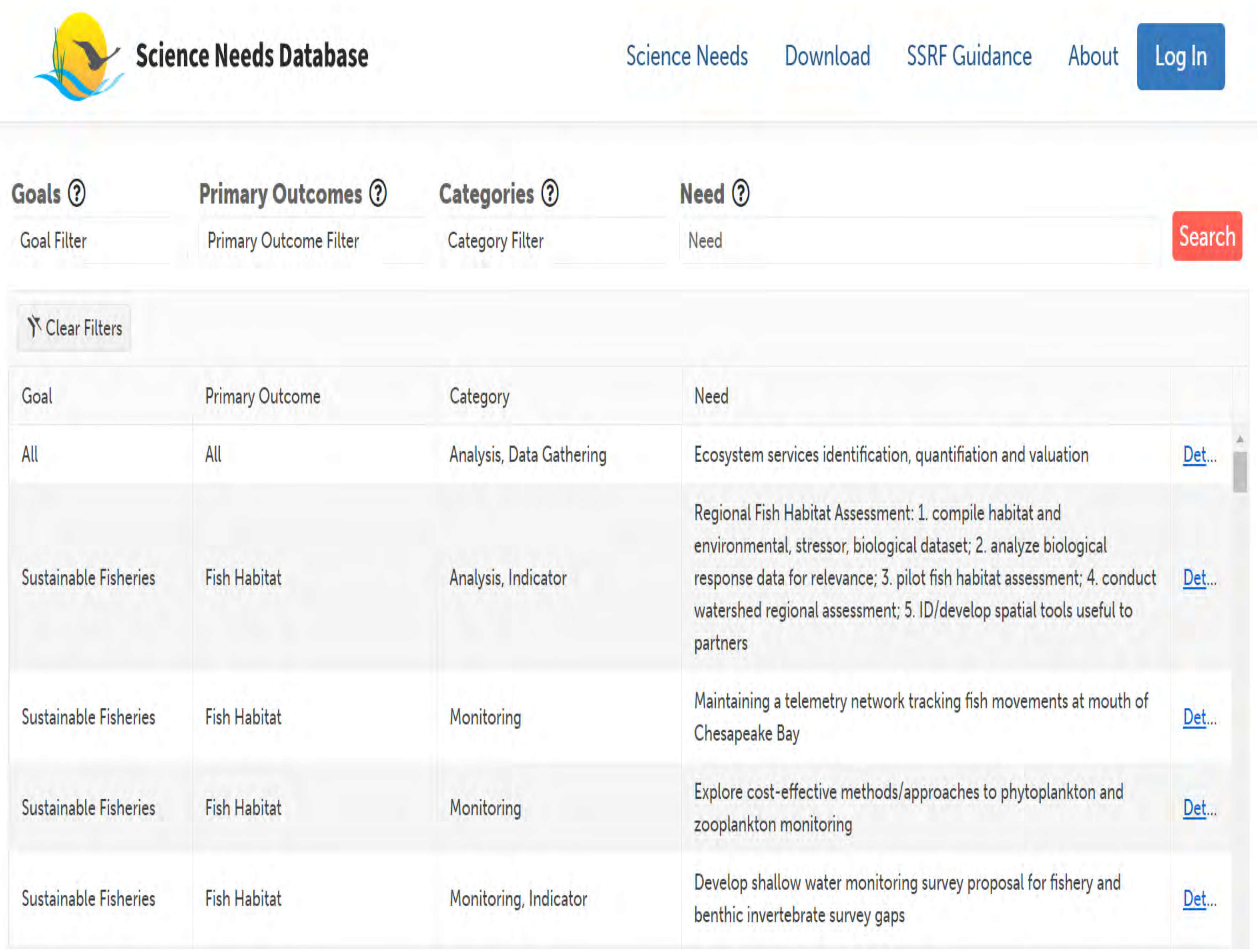
Find Resources to Complete Science Needs

Begin Strategy Review System (SRS)

Management Board Quarterly Progress Meeting (QPM)

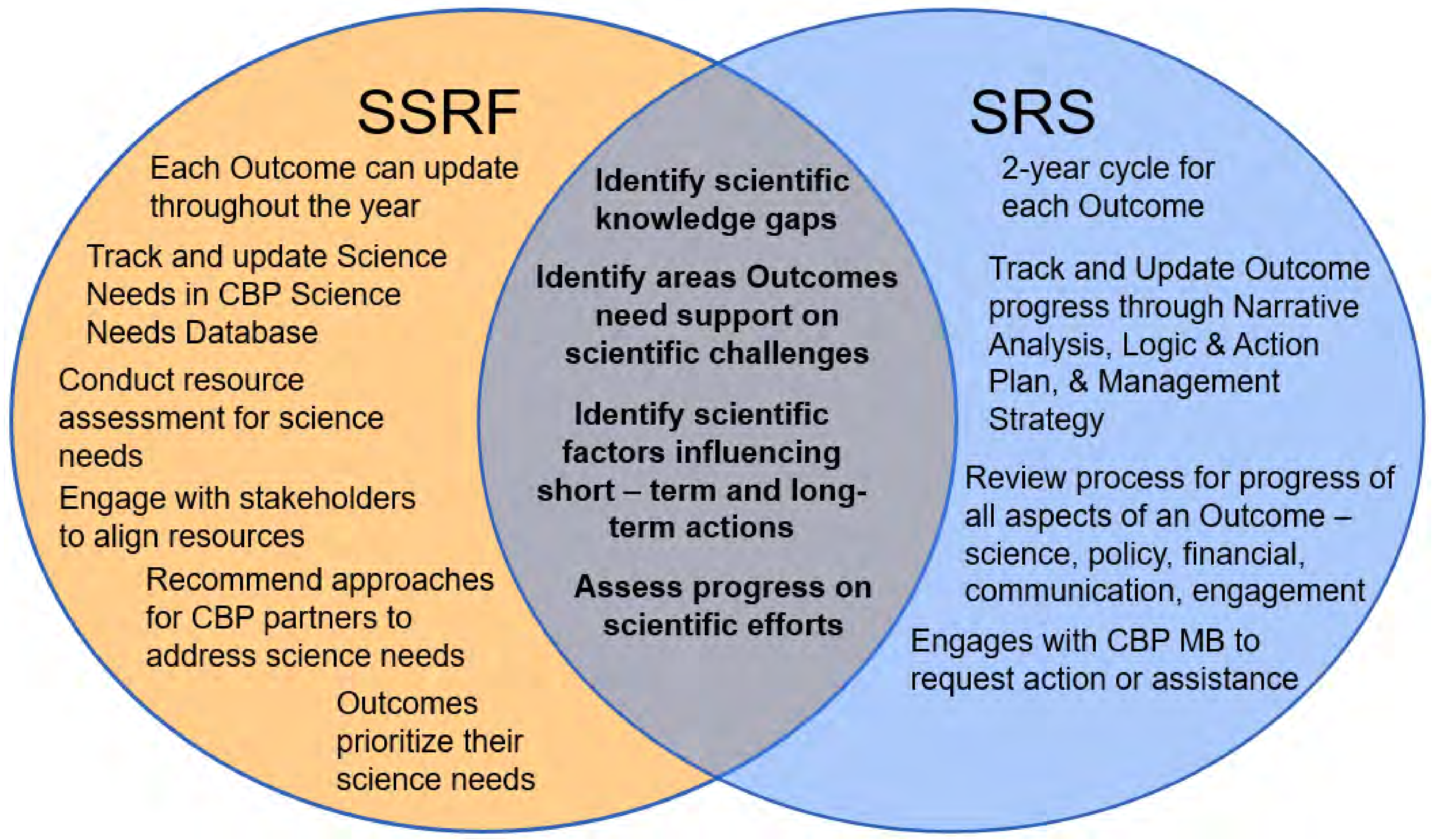
Repeat every 2 years

The Science Needs Database: One Stop Shop for Science Needs



Goal	Primary Outcome	Category	Need	
All	All	Analysis, Data Gathering	Ecosystem services identification, quantifiation and valuation	Det...
Sustainable Fisheries	Fish Habitat	Analysis, Indicator	Regional Fish Habitat Assessment: 1. compile habitat and environmental, stressor, biological dataset; 2. analyze biological response data for relevance; 3. pilot fish habitat assessment; 4. conduct watershed regional assessment; 5. ID/develop spatial tools useful to partners	Det...
Sustainable Fisheries	Fish Habitat	Monitoring	Maintaining a telemetry network tracking fish movements at mouth of Chesapeake Bay	Det...
Sustainable Fisheries	Fish Habitat	Monitoring	Explore cost-effective methods/approaches to phytoplankton and zooplankton monitoring	Det...
Sustainable Fisheries	Fish Habitat	Monitoring, Indicator	Develop shallow water monitoring survey proposal for fishery and benthic invertebrate survey gaps	Det...

The SSRF Complements Adaptive Management



SSRF

Each Outcome can update throughout the year

Track and update Science Needs in CBP Science Needs Database

Conduct resource assessment for science needs

Engage with stakeholders to align resources

Recommend approaches for CBP partners to address science needs

Outcomes prioritize their science needs

Identify scientific knowledge gaps

Identify areas Outcomes need support on scientific challenges

Identify scientific factors influencing short – term and long-term actions

Assess progress on scientific efforts

SRS

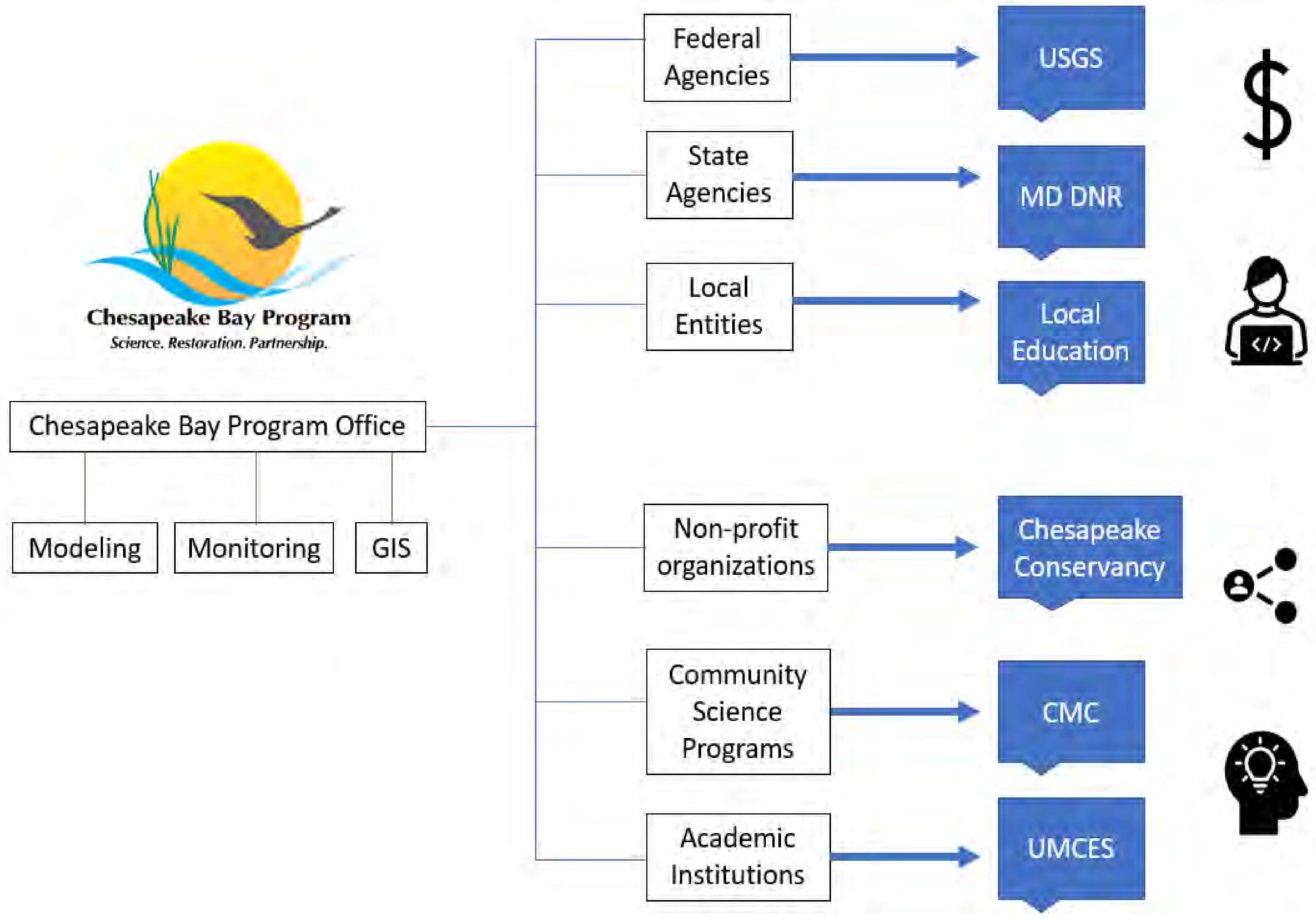
2-year cycle for each Outcome

Track and Update Outcome progress through Narrative Analysis, Logic & Action Plan, & Management Strategy

Review process for progress of all aspects of an Outcome – science, policy, financial, communication, engagement

Engages with CBP MB to request action or assistance

A Partnership Approach to Addressing Science Needs



Chesapeake Bay Program Office

Modeling

Monitoring

GIS

Federal Agencies → USGS

State Agencies → MD DNR

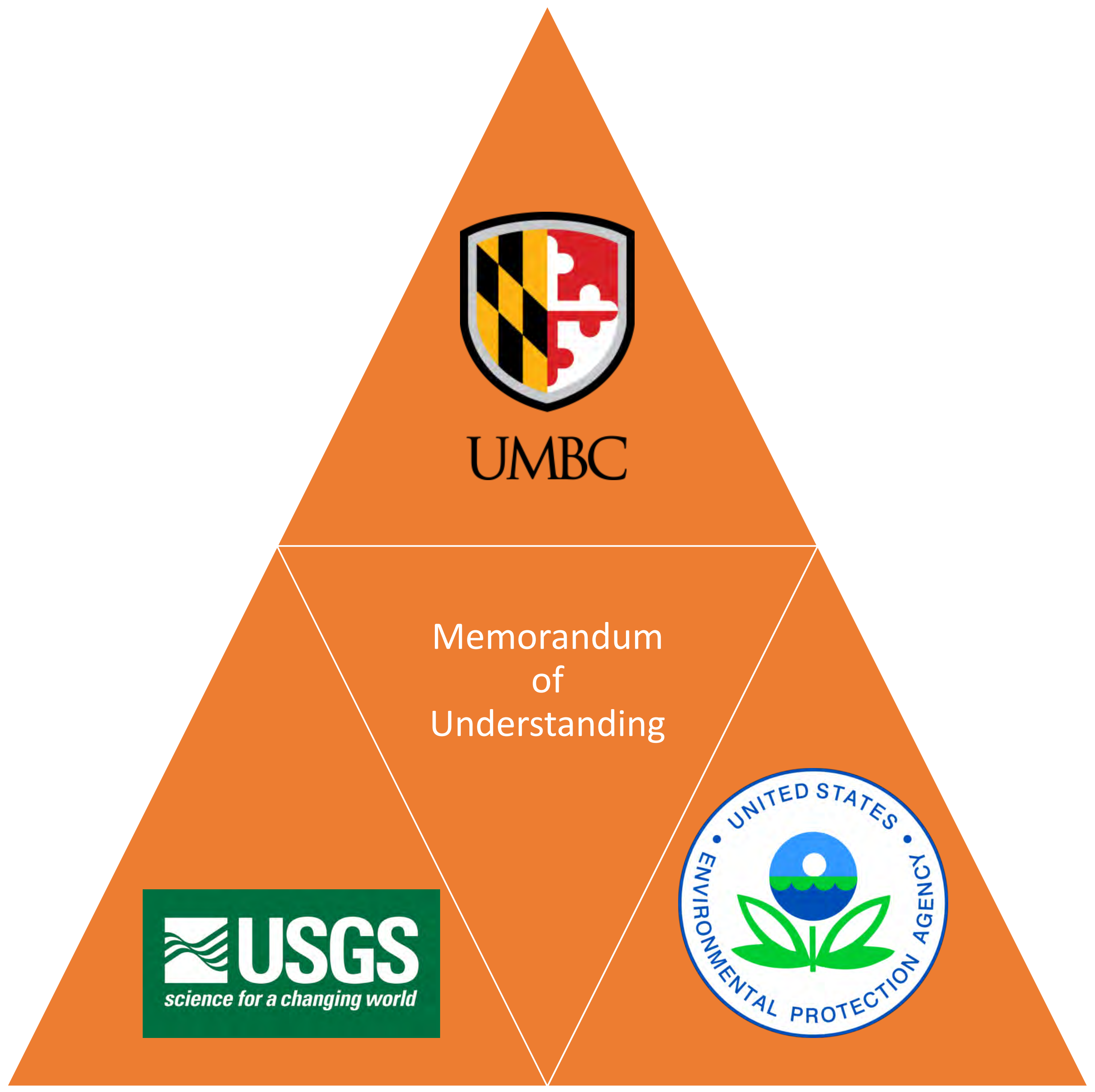
Local Entities → Local Education

Non-profit organizations → Chesapeake Conservancy

Community Science Programs → CMC

Academic Institutions → UMCES

Example of Partner Engagement



Memorandum of Understanding

Chesapeake Bay Program
Science. Restoration. Partnership.

Restoring Wetlands of the Chesapeake Bay Watershed

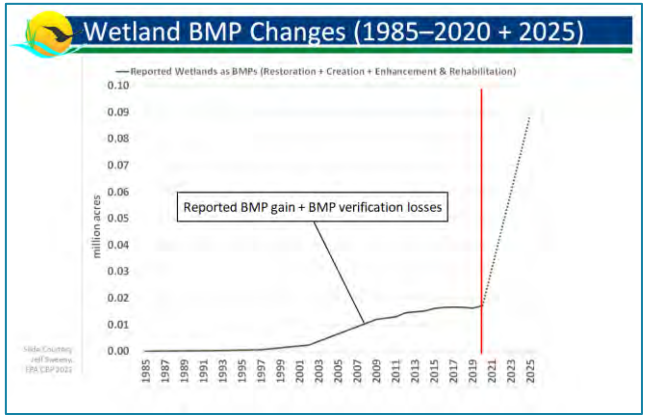
Katlyn Fuentes[1], Dede Lawal[1], and Chris Guy[2]
[1]Chesapeake Research Consortium, [2]U.S. Fish & Wildlife Service

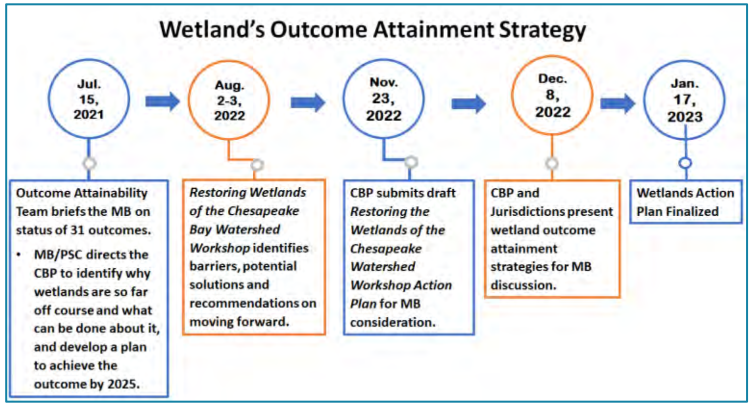
Wetlands Outcome

- 85,000 acres of wetlands created or restored
- 150,000 acres enhanced

OUTLOOK **OFF COURSE**

RECENT PROGRESS **INCREASE**





Wetland's Outcome Attainment Strategy

Jul. 15, 2021
Outcome Attainability Team briefs the MB on status of 31 outcomes.
- **MB/PSC directs the CBP to identify why wetlands are so far off course and what can be done about it, and develop a plan to achieve the outcome by 2025.**

Aug. 2-3, 2022
***Restoring Wetlands of the Chesapeake Bay Watershed Workshop* identifies barriers, potential solutions and recommendations on moving forward.**

Nov. 23, 2022
CBP submits draft *Restoring the Wetlands of the Chesapeake Watershed Workshop Action Plan* for MB consideration.

Dec. 8, 2022
CBP and Jurisdictions present wetland outcome attainment strategies for MB discussion.

Jan. 17, 2023
Wetlands Action Plan Finalized

Wetlands Workshop Process:

- PURPOSE: "Bring together key people to identify actions to overcome the barriers of implementing nontidal and tidal wetland restoration and accelerate progress towards the Wetlands Outcome identified in the 2014 Chesapeake Bay Watershed Agreement."
- OUTCOMES:
    1. Understanding of Barriers
    2. Identification of Approaches
    3. Development of an Action Plan
- STATS:
    - ❖ 167 attendees over two days
    - ❖ 400+ participants throughout the workshop planning & execution process
    - ❖ Representatives from each Bay State in attendance
    - ❖ 14 jurisdictional-specific office hours in October and November 2022

Workshop Recommendations

Cohesive Strategy	Cohesive strategy for tidal and nontidal wetlands across the watershed for site selection and priorities that take into consideration 10 goals and 31 outcomes associated with the Chesapeake Bay 2014 Agreement.
Long-term Capacity	Dedicated increased long-term capacity is needed to accelerate efforts –because of the time and complexity to complete wetland restoration projects, grant funded capacity does not retain and grow expertise.
Outreach and Design	Outreach and design are priority areas to grow capacity to increase the pipeline of projects and advance them to implementation.
Increased Funding	New and increased funding should be directed to the states to build wetland capacity. This is critical to be able to access and leverage increased federal funds that will be available.
Reporting of Progress	MB representatives meet formally with all the agencies within their jurisdictions report out progress of the wetland outcome attainment annually. Bay Program reports to PSC annually.

Action Plan: Partnership Action Plans

- JURISDICTIONS:
    - District of Columbia,
    - Delaware
    - Maryland
    - New York
    - Pennsylvania
    - Virginia
- FEDERAL : NOAA, NRCS, USACE, USEPA, USFWS
- NGOs: The Nature Conservancy


American Black Duck
(*Anas rubripes*)

Scan to view the following resources:

Habitat GIT | Wetland Workgroup | Workshop Materials | Wetlands Action Plan

Chesapeake Assessment Scenario Tool

Olivia Devereux & Helen Golimowski, Devereux Consulting, Inc.

Partnership Planning with CAST

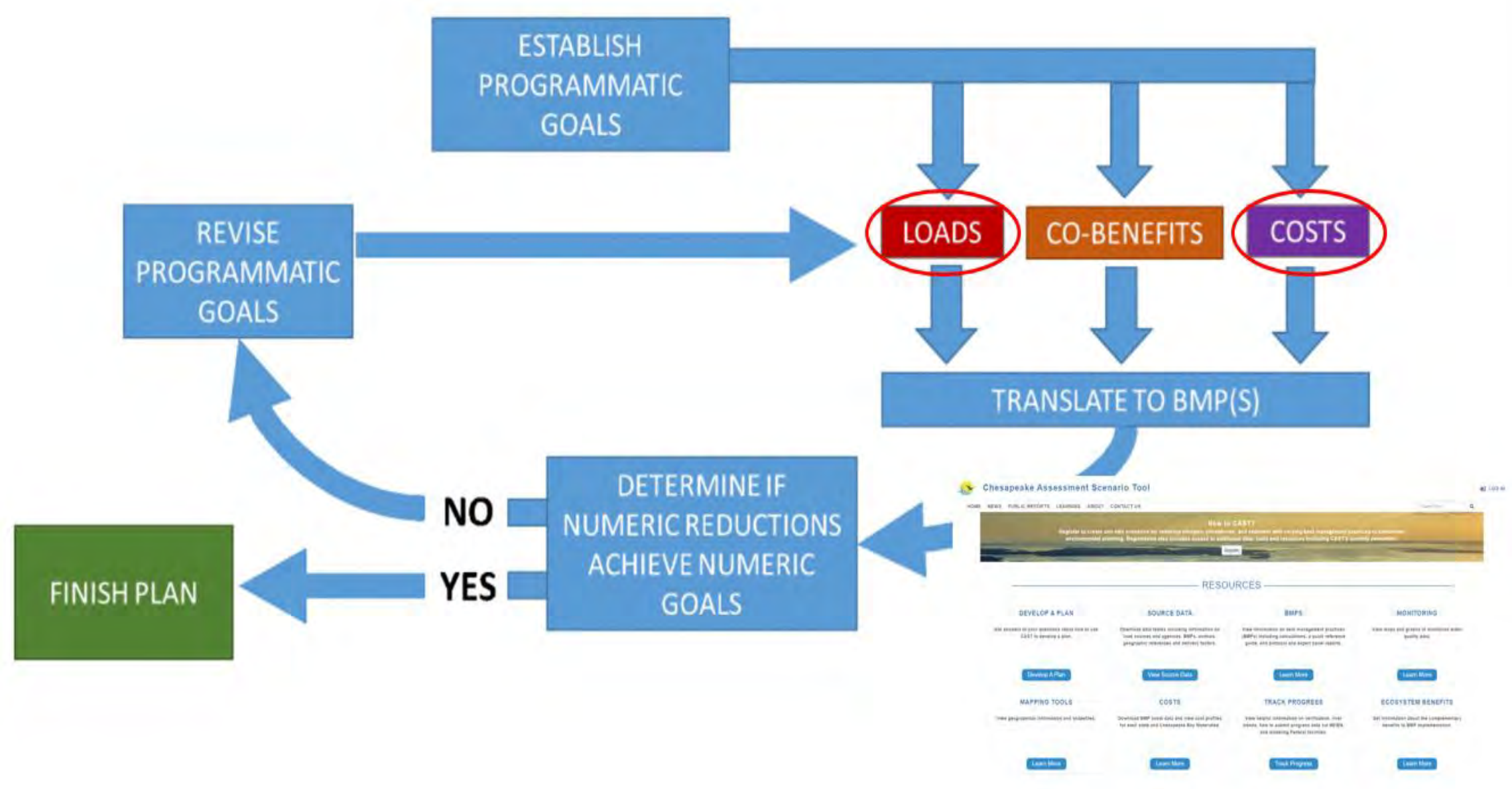
Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning. Users specify a geographical area and apply Best Management Practices (BMPs) on that area. CAST builds the scenario and estimates nitrogen, phosphorus, and sediment load reductions. CAST also estimates the cost of a scenario so that users may select the most cost-effective practices to reduce pollutant loads.

The following diagram summarizes a sequence of steps for developing a water quality improvement plan.

1. Establish programmatic goals that include quantifiable loads for nitrogen, phosphorus and sediment; ecosystem benefits from implementing BMPs; and the costs of implementation.
2. Translate a combination of programmatic goals into specific BMPs, and then use those BMPs in a CAST scenario to estimate nitrogen, phosphorus and sediment loads.
3. Determine if the loads are achieving the programmatic goals. If not, revise programmatic goals, perhaps changing ecosystem benefits and/or costs, and then revising the scenario to estimate loads again.
4. Once the estimated loads meet programmatic goals, finish the plan and send it to the next level of the planning process.

https://cast.chesapeakebay.net/Documentation/DevelopPlans

Steps to Developing a Plan and Assessing Progress Using CAST



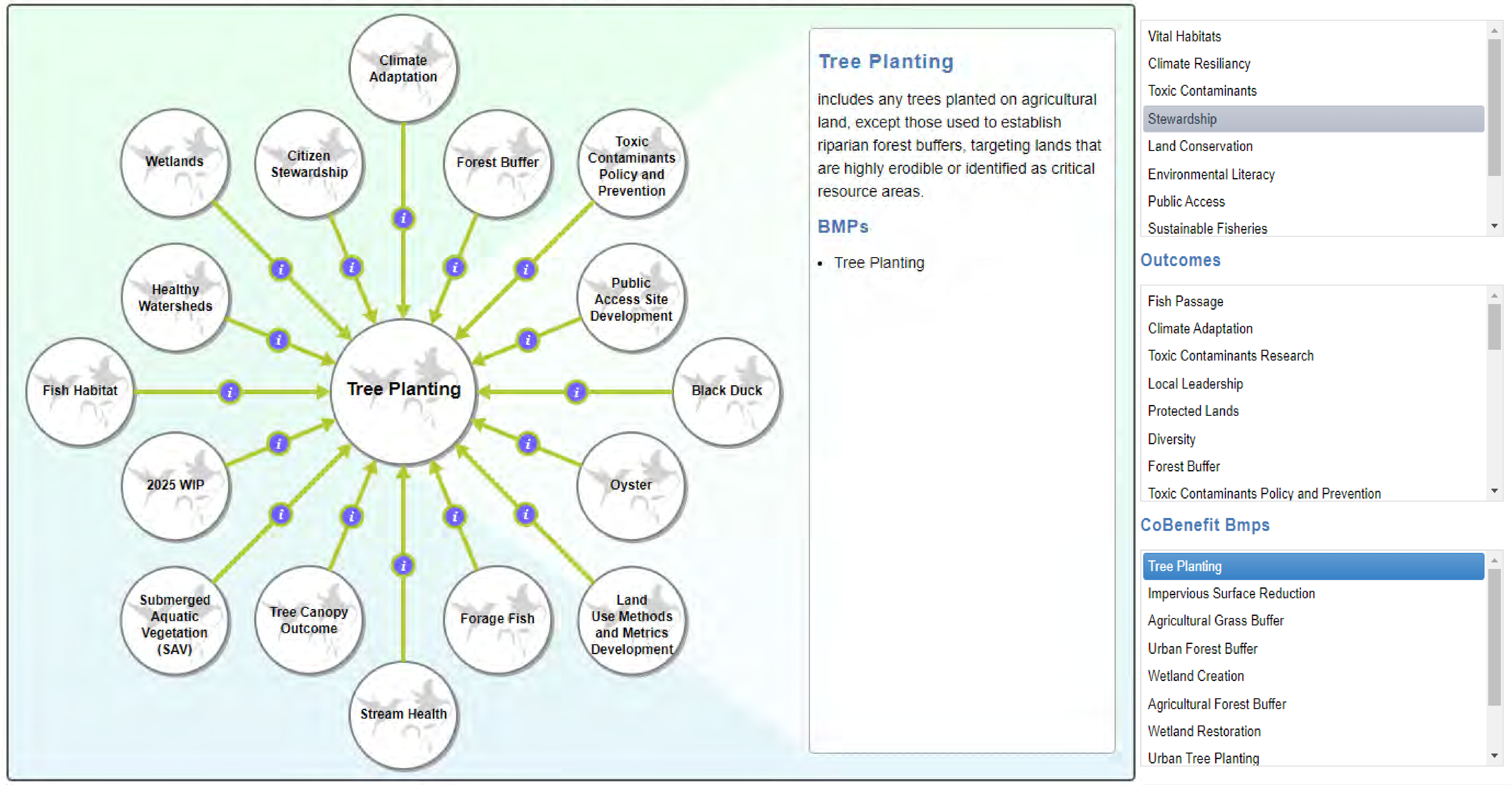
1. **Science:** Data on watershed land uses, loads, and BMPs to be used for targeting and planning purposes.
2. **Restoration:** Information on BMP ecosystem benefits available, including which BMPs support Chesapeake Bay Goals and Outcomes.
3. **Partnership:** Assists the Chesapeake Bay partners with assessing the achievements of their commitments and goals under the 2014 Chesapeake Bay Watershed Agreement and TMDL.

Restoration: Ecosystem Benefits

In addition to nitrogen, phosphorus and sediment goals, there may be additional, complementary objectives to BMP implementation called ecosystem benefits (often referred to as co-benefits). Examples of ecosystem benefits include: improve stream health, increase fish habitat, and reduce toxic contaminants. Identifying these additional objectives early in the planning process allows for selection of BMPs that meet the load reduction goals as well as achieve these complementary objectives.

Ecosystem Benefits Browser

Click on the topic bubbles to explore. Click on the linkages (*i*) to view the relationship between elements.



Tree Planting

includes any trees planted on agricultural land, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.

BMPs

- Tree Planting

Goals

- Vital Habitats
- Climate Resiliancy
- Toxic Contaminants
- Stewardship
- Land Conservation
- Environmental Literacy
- Public Access
- Sustainable Fisheries

Outcomes

- Fish Passage
- Climate Adaptation
- Toxic Contaminants Research
- Local Leadership
- Protected Lands
- Diversity
- Forest Buffer
- Toxic Contaminants Policy and Prevention

CoBenefit Bmps

- Tree Planting
- Impervious Surface Reduction
- Agricultural Grass Buffer
- Urban Forest Buffer
- Wetland Creation
- Agricultural Forest Buffer
- Wetland Restoration
- Urban Tree Planting

The Chesapeake Bay Program developed the Ecosystem Benefits Browser, in interactive tool that visualizes and summarizes the Goals, Outcomes, and Ecosystem Benefits associated with CAST BMPs. When using the browser online, click on the topic bubbles to explore the relationships between the Chesapeake Bay Program Goals and Outcomes, and CAST BMPs. Alternatively, select a Goal, Outcome, or BMP from the lists to update the browser chart and learn more.

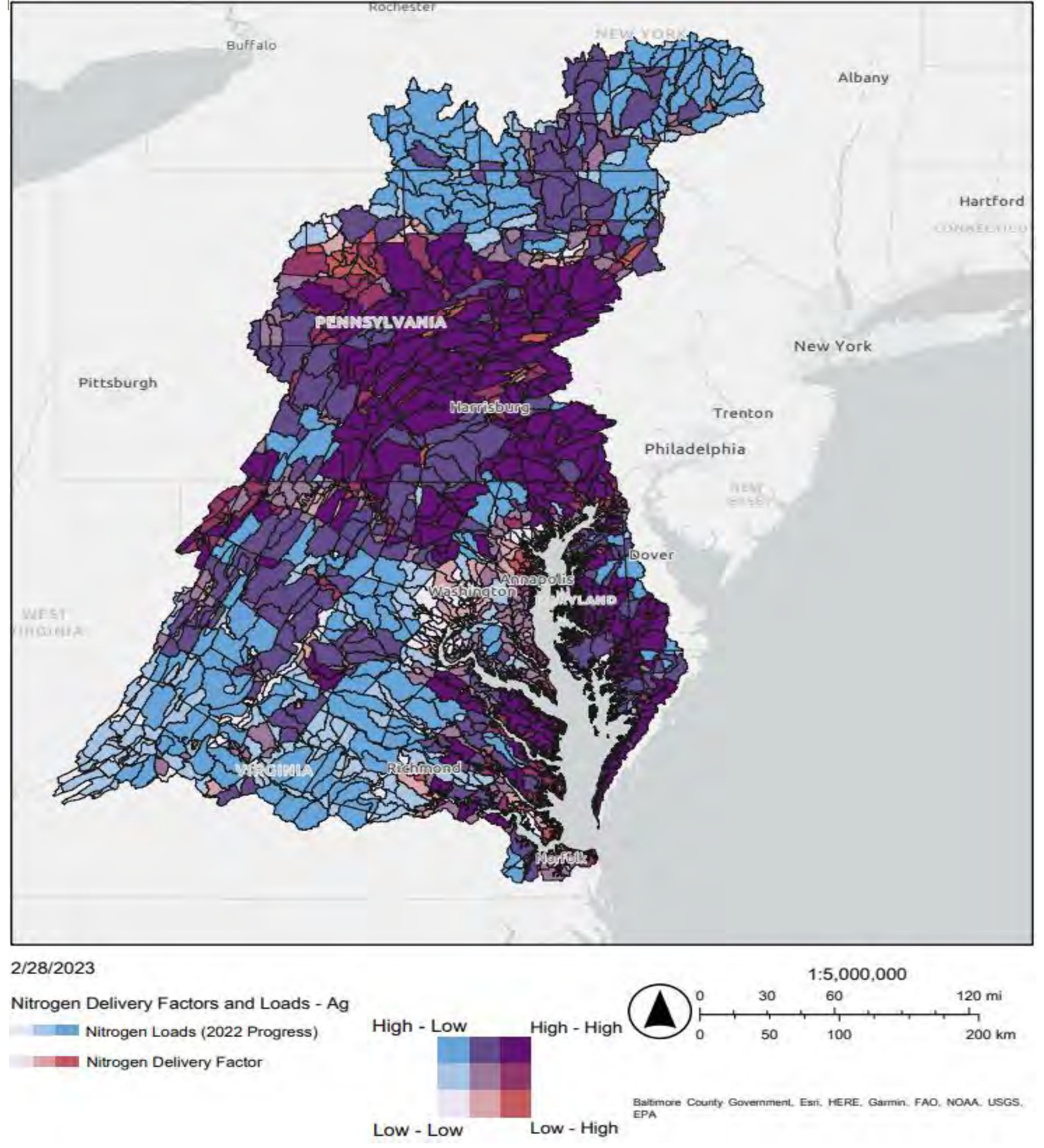
https://cast.chesapeakebay.net/ecohealth/index

Science: BMP Targeting Maps

Devereux Consulting used data in CAST to produce BMP targeting maps. By using delivery factors and 2022 annual progress loads, these maps communicate which land-river segments in the watershed would be most effective for BMP targeting. Delivery factors represent the fate and transport of nutrients and sediment from the land to the water. The higher the delivery factor, the higher the amount of nutrients and sediment are likely to run off from that area. There are six bivariate targeting maps posted on the CAST site, one for each nutrient and sector. The legend on each map has a box with 9 colors representing the variation of loads and delivery factors in each land-river segment from low to high. The lightest, bottom-left square in the legend correlates to the land-river segments on the map that have the lowest loads and delivery factors. The square in the top-right of the legend with the darkest coloring corresponds to the areas that have the highest loads, and the highest delivery factors. These are the areas that would be most effective for BMP targeting.

https://cast.chesapeakebay.net/Documentation/MapToolSpatialData

CBWS Ag BMP Targeting: Nitrogen



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cast.chesapeakebay.net

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The Chessie BIBI: An Index Twenty Years in the Making Now Supports CBP Stream Health Outcome Assessments

FAQs:

What is the Chessie BIBI?

It is the **Chesapeake Basin-wide Index of Biotic Integrity,** a multi-metric index of stream biological health applicable anywhere in the Chesapeake watershed.

What Data are Used?

Macroinvertebrate samples routinely collected in streams and small rivers by federal, state, local and citizen monitoring programs and **voluntarily shared** with the Chesapeake Bay Program.

Are the Data Available?

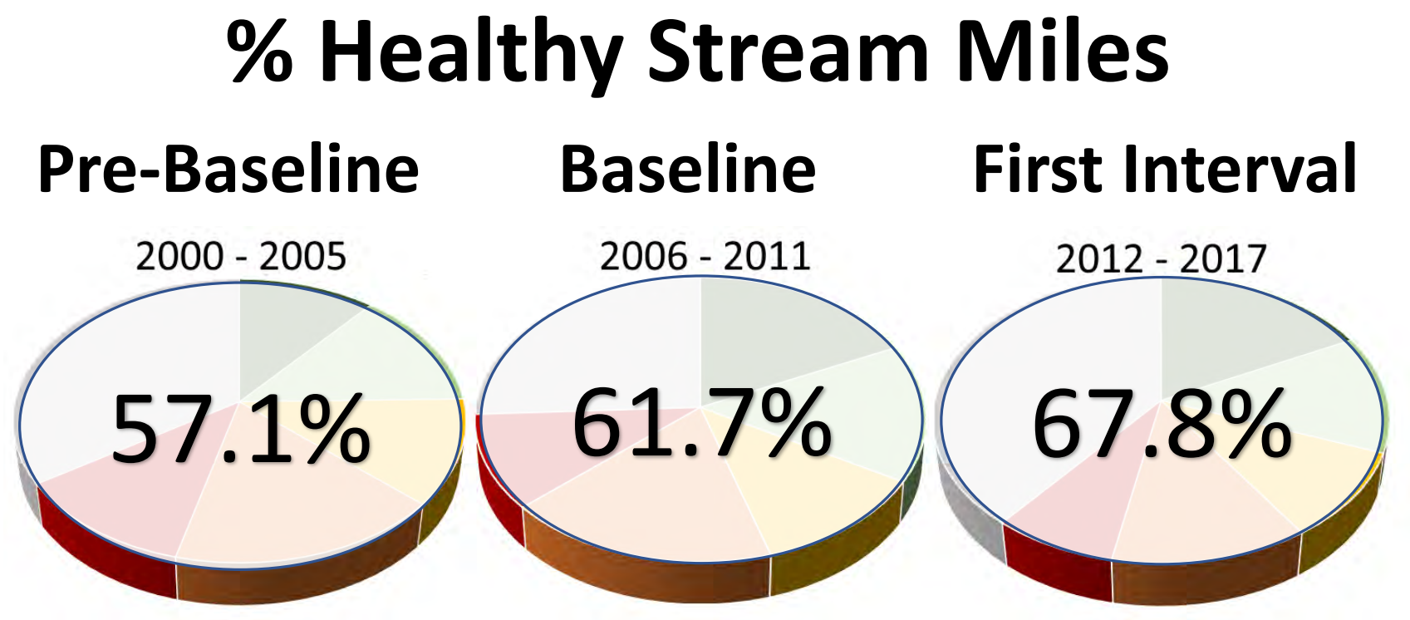
Yes, the raw data, calculated metrics, and R-programs used to calculate the index can be obtained from the Chesapeake Environmental Data Repository at www.chesapeakebay.net

How Often Will the Index Be Updated?

About every six (6) years, to account for state rotational sampling schedules.

Any Progress?

The Chesapeake watershed is on track to meet the stream health outcomes in both the **Executive Order** (70% healthy streams) and **2014 Agreement** (10% improvement above Baseline).

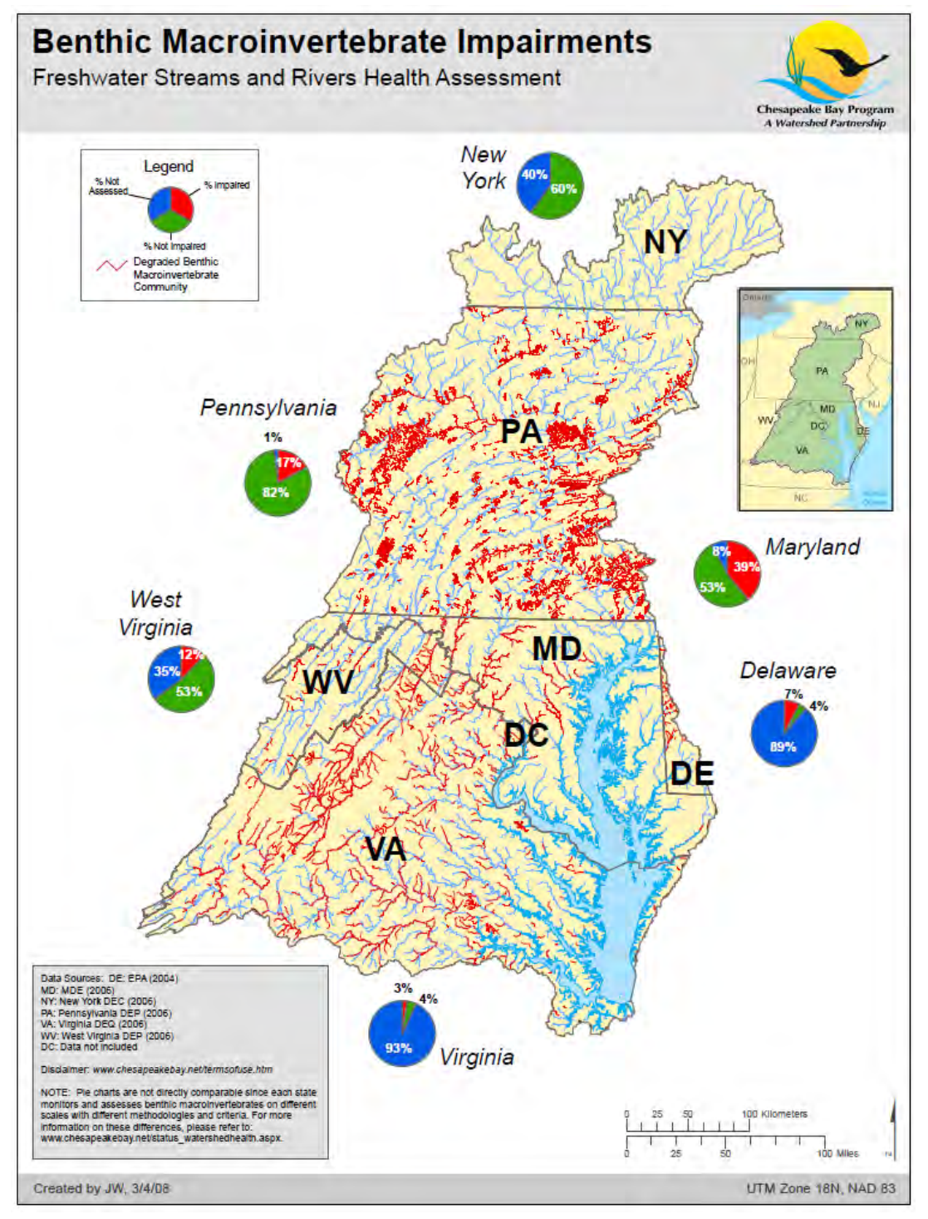

% Healthy Stream Miles

However, identifying which environmental factors are responsible for the net improvement would be speculative at this point … long-term efforts to conserve forests, preserve and restore riparian corridors and wetlands, mitigate acid rain and mine drainage, slow stormwater runoff and reduce nutrient and sediment loads have all likely contributed, and these efforts need to continue.

Chesapeake Bay Program

Gaps

Need for a Watershed-Wide Stream Health Indicator is Recognized



"State Assessments Are Not Comparable"

CBP Non-Tidal Workgroup

Outcomes

Chesapeake Bay Executive Order 13508

Improve the health of streams so that 70 percent of sampled streams throughout the Chesapeake watershed are in fair, good or excellent condition as measured by the Index of Biotic Integrity by 2025

2014 Chesapeake Agreement Signed

Improve health and function of ten percent of stream miles above the 2008 baseline for the Chesapeake Bay watershed

Chessie BIBI Selected as CBP Stream Biological Health Indicator

CBP Stream Health Mgmt Strategy Team

2006 – 2011 Selected as "2008 Baseline"

[8, 9]

Cacapon WV 2018 Workshop

Models

Landscape Features Are Used to Predict Chessie BIBI & Model its Responses to Climate Change, Development, and Flow Alteration

[10, 11, 12, 13]

USGS Eastern Ecological Science Center

Progress Report Submitted to CBP

[14]

Development

Potomac Benthic Index of Biotic Integrity is Created

[1, 2]

Proof of Concept for Chesapeake Completed

ICPRB Pilot Project

Data Call

& ICPRB Database Built

Chessie BIBI 1.0

[3]

Index Sensitivity to Nutrients, Land Use & Flow Alteration Demonstrated

[4, 5, 6]

Updates

Data Call

& ICPRB Database Updated

Chessie BIBI 2.0 "Refinement"

[7]

Data Call

Data Updated, Analysis Tools Developed, Conversion to Chesapeake Environmental Data Repository

Chessie BIBI 3.0

[chesapeakebay.net/what/data]

Assessments

Chessie BIBI Selected as an Indicator for Potomac Water Resources Comprehensive Plan

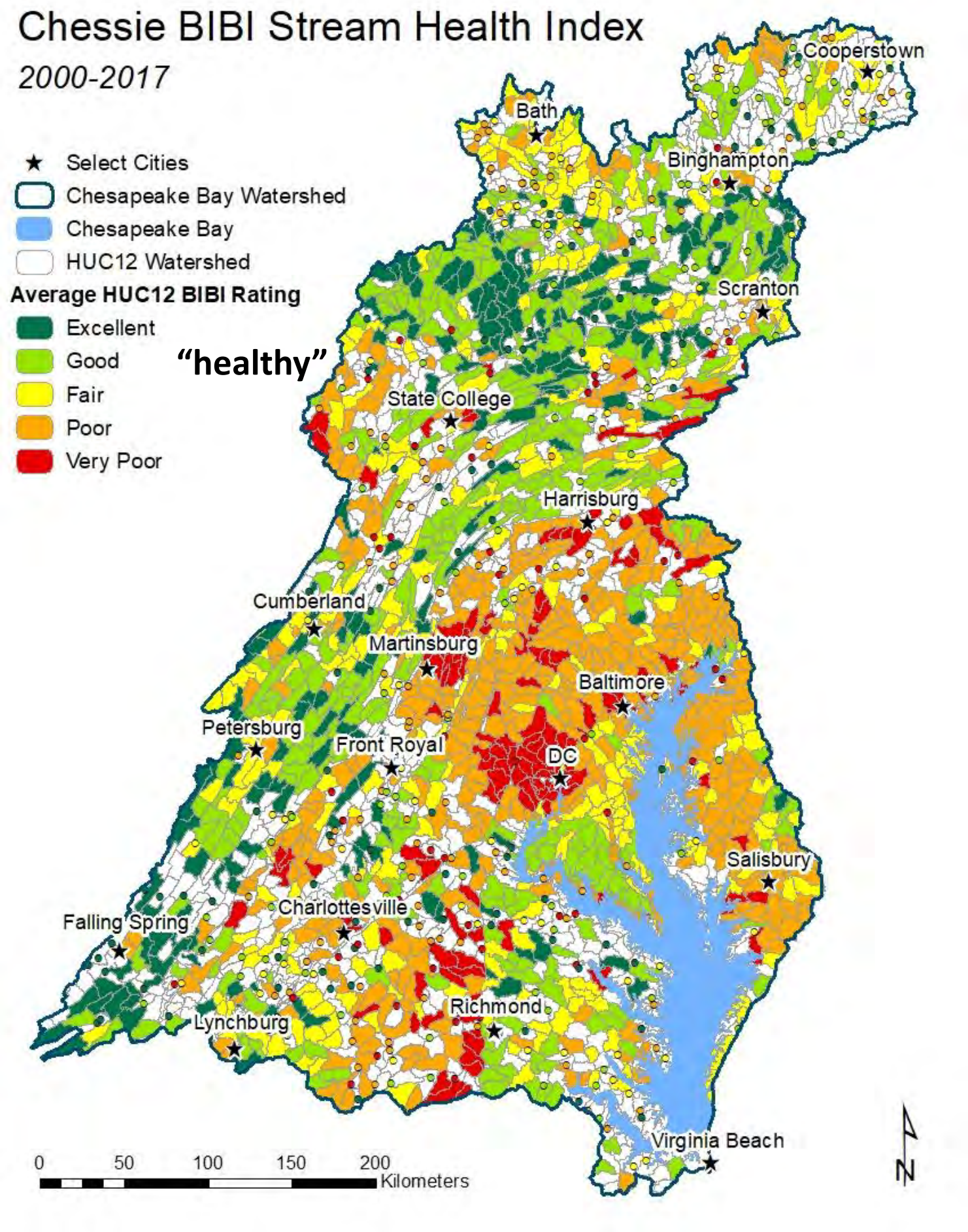
[15]

ICPRB Advisory Committee

Data Call

& Update CEDR Database

Progress Report to CBP



Interstate Commission on the Potomac River Basin

Credits:

Chessie BIBI Development Team, Past & Present

Claire Buchanan (ICPRB)
Rikke Jepsen (ICPRB)
Michael Mallonee (ICPRB/CBPO)
Andrea Nagel (ICPRB)
Zachary Smith (formerly ICPRB)
Adam Griggs (formerly ICPRB)
Jacqueline Johnson (formerly ICPRB/CBPO)
Katherine Foreman (formerly UMCES/CBPO)

Stream Monitoring Programs that Answered the Data Call

Anne Arundel Co
Baltimore City
Baltimore Co
DC DOEE
Delaware NREC
Fairfax Co
Frederick Co
Howard Co
Loudoun Co
Maryland DNR
Montgomery Co
National Park Service
New York DEC
Pennsylvania DEP
Prince Georges Co
SRBC
USEPA
USFS
USGS NAWQA
Virginia DEQ
West Virginia DEP
Maryland SOS

Federal, State, County and Academic Representatives

who guided development of the Chessie BIBI index through their participation in our **Technical Advisory Groups** and **"2008 Baseline" Workshop**

Consultation and Collaboration

of key individuals who gave freely of their time and insights, including Kelly O. Maloney & John Young & Kevin Krause & Rich Walker (USGS, Leetown); Greg Pond (EPA3); Neely Law (formerly CWP and now Fairfax Co)

Chesapeake Bay Program

support was crucial in helping ICPRB expand the scope of the index from the Potomac to the Chesapeake. We thank

Peter Tango (USGS/CBPO)
Scott Phillips (USGS)
Jennifer Greiner (FWS)
and the members of the
Non-Tidal Workgroup,
Stream Health Mgmt. Strategy Team,
Stream Health Workgroup, and
CBPO Data Center Team

Citations

ICPRB Reports at potomacriver.org/publications/

1. doi.org/10.1016/j.ecolind.2005.08.030
2. doi.org/10.1016/j.ecolind.2006.09.004
3. ICPRB report 11-1
4. ICPRB Report 11-2
5. MPRWA_FINAL_April_2013.pdf
6. doi.org/10.1111/fwb.12240
7. ICPRB Report 17-5
8. ICPRB Report 18-6
9. ICPRB Report 19-7
10. doi.org/10.1086/700701
11. doi.org/10.1111/gcb.14961
12. doi.org/10.1007/s00267-021-01450-5
13. doi.org/10.1016/j.jenvman.2022.116068
14. ICPRB Report 23-1
15. ICPRB Report 18-1

More information:

http://bit.ly/Chessie_BIBI

Poster prepared April 2023 by Claire Buchanan with Renee Bourassa and Rikke Jepsen

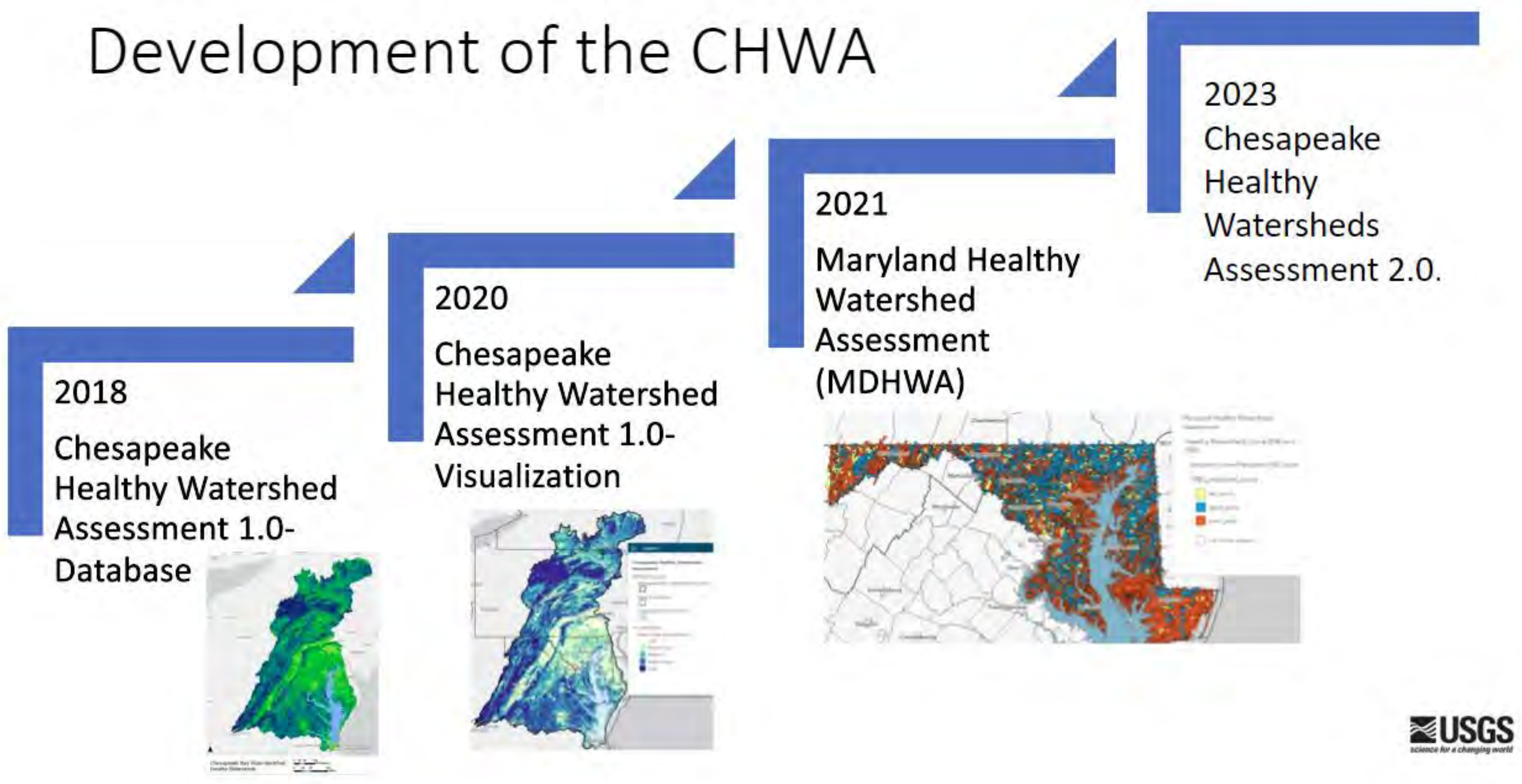
Development and Applications of the Chesapeake Healthy Watersheds Assessment

Goal: Sustain state-identified healthy waters and watersheds recognized for their high quality and/or high ecological value

Outcome: 100 percent of state-identified healthy waters and watersheds remain healthy.

Healthy Watersheds Goal

Development of the CHWA



2018
Chesapeake Healthy Watershed Assessment 1.0-Database

2020
Chesapeake Healthy Watershed Assessment 1.0-Visualization

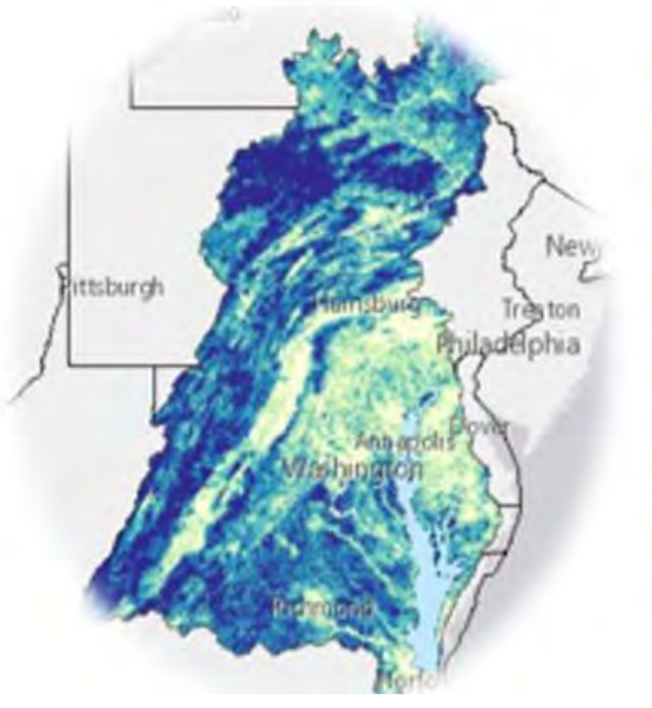
2021
Maryland Healthy Watershed Assessment (MDHWA)

2023
Chesapeake Healthy Watersheds Assessment 2.0.

Chesapeake Bay Program
Science. Restoration. Partnership.

How healthy is your watershed?

https://gis.chesapeakebay.net/healthywatersheds/assessment/



Chesapeake Healthy Watersheds Assessment, an online, geospatial tool that summarizes the different landscape and water conditions in catchments across the entire watershed.

It was designed to help support and inform land use decisions that prioritize infrastructure resiliency, public health, and education while also protecting the environment in your community.

Modeled after EPA's Preliminary Healthy Watersheds Assessment, the health metrics include data related to landscape, hydrology, geomorphology, habitat, biological condition, and water quality that can be summarized into an overall watershed health index.

Download data for your own use

Bookmark locations for easy navigation

Create a **Watershed Health Report** with a summary of all metrics

Filter data by your region or interest

Add your own **data** to the viewer

The complementary vulnerability metrics incorporate potential stressors related to land use change, water use, climate and wildfire risk.

Management Applications for the CHWA

Examining/quantifying stressors affecting stream health (not just in healthy watersheds)

Assessing landscape factors affecting fish habitat in non-tidal and tidal watersheds

Identifying areas of Brook Trout populations susceptible to climate shifts

Coordination with Chesapeake Bay Program's fish habitat assessment

Engagement with local governments to inform land use decisions

Supporting land trusts and other organizations managing protected lands

Source water protection (drinking water)

Photos: Will Parson/Chesapeake Bay Program

Fish Habitat Outcome

Continually improve the effectiveness of fish habitat conservation and restoration efforts by identifying and characterizing critical spawning, nursery, and forage areas within the Bay and tributaries for important fish and shellfish, and use existing and new tools to integrate information and conduct assessments to inform restoration and conservation efforts.

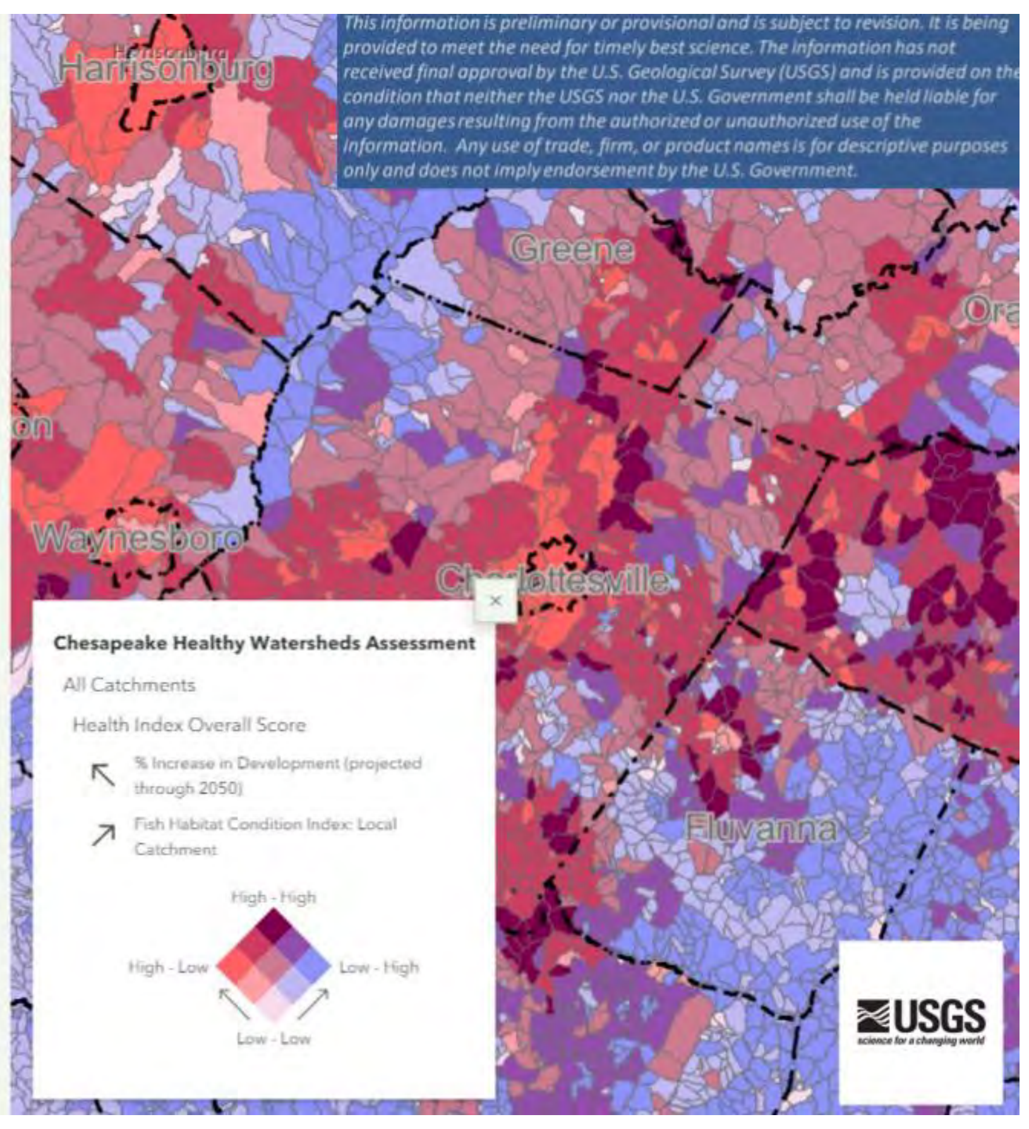
Management Question

Where are important fish habitats threatened by future development?

If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Fish Habitat Condition Index
- Percent Increase in Development (projected through 2050)



Brook Trout Outcome

Restore and sustain naturally reproducing brook trout populations in Chesapeake Bay headwater streams, with an eight percent increase in occupied habitat by 2025.

Management Question

Where is brook trout occupancy threatened by watershed imperviousness?

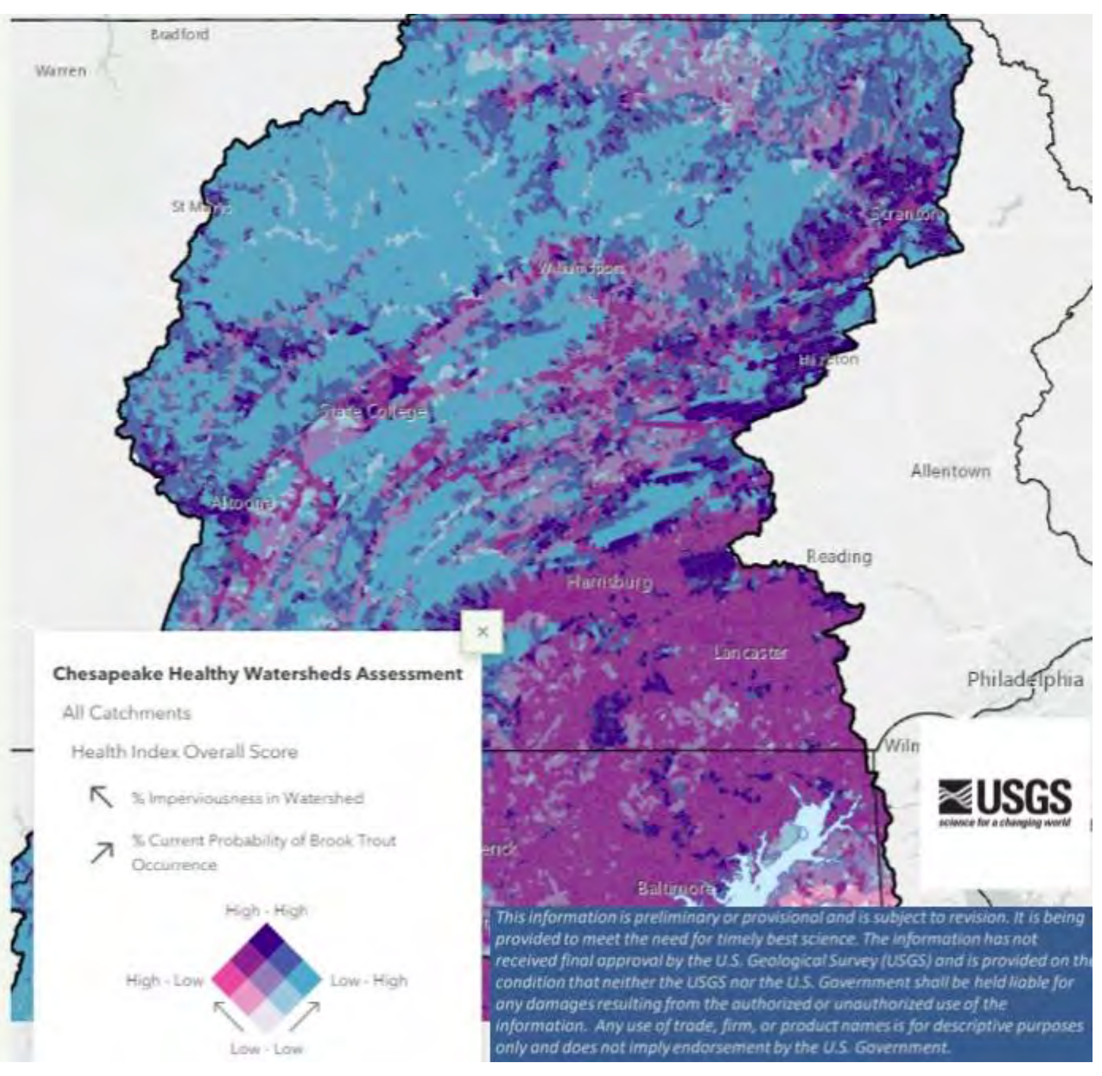
If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Probability of Brook Trout Occurrence
- Percent Imperviousness

Goal Teams and Workgroups

- Brook Trout Action Team
- Land Use Workgroup
- Maintain Healthy Watersheds GIT



Protected Lands Outcome

By 2025, protect an additional two million acres of lands throughout the watershed–currently identified as high-conservation priorities at the federal, state or local level–including 225,000 acres of wetlands and 695,000 acres of forest land of highest value for maintaining water quality.

Management Question

Are we protecting our healthiest watersheds?

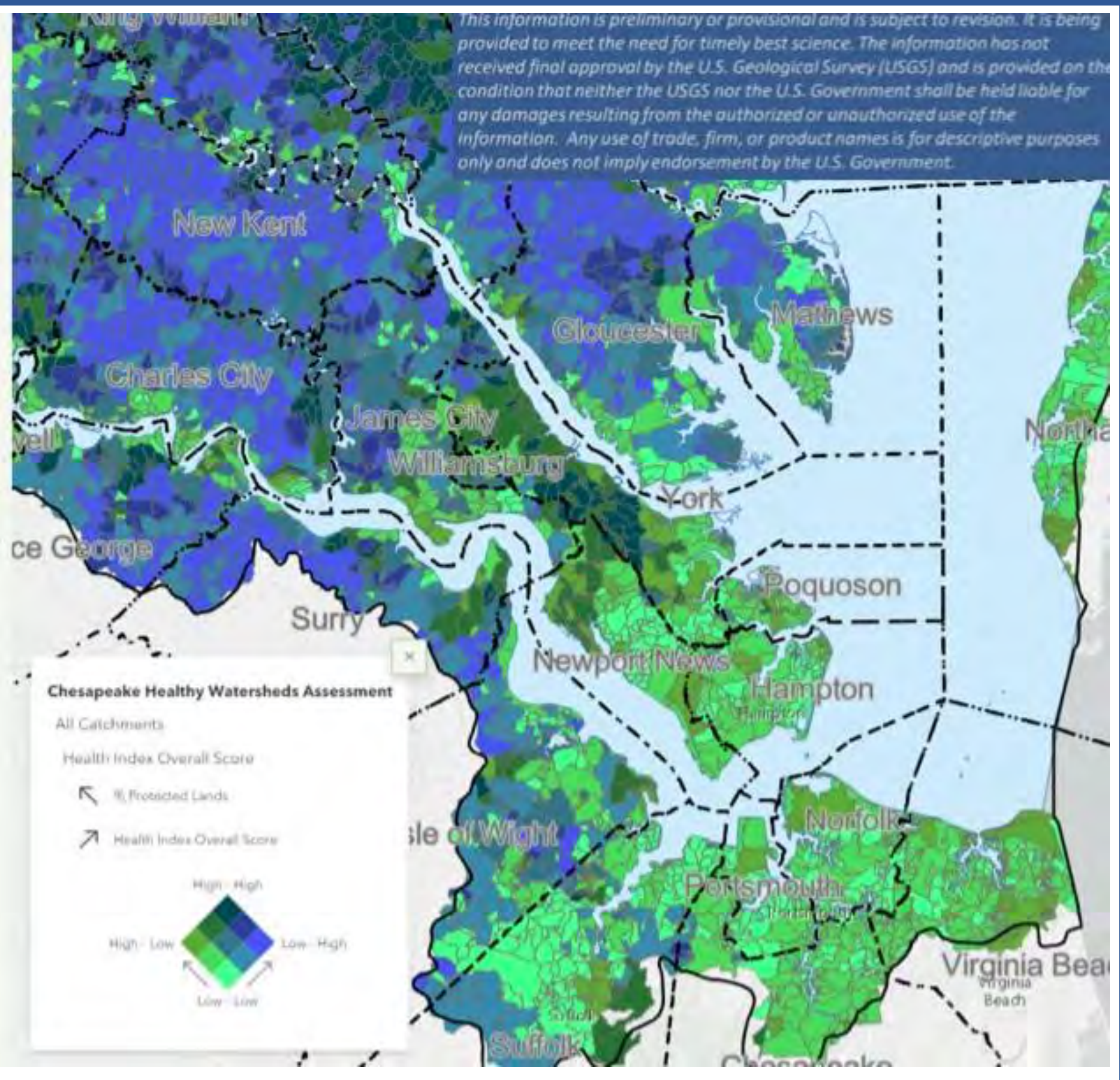
If map legend is not visible, click symbol in lower left corner to expand map legend. Click expand symbol in upper right corner to expand map to full screen.

Healthy Watersheds Metrics

- Health Index Overall Score
- Percent Protected

Goal Teams and Workgroups

- Chesapeake Conservation Partnership
- Stewardship GIT
- Maintain Healthy Watersheds GIT



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https://gis.chesapeakebay.net/healthywatersheds/assessment/

40 **Chesapeake Bay Program**
40 years of science, restoration and partnership

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Geographer, USGS, Lower Mississippi Gulf Water Science Center
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40 Chesapeake Bay Program
40 years of science, restoration and partnership

Using Geomorphic Characteristics to Inform Reach-Scale Stream and Floodplain Restoration Opportunities

Labeeb Ahmed*, Marina Metes*, Peter Claggett*, Krissy Hopkins*, Michelle Katoski*, Sam Lamont, Tristan Mohs*, Greg Noe*

* U.S. Geological Survey

STREAM CONDITION

It is important to assess stream conditions because healthy vs. impaired streams can impact flooding in urban areas, sediment and nutrient exchange, groundwater connectivity and aquatic and riparian habitat.

STREAM RESTORATION

Stream restoration aims to mitigate impaired streams, but it is challenging:

- Difficult to quantify results of a stream restoration project
- Lack of consistent long-term monitoring
- Segmented restoration: site-specific and/or shifting problems downstream

WHAT IS FACET?

FACET (floodplain and channel evaluation tool) was developed to remotely evaluate geomorphic conditions at a stream-reach scale. It is an automated open-source tool that maps and measures geomorphic metrics such as channel width, bank height and active flood extent.

FACET derived geomorphometry for ~85% of Chesapeake Bay watershed (CBW) is published on USGS along with the code. In 2023, FACET's geomorphometry will be derived using 1-meter DEMs for complete CBW

APPLICATIONS

- Metrics are used to model sediment and nutrient fluxes in Chesapeake Bay and Delaware River watersheds (Greg Noe, USGS)
- Quantifying ecosystem services (sediment & nutrient retention, flood attenuation) provided by floodplains (Krissy Hopkins, USGS)
- CBP 30-meter riparian buffer

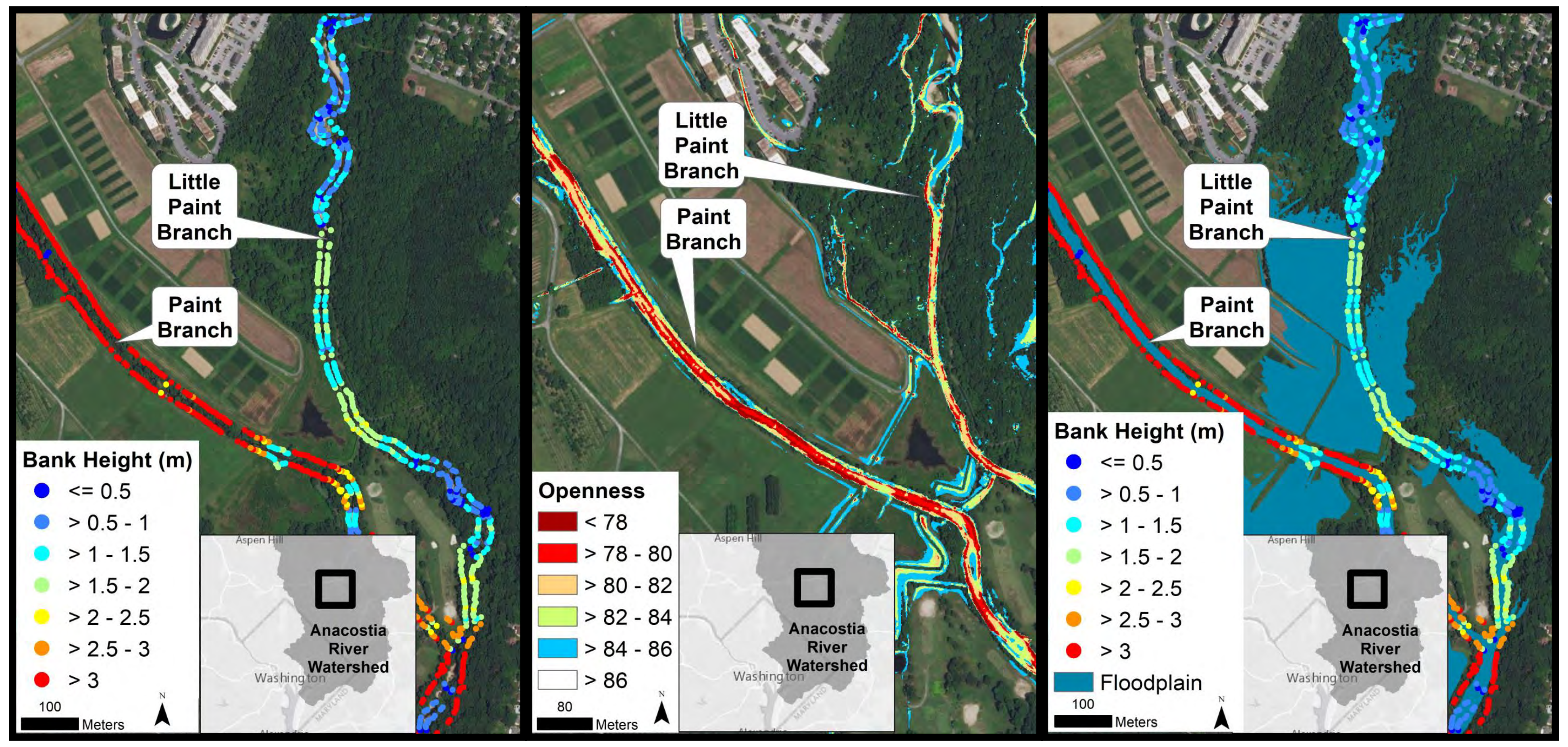
DATA

CODE

WEB APP

U.S. Department of the Interior
U.S. Geological Survey

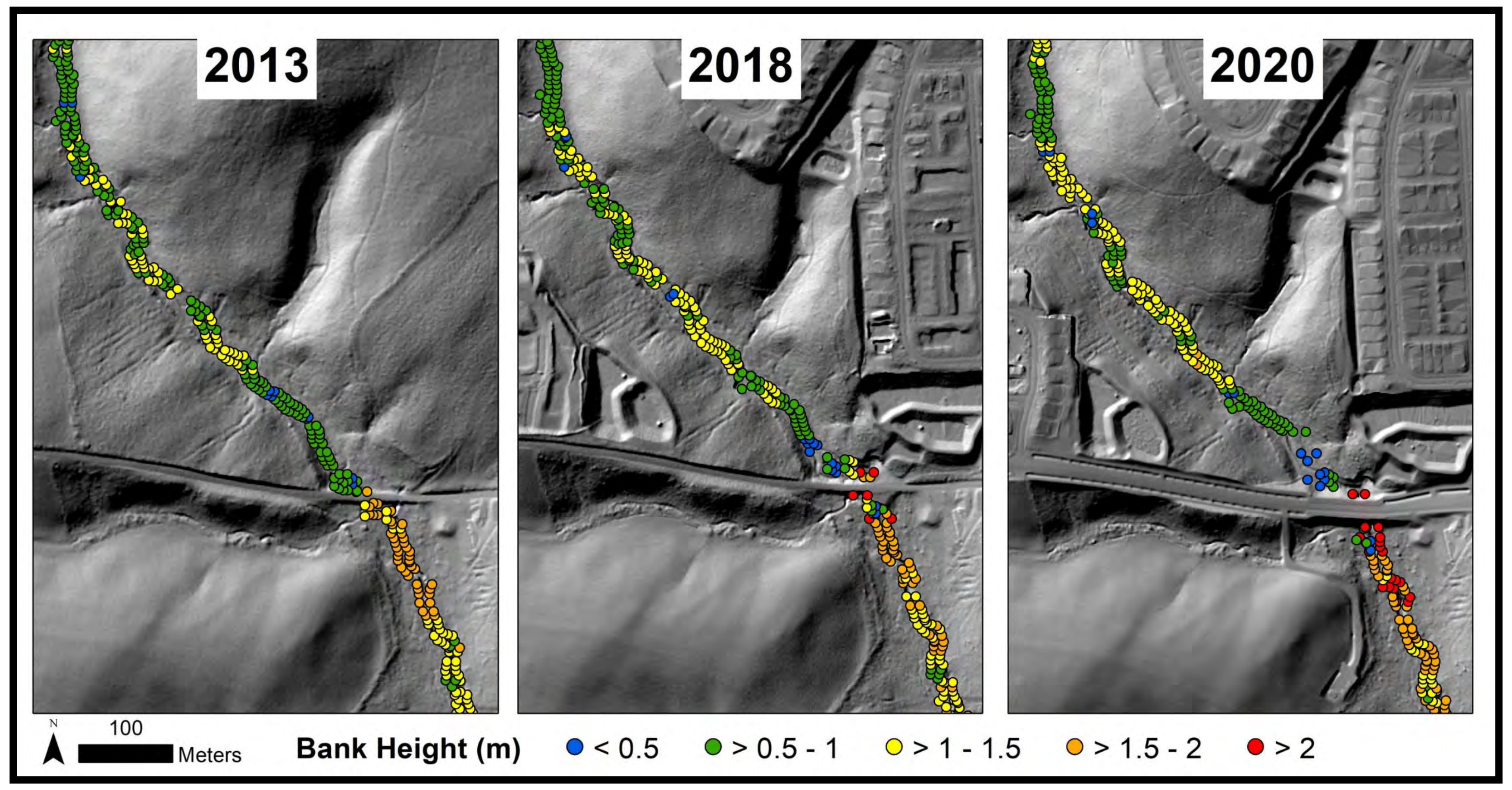
Evaluating Channel Conditions at Local Scale



Variations in bank height (A), incision (B), and floodplain extent (C) along two nearby tributaries

Source: Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1.

Evaluating Geomorphic Change with Repeat Lidar



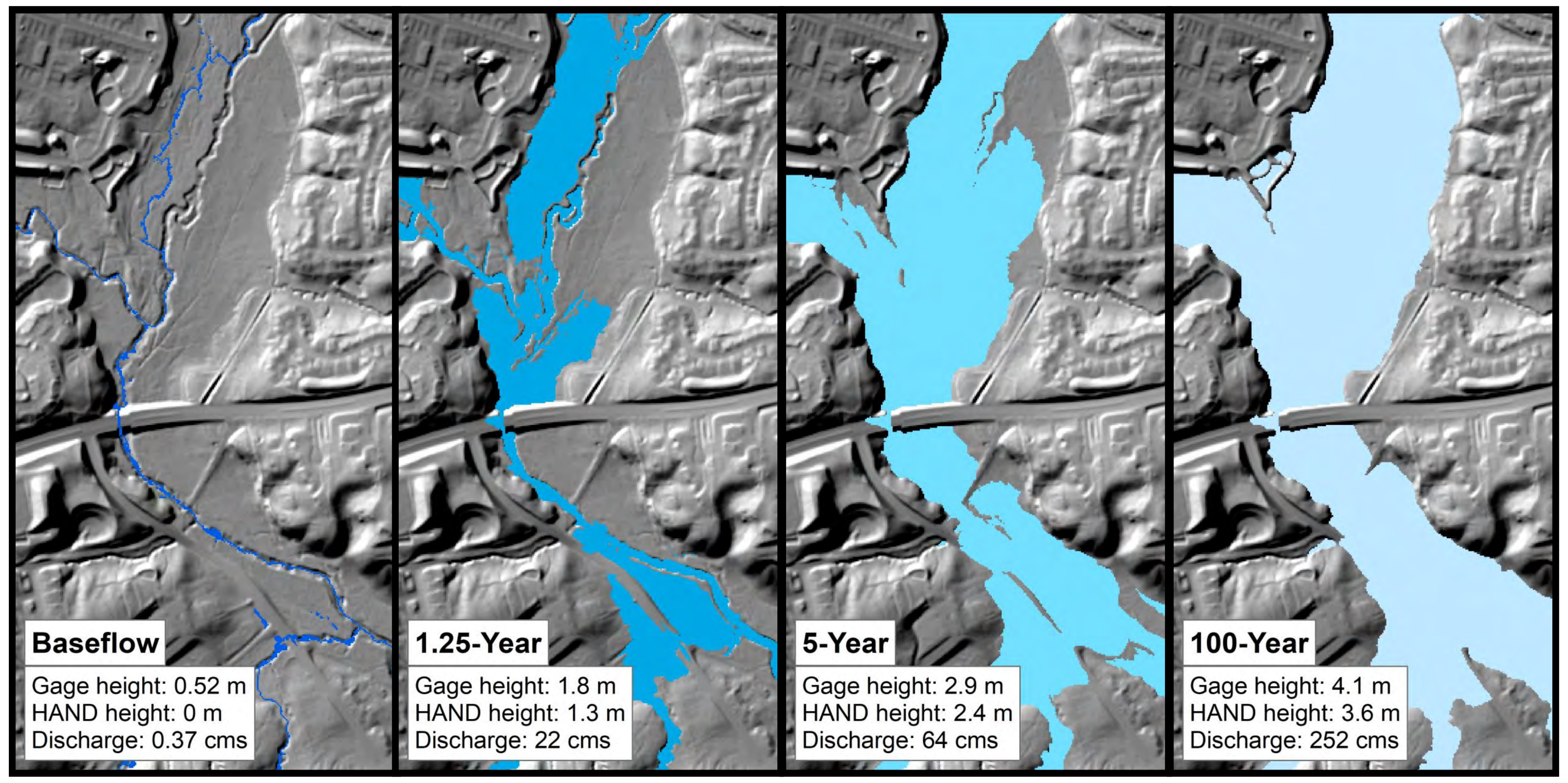
Site: Urbanizing **headwater** stream

Change: channel **deepening** between 2013 and 2020

Source(s) : Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1

Metes, M.J. and Jones, D.K., 2021, Lidar-derived digital elevation models in Clarksburg, MD representing the years 2002, 2008, 2013, and 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P9YQFR17.

Current Focus: Calibrate Floodplain Extents to Various Flood Recurrence Intervals



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

USGS science for a changing world

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40 years of science, restoration and partnership

Using Geomorphic Characteristics to Inform Reach-Scale Stream and Floodplain Restoration Opportunities

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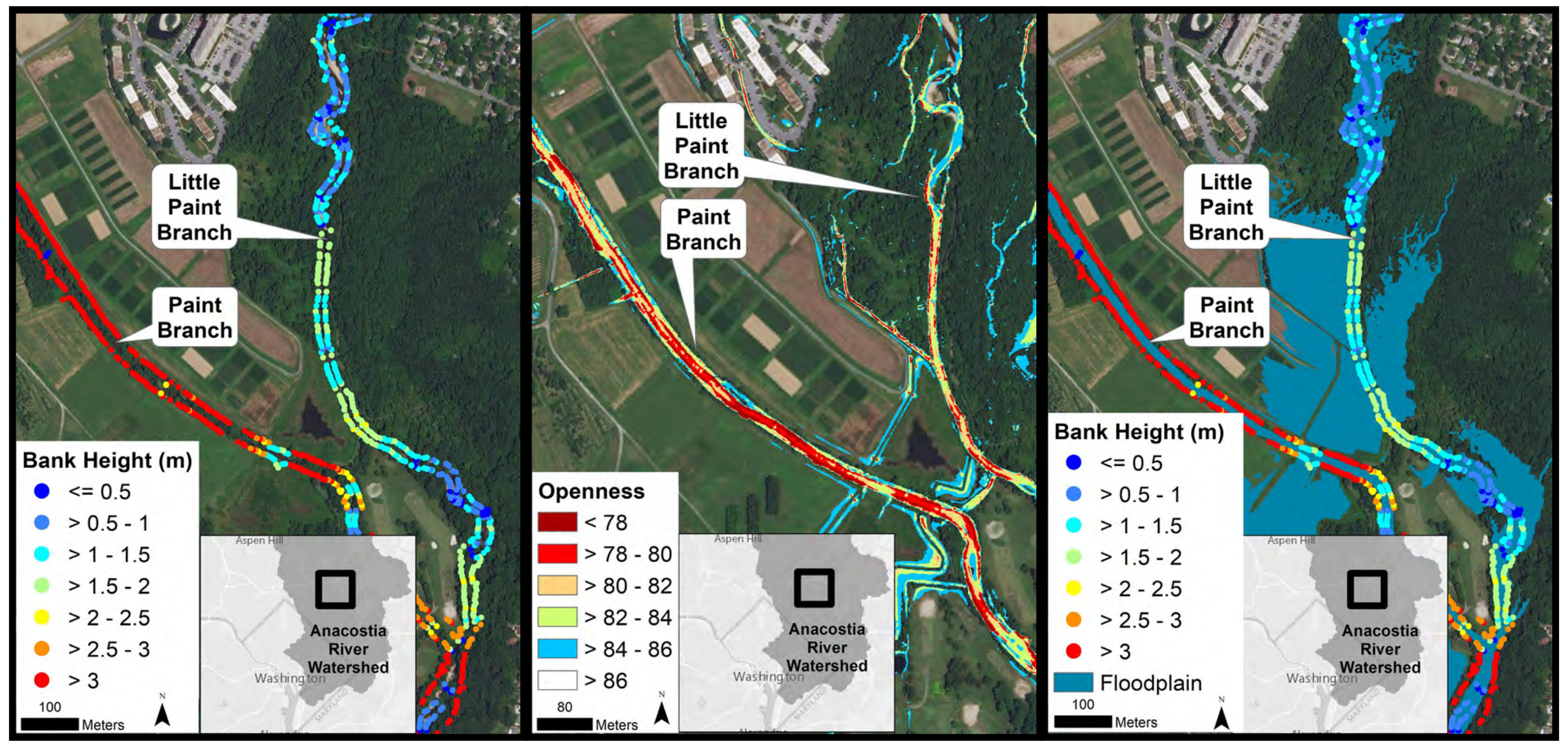

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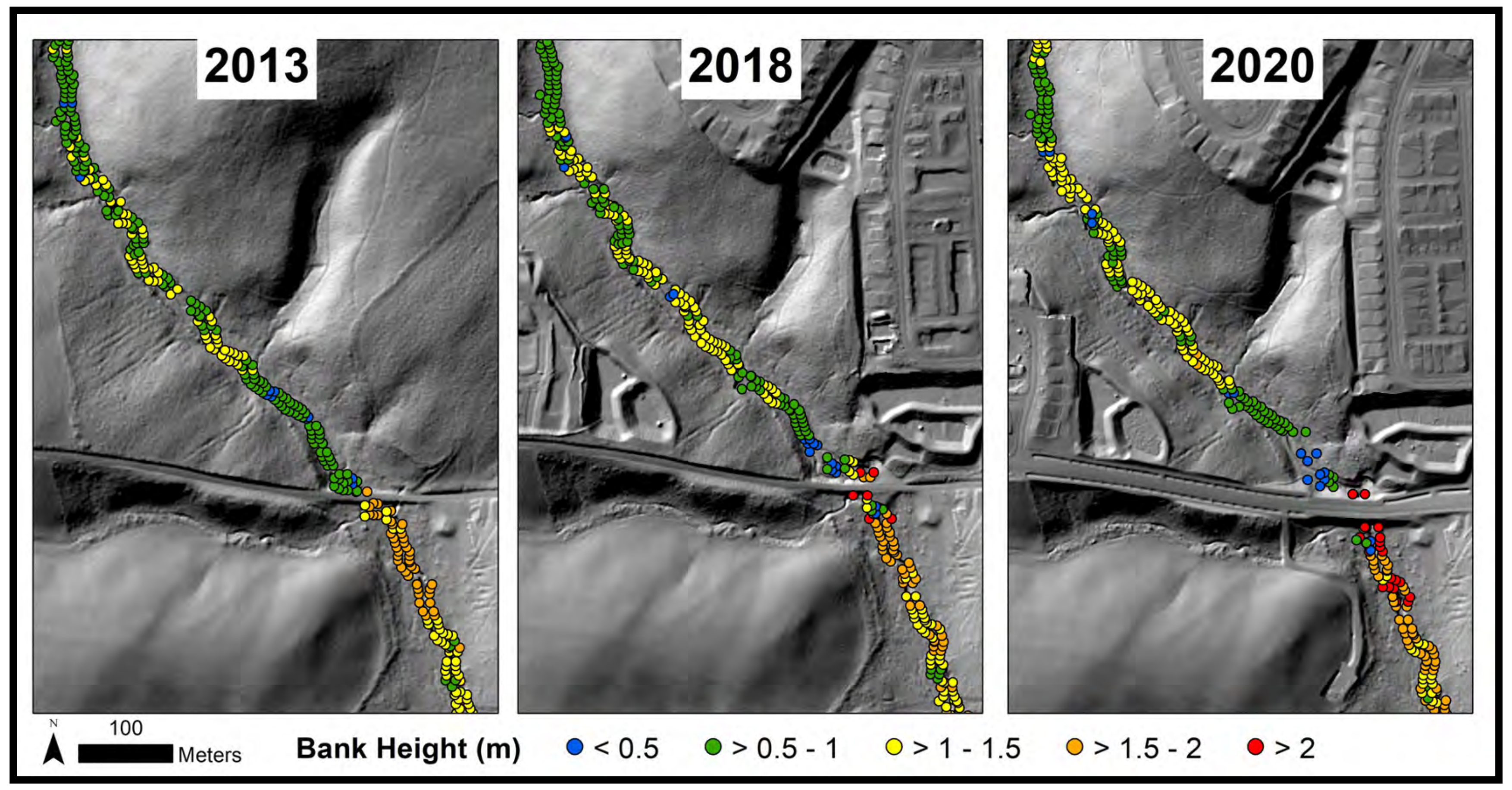


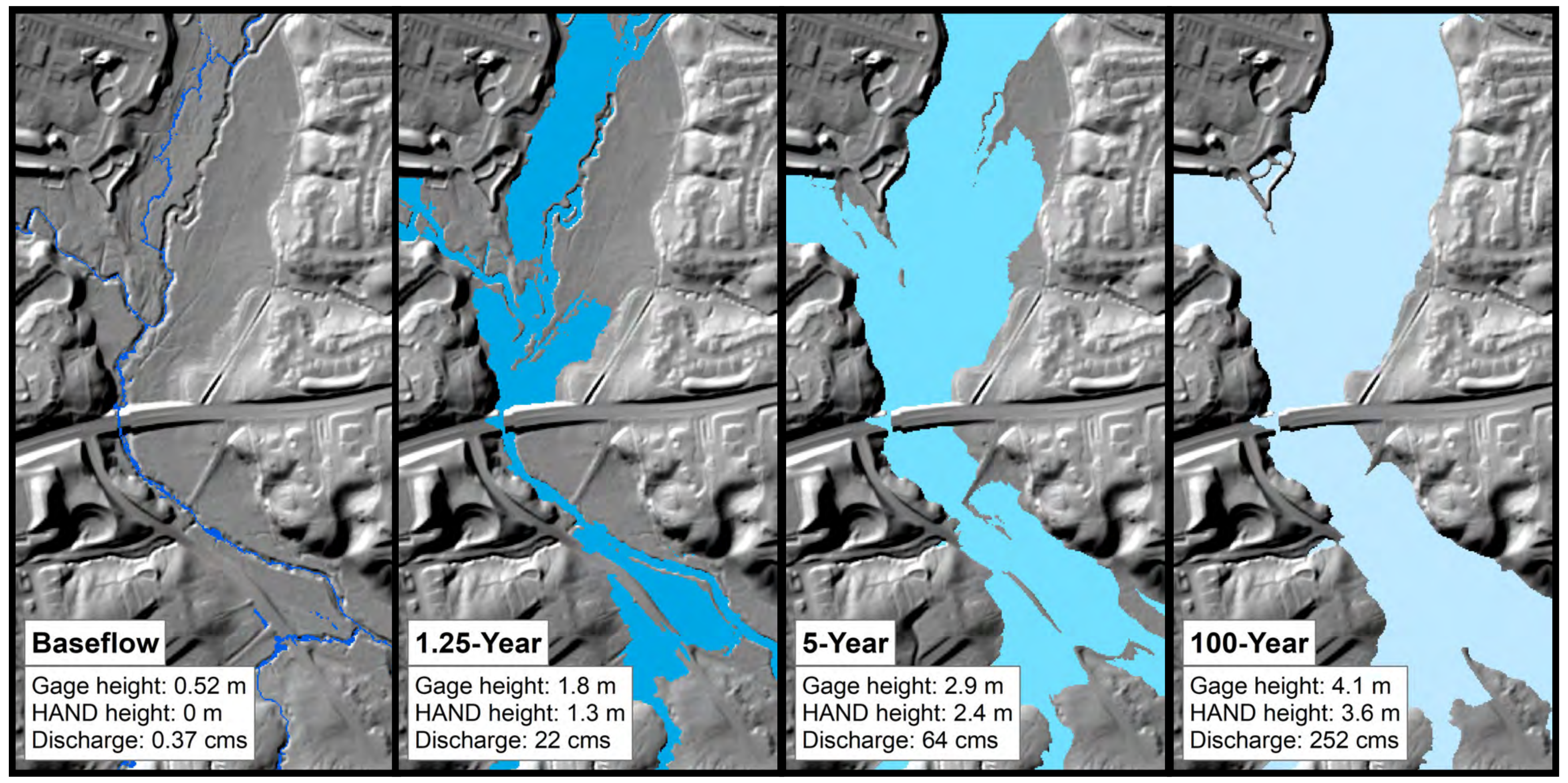
Site: Urbanizing headwater stream

Change: channel deepening between 2013 and 2020

Source(s) : Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1

Metes, M.J. and Jones, D.K., 2021, Lidar-derived digital elevation models in Clarksburg, MD representing the years 2002, 2008, 2013, and 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P9YQFR17.

Current Focus: Calibrate Floodplain Extents to Various Flood Recurrence Intervals



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

Disclaimer: This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

Chesapeake Bay Open Water Response to Geographic Nutrient Loads

Gary Shenk[1], Emily Trentacoste[2], Richard Tian[3], and John Wolf[4]

[1] USGS – Virginia/West Virginia Water Science Center, [2] USEPA – Chesapeake Bay Program Office, [3] University of Maryland Center for Environmental Science, [4] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Abstract

Geographic isolation runs are used to investigate the effects on Chesapeake Bay Chlorophyll concentration based on changes in nitrogen or phosphorus loads from both point and non-point sources. This poster demonstrates the use of a tool to visualize the source nutrient loads for each tidal water segment in Chesapeake Bay. The tool extends the approach used to assess relative effectiveness for the Chesapeake Bay Total Maximum Daily Load to all Open Water segments.

Key Factors

- ☐ Watershed Characteristics
- ☐ Travel time
- ☐ Existence of impoundments
- ☐ Position along mainstem bay
- ☐ Estuarine circulation

Methods

- ☐ Using the CBP's estuarine water quality model, run a separate scenario for each CB segment, nutrient, and source type (point or nonpoint)
- ☐ Add 5 million lbs of N or 0.5 Mlbs/yr P each year by an annual coefficient to the loads in each CBSEG
- ☐ Separate PS and NPS runs
- ☐ Model the change in June-September Chlorophyll concentration to the depth of the long-term surface mixed layer
- ☐ Multiply by watershed delivery
- ☐ **Calculation**

- Watershed delivery:
  - ☐ Pound delivered per pound produced
- Estuarine delivery
  - ☐ Chlorophyll increase per pound delivered
- Overall Effectiveness
  - ☐ Chlorophyll increase per pound produced

Summary

- ☐ Visualization of Chlorophyll response - related to oxygen and clarity
- ☐ Visualization only – no nutrient exchanges based on these runs
- ☐ Shows primacy of local watersheds to small bays

Expanding TMDL Approach to Open Water Segments

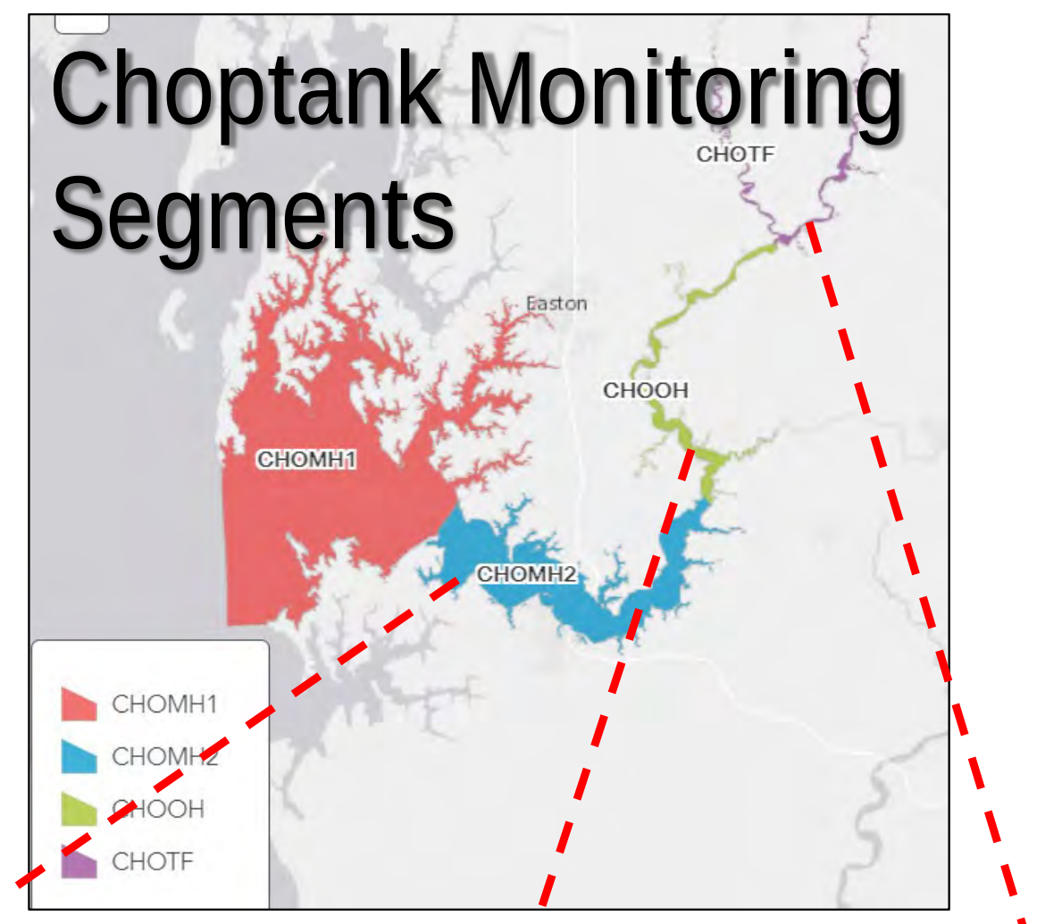
Existing relative effectiveness for used for nitrogen and phosphorus planning targets was based on sub-pycnocline dissolved oxygen in the mesohaline regions of the Bay and Potomac rivers

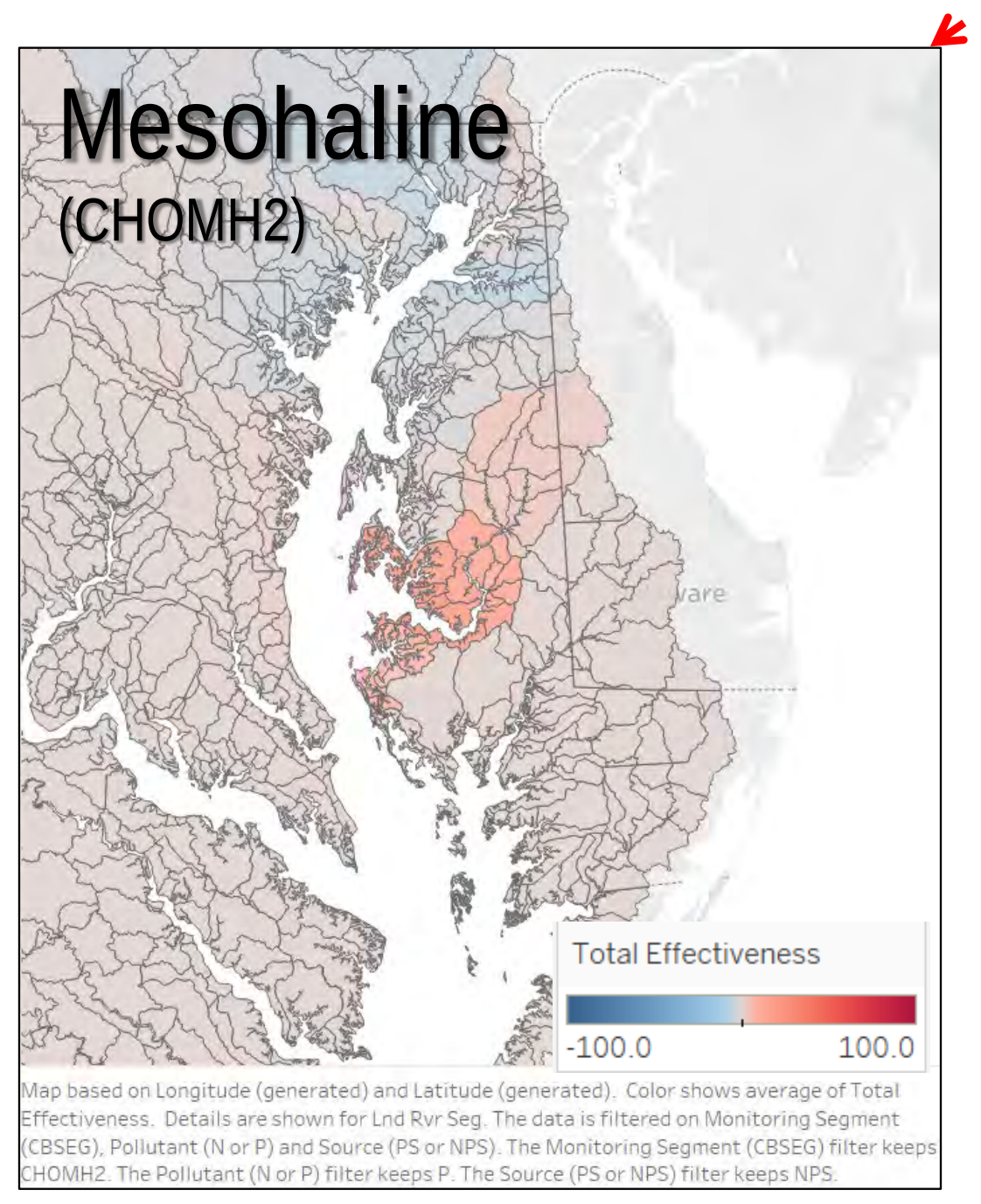
Goal is to provide a tool for the Partnership to visualize the source of load effecting the surface mixed layer for each Tidal Segment

Choptank River, Maryland Example

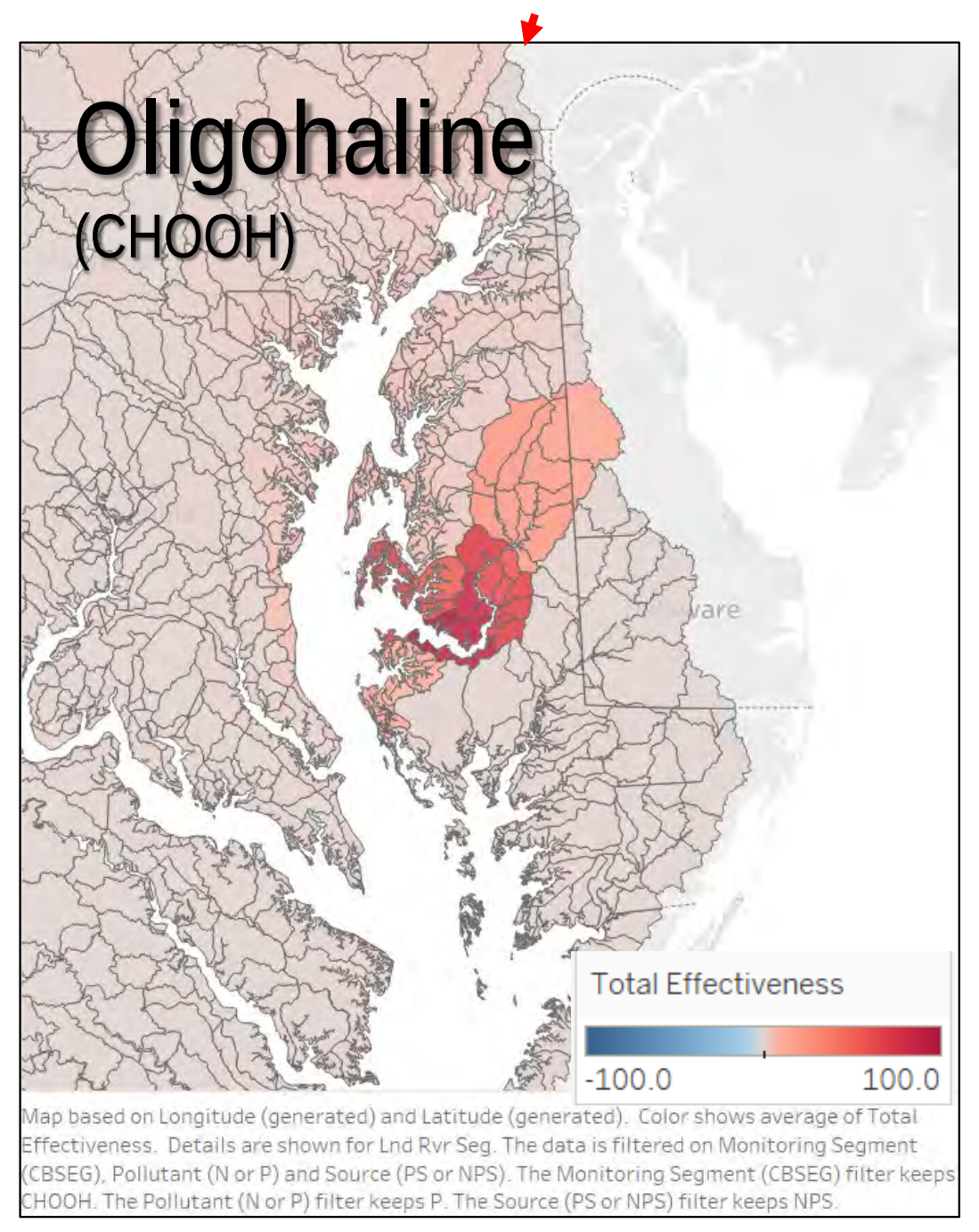
(Phosphorus – Non-Point Sources)

As you progress downstream from tidal fresh near Greensboro, Maryland to oligohaline to mesohaline conditions at the mouth of the river, the impact on Chlorophyll from phosphorus in the upstream watershed decreases relative to the influence of nitrogen and relative to nutrients from other basins. In some cases the total effectiveness becomes negative, indicating that a decrease in the upstream contribution of phosphorus would be expected to increase Chlorophyll a concentrations.





Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps CHOMH2. The Pollutant (N or P) filter keeps P. The Source (PS or NPS) filter keeps NPS.



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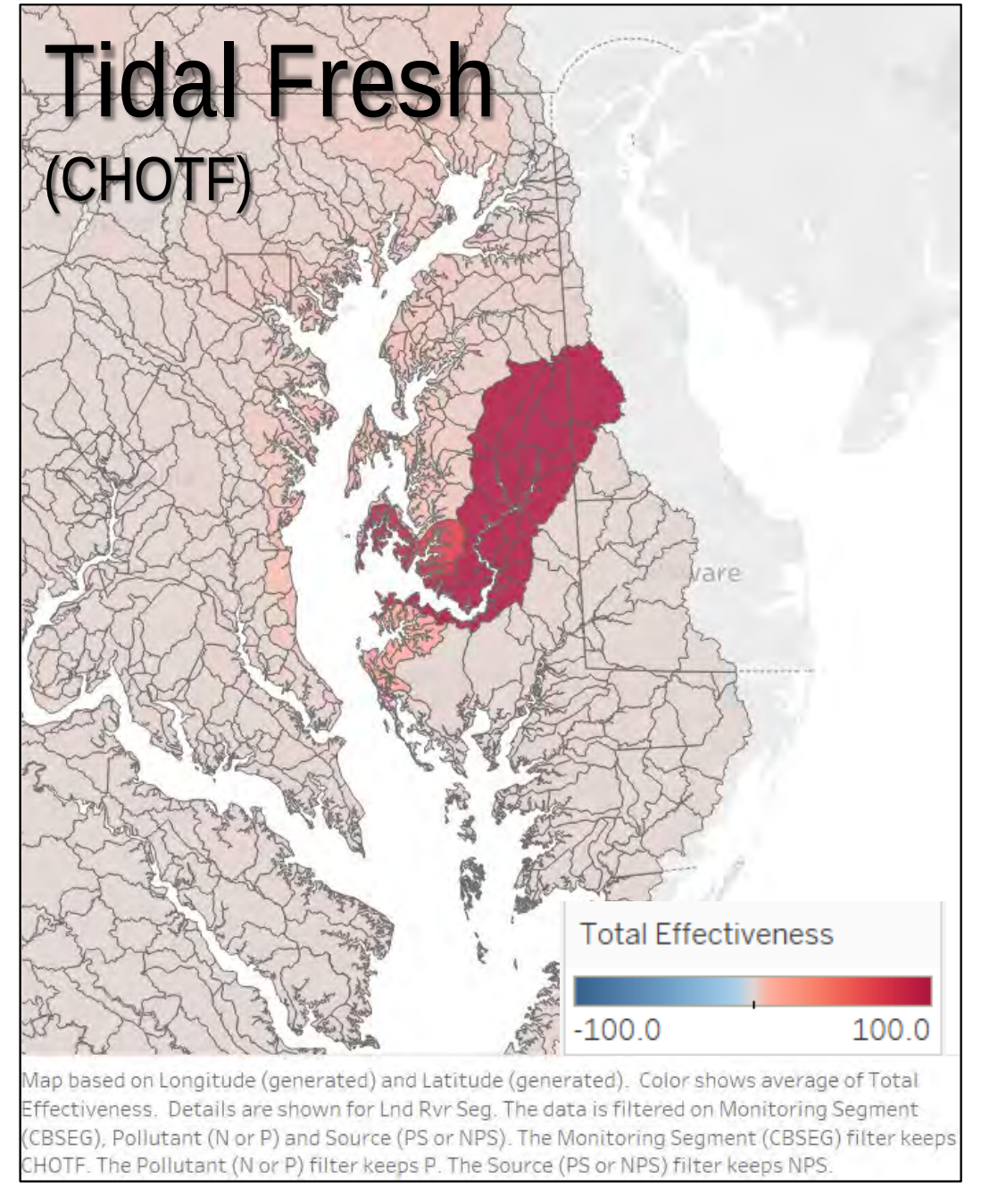


Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps CHOTF. The Pollutant (N or P) filter keeps P. The Source (PS or NPS) filter keeps NPS.

Photo: Jane Thomas, UMCES IAN.

Photo: Wikipedia

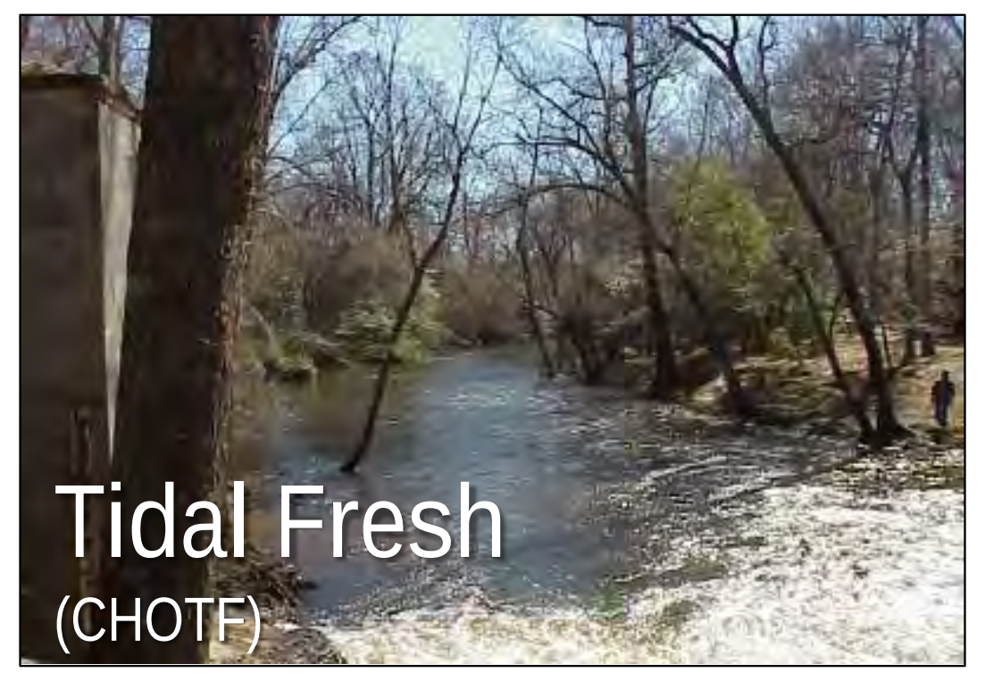


Photo: USGS Water Data for the Nation. CHOPTANK RIVER NEAR GREENSBORO, MD

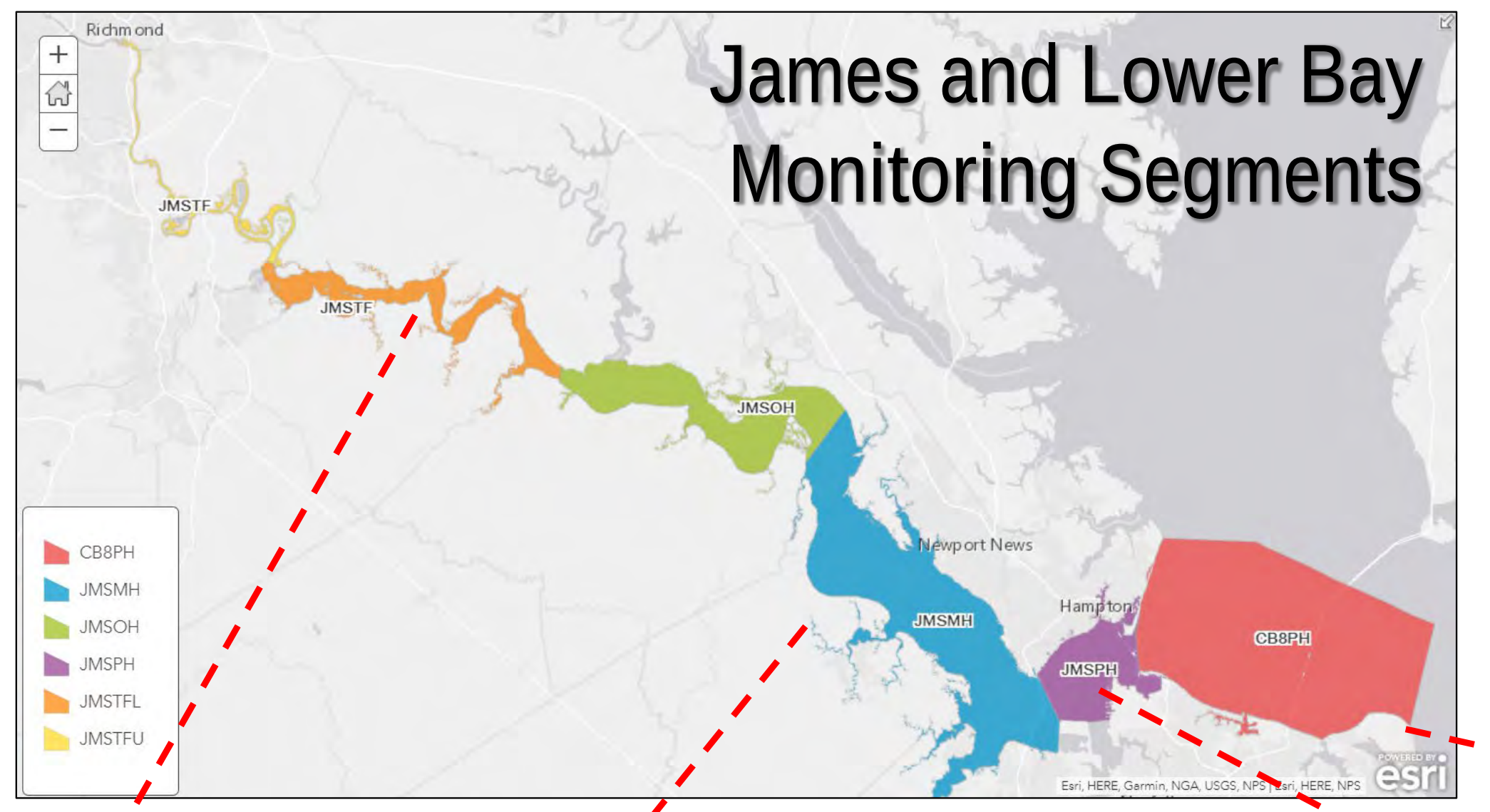
James River, Virginia Example

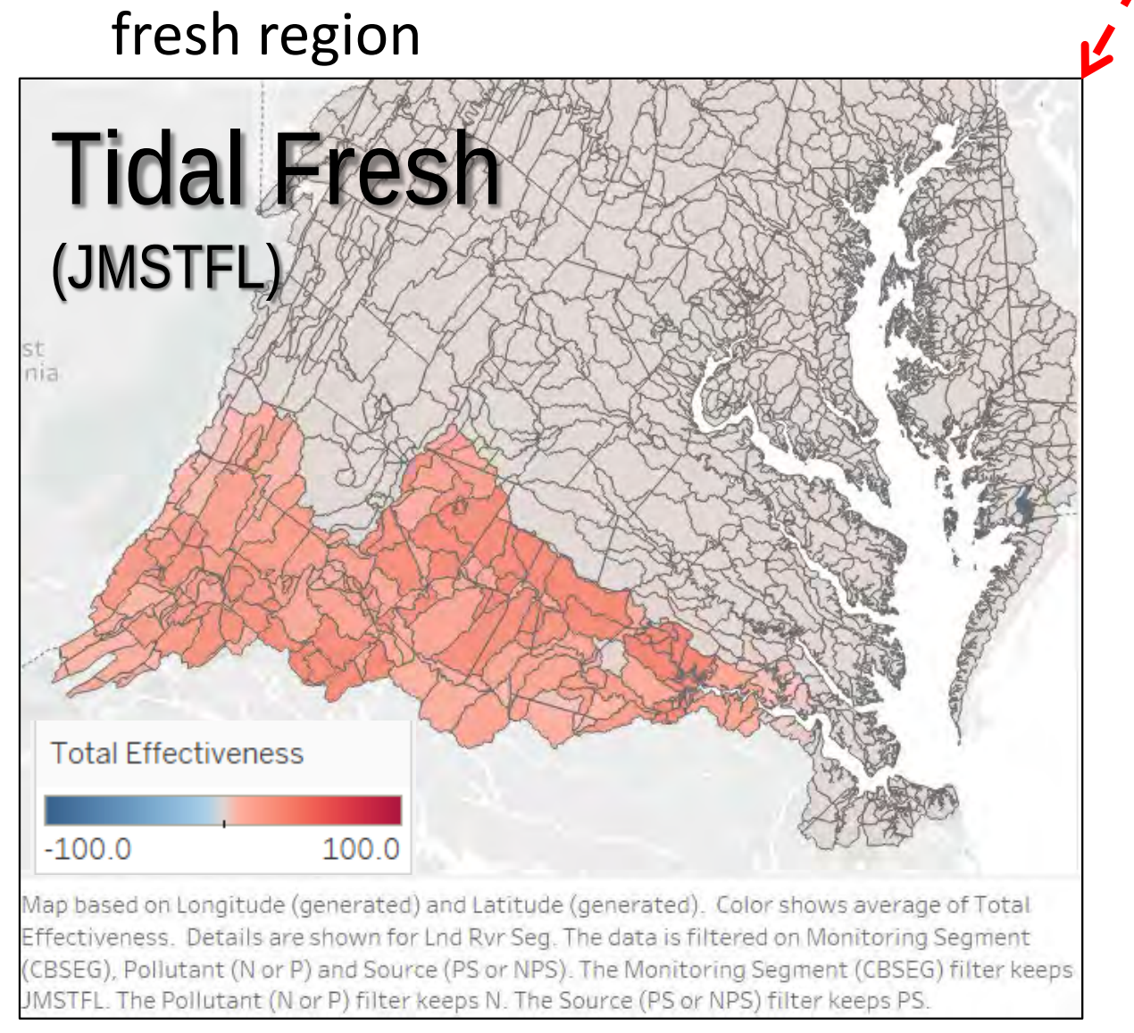
(Nitrogen – Point Sources)

Tidal Fresh
- ☐ Nitrogen has relatively little influence in the generally phosphorus-limited tidal fresh
- ☐ Only the James watershed has any influence on the tidal fresh region

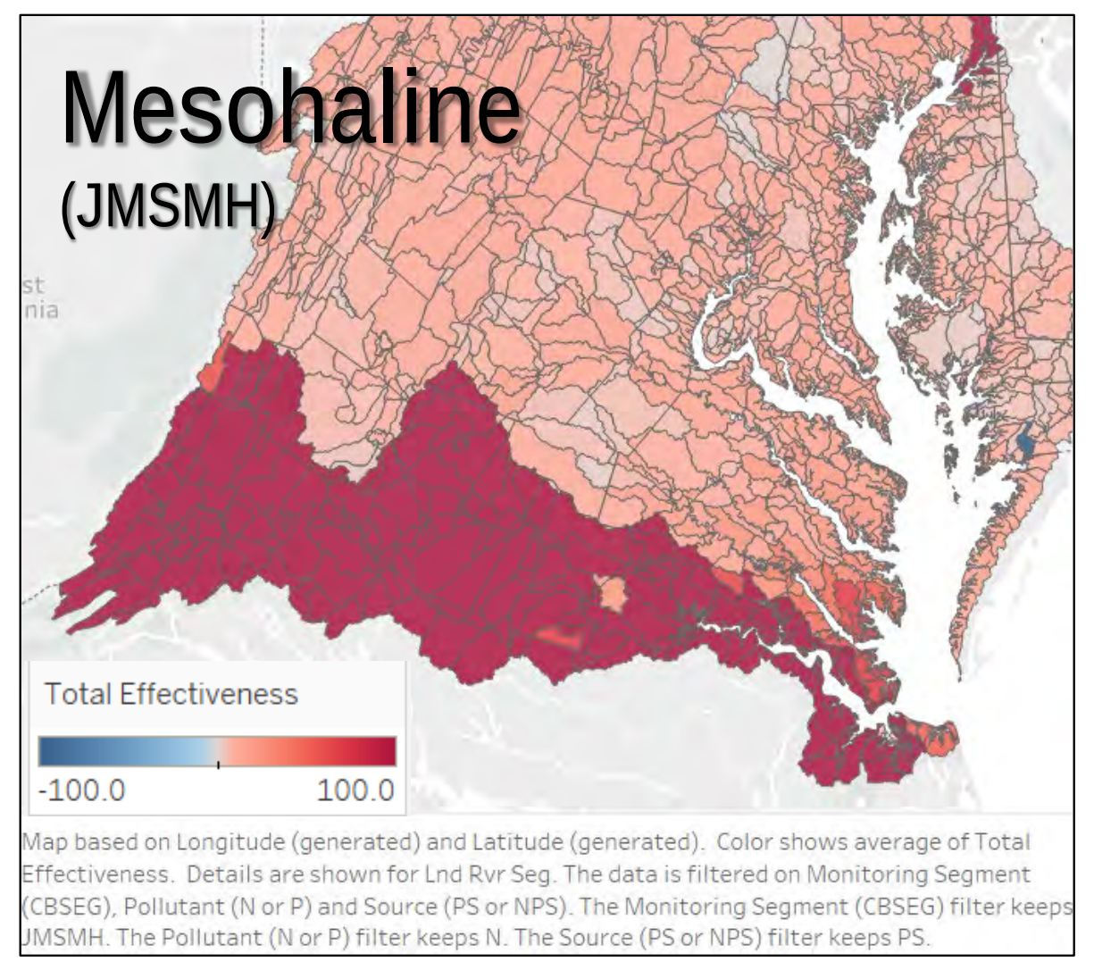
Mesohaline
- ☐ Nitrogen is much more effective at controlling chlorophyll in the mesohaline region compared to the tidal fresh. Mesohaline regions tend to be more nitrogen-limited that phosphorus-limited in the summer. The James is still the most important basin, but the influence of other basins starts to be seen.

Polyhaline
- ☐ Similar to the Mesohaline, nitrogen tends to be the more important nutrient for controlling chlorophyll in the summer
- ☐ The influence of other basins is increased relative to the James

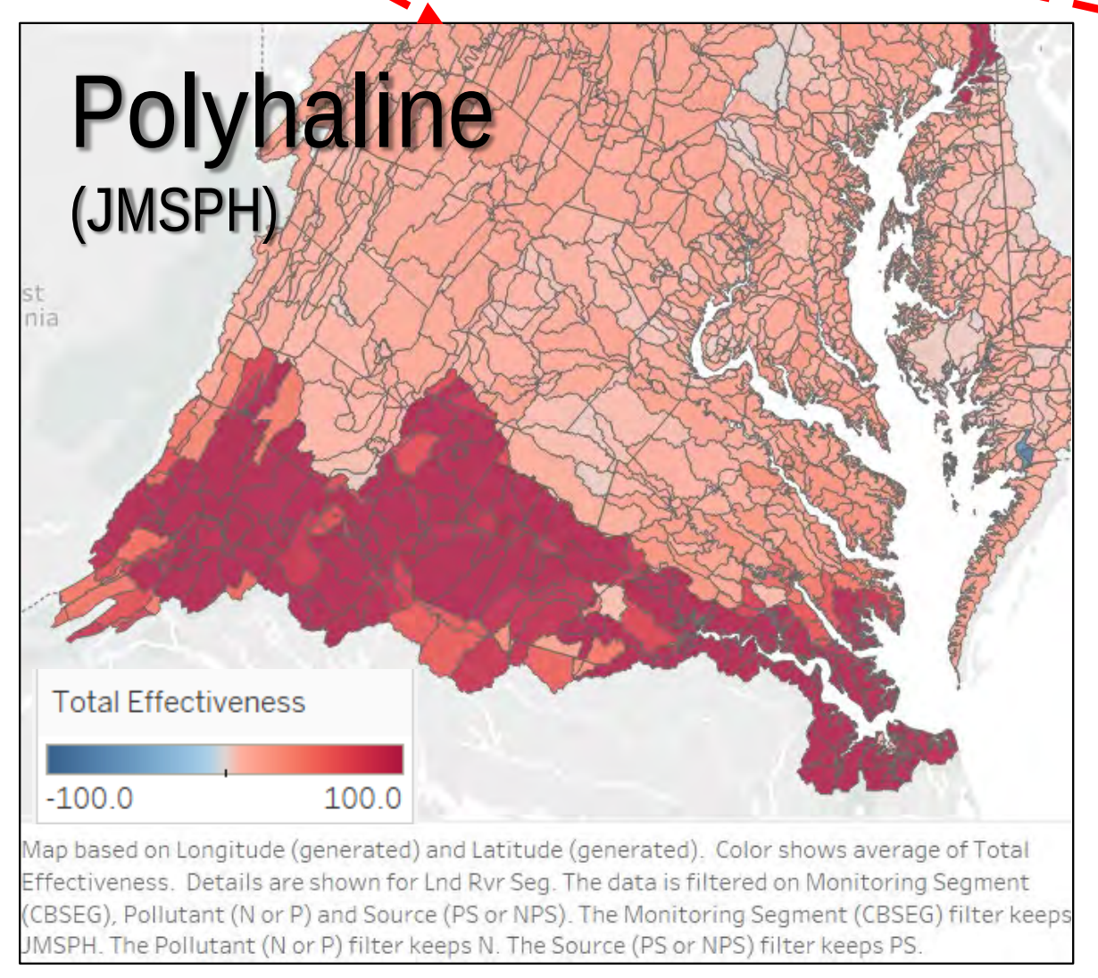




Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps JMSTFL. The Pollutant (N or P) filter keeps N. The Source (PS or NPS) filter keeps PS.



Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps JMSMH. The Pollutant (N or P) filter keeps N. The Source (PS or NPS) filter keeps PS.



Map based on Longitude (generated) and Latitude (generated). Color shows average of Total Effectiveness. Details are shown for Lnd Rvr Seg. The data is filtered on Monitoring Segment (CBSEG), Pollutant (N or P) and Source (PS or NPS). The Monitoring Segment (CBSEG) filter keeps JMSPH. The Pollutant (N or P) filter keeps N. The Source (PS or NPS) filter keeps PS.

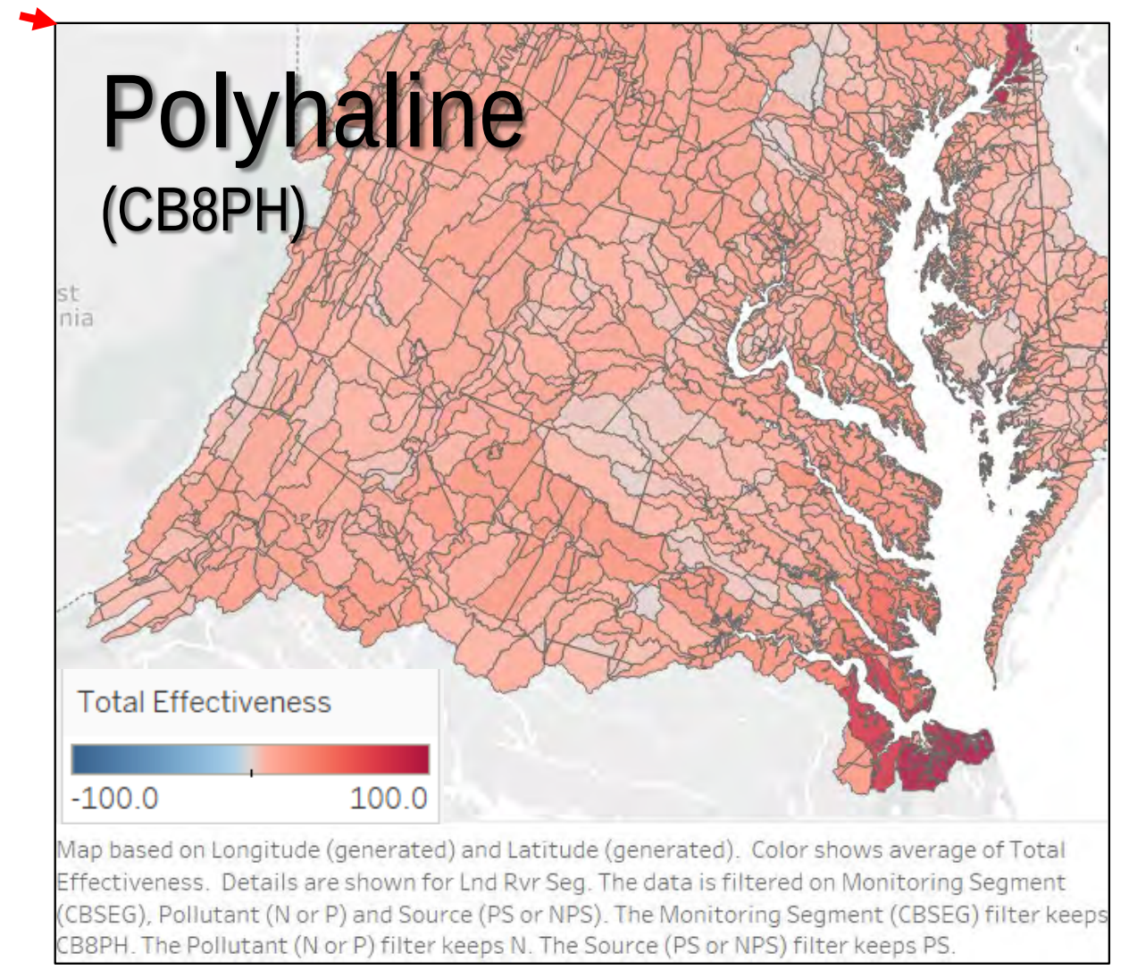


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Photo: Chesapeake Bay Gateways Network

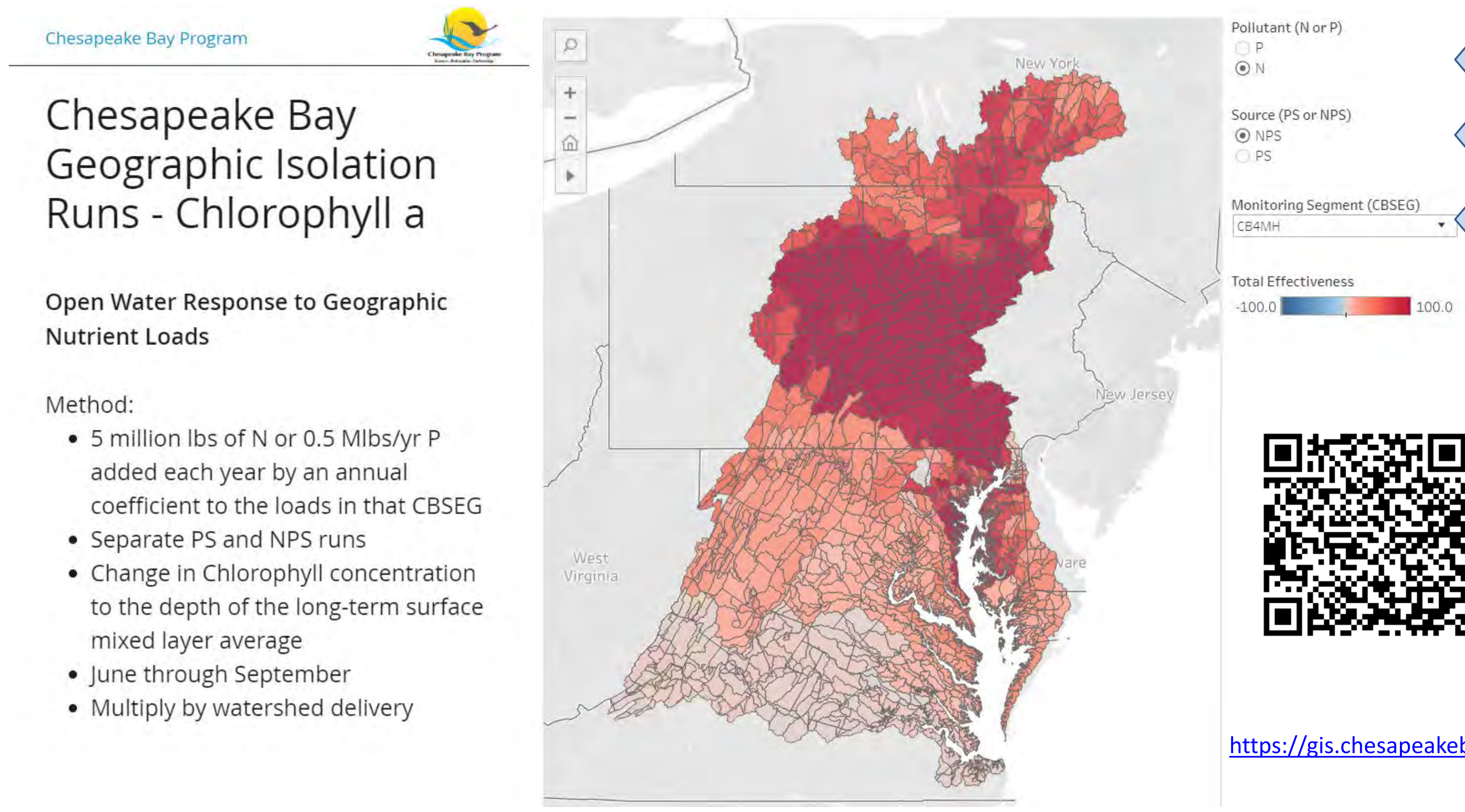
Photo: Hoffler Creek Wildlife Preserve

Photo: Envision the James (Chesapeake Conservancy)

Photo: Commonwealth of Virginia

Chesapeake Bay Program
Science. Restoration. Partnership.

Interactive Web Application



Chesapeake Bay Program

Chesapeake Bay Geographic Isolation Runs - Chlorophyll a

Open Water Response to Geographic Nutrient Loads

Method:
- 5 million lbs of N or 0.5 Mlbs/yr P added each year by an annual coefficient to the loads in that CBSEG
- Separate PS and NPS runs
- Change in Chlorophyll concentration to the depth of the long-term surface mixed layer average
- June through September
- Multiply by watershed delivery

Pollutant (N or P)
○ P
● N

Source (PS or NPS)
● NPS
○ PS

Monitoring Segment (CBSEG)
CB4MH

Total Effectiveness
-100.0 100.0

User selects …

(1) Pollutant

(2) Source

(3) Segment

This QR Code will launch the Chesapeake Bay Geographic Isolation Runs - Chlorophyll a application.

https://gis.chesapeakebay.net/modeling/geoisoruns/

Fostering Chesapeake Stewardship Goal Implementation Team (GIT 5):

Environmental Literacy * Stewardship * Protected Lands * Public Access * Diversity

Invest in Engagement

18 Million People in the Watershed Who:

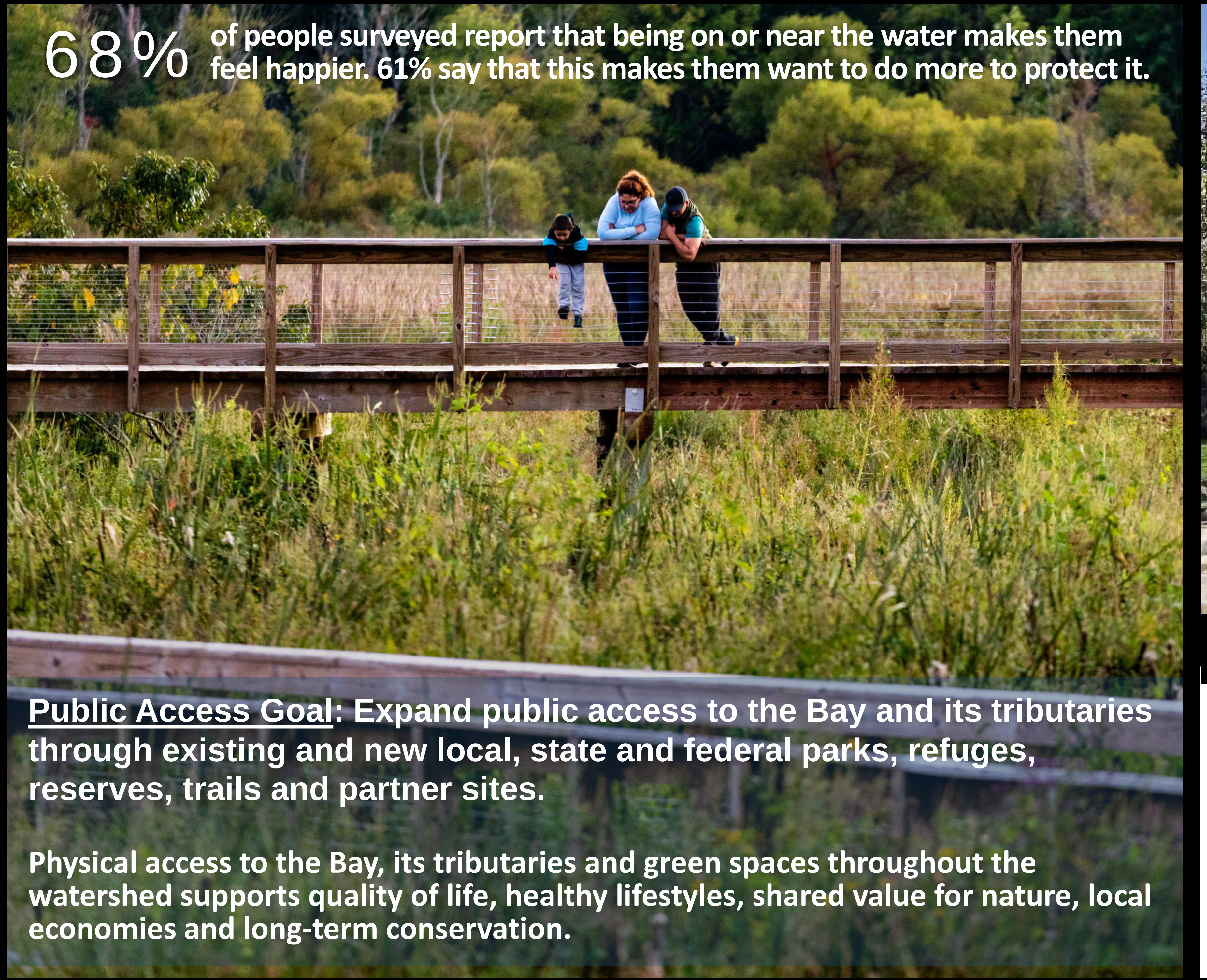
Live
Play
Learn
Work
Vote
$pend
Decide
Act
Care
Love
Use resources
Need clean water & air

Resources and Tools:

- CBP Environmental Justice & Equity Dashboard
- Green Space Equity Mapper
- Chesapeake Conservation Atlas
- CBP Targeting Tools Portal
- Bay Backpack
- Find a Bay Organization
- Chesapeake Behavior Change
- Public Access to Waterways
- Chesapeake Gateways

People who can, should and want to be part of the solution.

Prioritize Health & Quality of Life

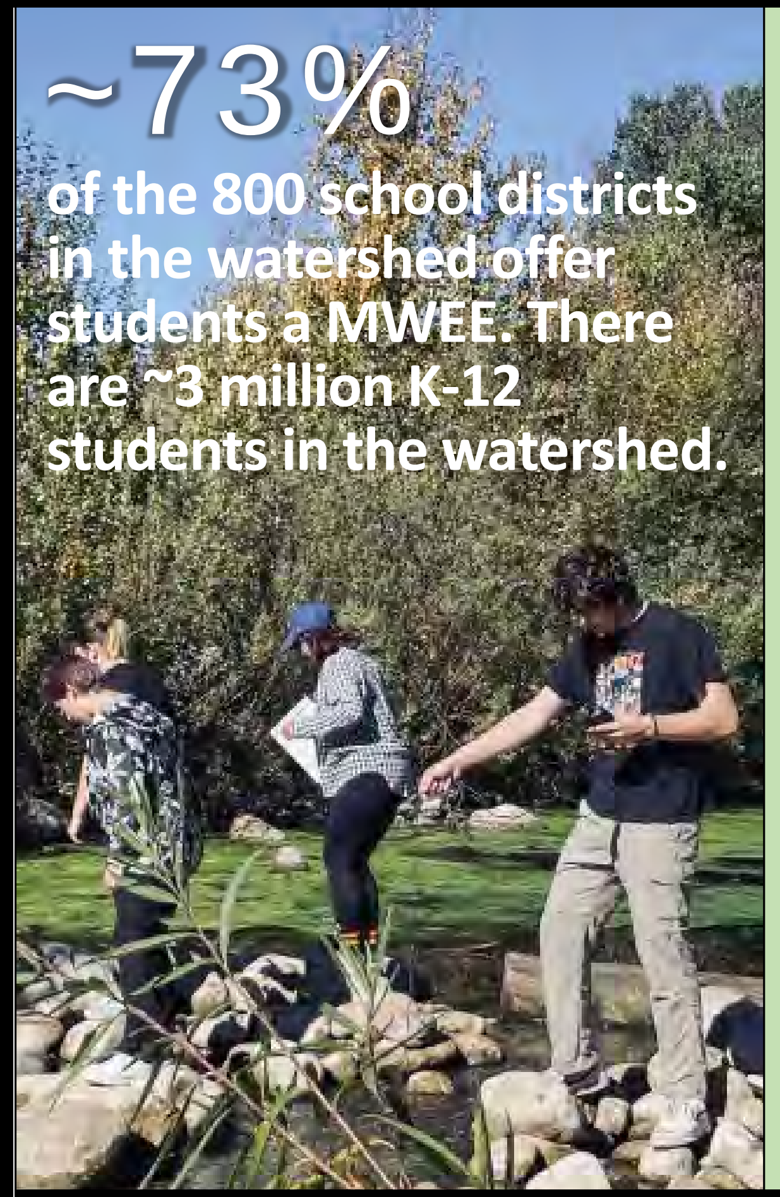


68% of people surveyed report that being on or near the water makes them feel happier. 61% say that this makes them want to do more to protect it.

Public Access Goal: Expand public access to the Bay and its tributaries through existing and new local, state and federal parks, refuges, reserves, trails and partner sites.

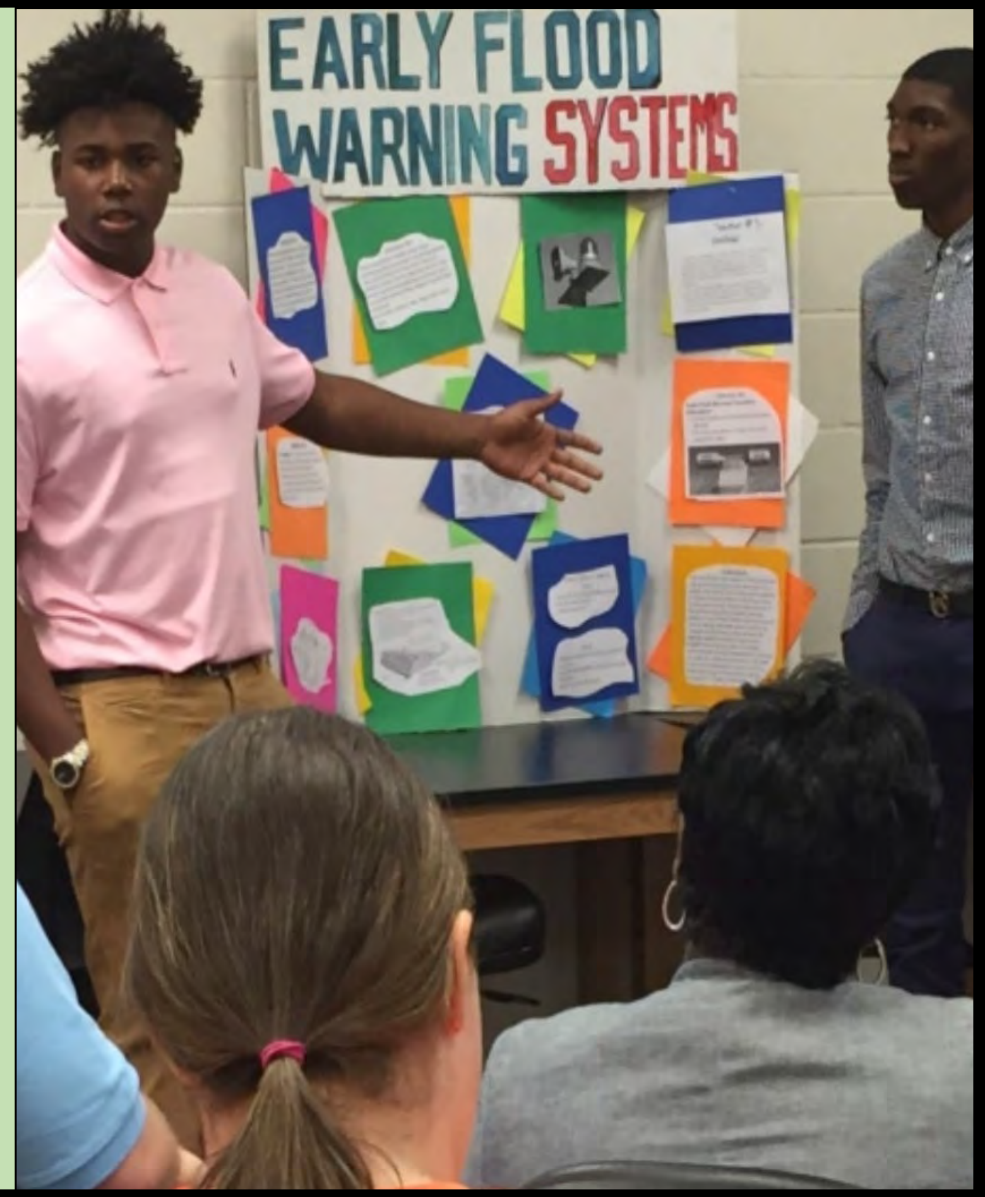
Physical access to the Bay, its tributaries and green spaces throughout the watershed supports quality of life, healthy lifestyles, shared value for nature, local economies and long-term conservation.

Increase Environmental Literacy



~73% of the 800 school districts in the watershed offer students a MWEE. There are ~3 million K-12 students in the watershed.

Enable students in the region to graduate with the knowledge and skills to act responsibly to protect and restore their local watershed.



What is a MWEE? Meaningful Watershed Educational Experience

It is NOT a one day field trip – it includes multiple outdoor field experiences and an extended set of opportunities for students to:

- ✓ Strengthen their connection to the natural world
- ✓ Explore, research and reflect on environmental topics
- ✓ Develop solutions
- ✓ Take action to address issues at school or in their local community
- ✓ Build life skills

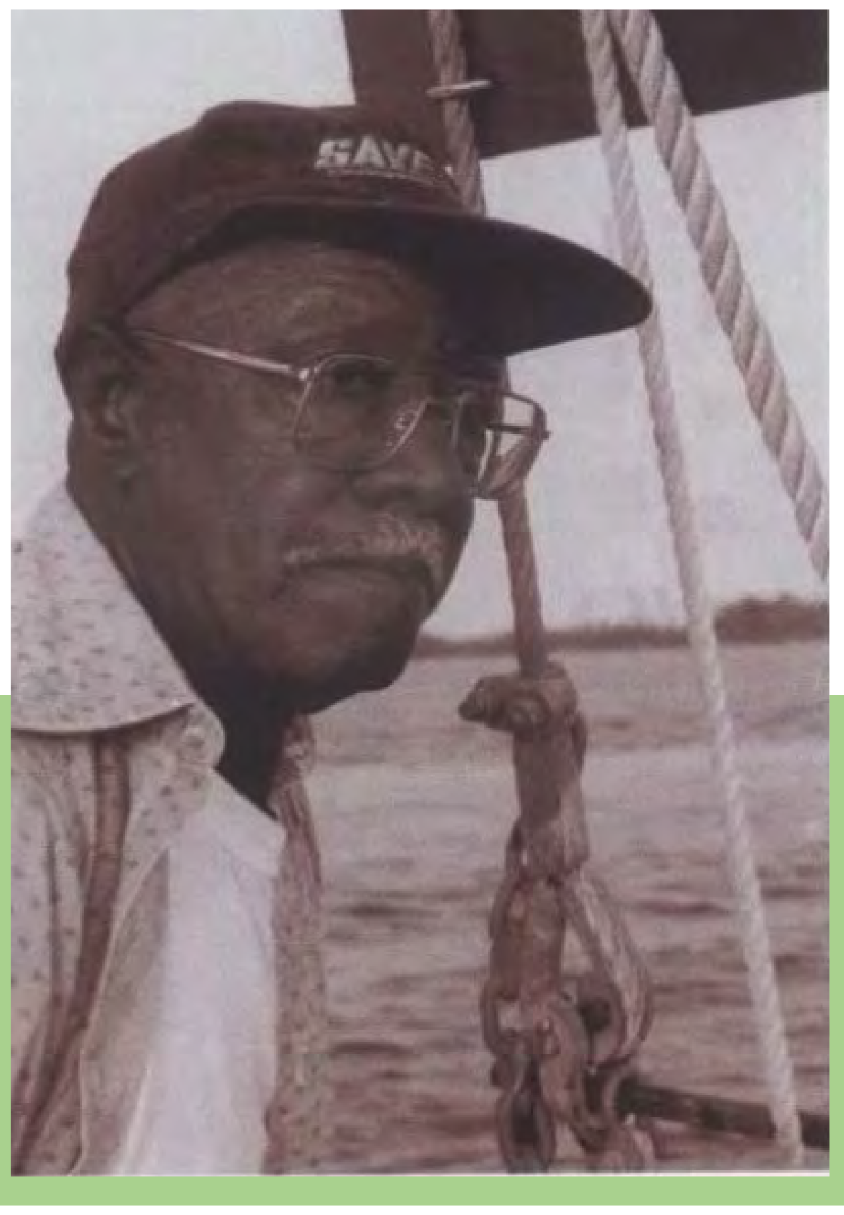
Practice Inclusion

84% **of Latino voters polled in 2021 support Bay conservation;** an overwhelming majority support conserving 30% of lands and waters by 2030, and are concerned about climate change, water pollution, access to nature and historic sites.

Tu Chesapeake is a partnership initiative of National Park Service Chesapeake Gateways and Corazón Latino.

Tell Their Stories

Preserve, celebrate and amplify the voices and actions of people not often recognized as having shaped our history. **Chesapeake Gateways** – a system of places to enjoy, learn about and help conserve the Chesapeake Bay and its watershed – is one example. This network of natural, cultural, historical and recreational sites, trails, museums, parks, refuges and more showcases ways to share inclusive stories and facilitate community engagement.



Traditionally excluded and underrepresented demographics care more about environmental issues than often is assumed, and are the most impacted by these issues. **Therefore, it is important that we are intentional about inclusion and representation.**

Save the Landscape

30% of the watershed protected by 2030 is a goal toward increased resilience to climate impacts, and for protecting our biodiversity and ecosystem services.

Building Resilient Communities & Landscapes

Conserving large landscapes throughout the region to benefit multiple values, including economic sustainability; scenic, historic and cultural heritage; working lands; important wildlife habitat; water quality and supply; and overall quality of life.

Our Land, Our Heritage, Our Future
Farms * Forests * Habitat * Heritage * Human Health
Chesapeake Conservation Partnership

Build Active Bay Stewards

24 out of 100 is the baseline stewardship score for watershed residents (2017) – a combined reflection of reported personal action, volunteerism, and attitudes about stewardship. Will the 2022 results show growth?

71% of residents surveyed want to do more to make their creeks, rivers and lakes healthier, and 65% agree polluted water affects them personally.

Spectrum of Community Engagement/ Public Participation

INFORM → CONSULT → INVOLVE → COLLABORATE → CO-LEAD/ EMPOWER

Using Social Science throughout CBP work will:

- Build support for Bay goals with the broader public
- Encourage pro-environmental behaviors
- Discourage environmentally harmful behaviors
- Involve watershed residents in lasting solutions

Devereux Consulting
Data ✦ Research ✦ Analysis ✦ Strategy

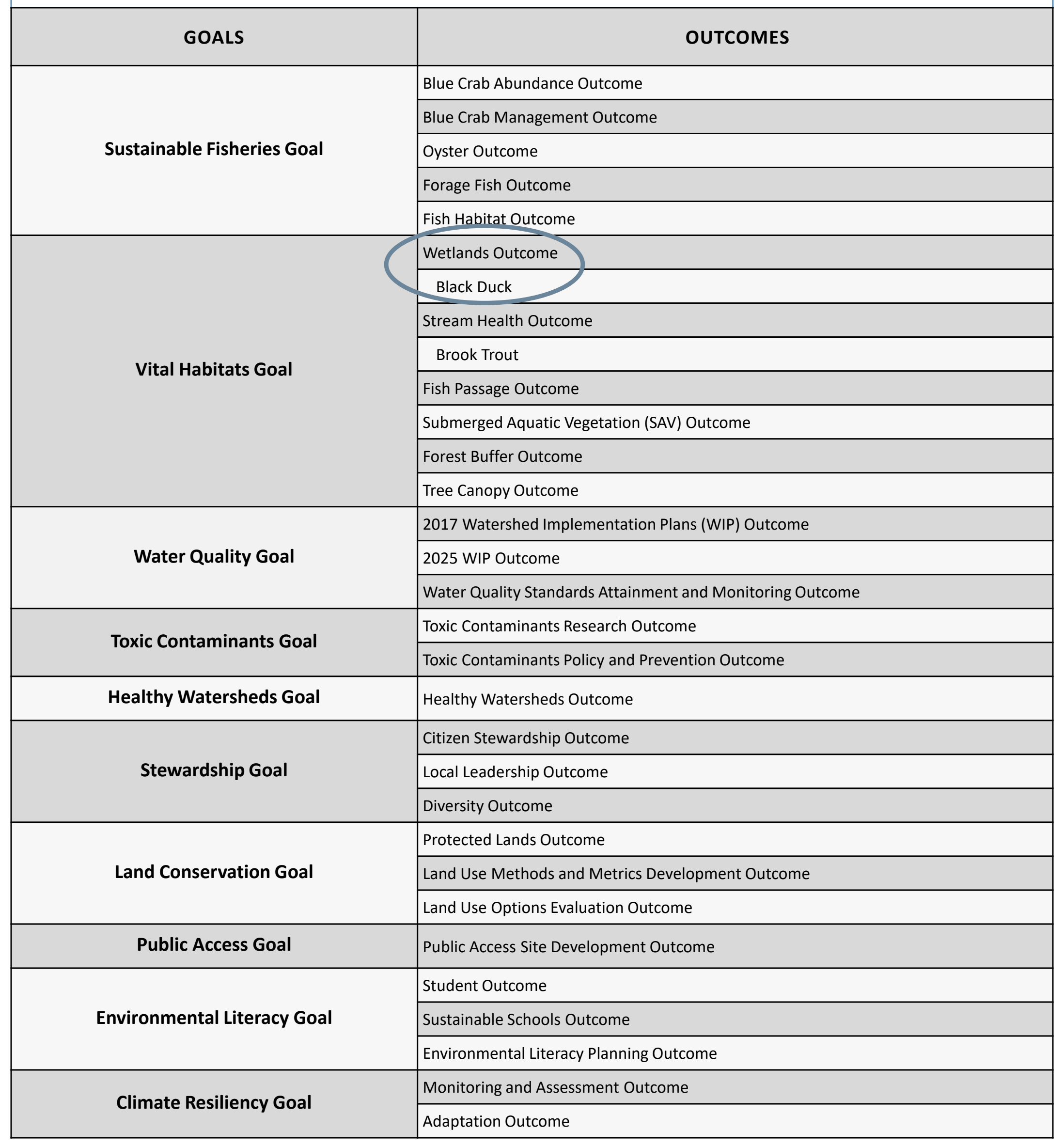
Habitat Tracker

Olivia Devereux & Helen Golimowski, Devereux Consulting, Inc.

habitat-tracker.net

2014 Chesapeake Bay Agreement

10 Goals | 31 Outcomes



GOALS	OUTCOMES
Sustainable Fisheries Goal	Blue Crab Abundance Outcome
	Blue Crab Management Outcome
	Oyster Outcome
	Forage Fish Outcome
	Fish Habitat Outcome
Vital Habitats Goal	Wetlands Outcome
	Black Duck
	Stream Health Outcome
	Brook Trout
	Fish Passage Outcome
	Submerged Aquatic Vegetation (SAV) Outcome
	Forest Buffer Outcome
	Tree Canopy Outcome
Water Quality Goal	2017 Watershed Implementation Plans (WIP) Outcome
	2025 WIP Outcome
	Water Quality Standards Attainment and Monitoring Outcome
Toxic Contaminants Goal	Toxic Contaminants Research Outcome
	Toxic Contaminants Policy and Prevention Outcome
Healthy Watersheds Goal	Healthy Watersheds Outcome
Stewardship Goal	Citizen Stewardship Outcome
	Local Leadership Outcome
	Diversity Outcome
Land Conservation Goal	Protected Lands Outcome
	Land Use Methods and Metrics Development Outcome
	Land Use Options Evaluation Outcome
Public Access Goal	Public Access Site Development Outcome
Environmental Literacy Goal	Student Outcome
	Sustainable Schools Outcome
	Environmental Literacy Planning Outcome
Climate Resiliency Goal	Monitoring and Assessment Outcome
	Adaptation Outcome

Scientific & Restoration Questions Habitat Tracker Can Answer

How many acres of wetlands are newly created (trend over time)?

How many acres of wetlands are in tidal areas, and expected to support black ducks?

How many acres of wetlands are in nontidal areas?

How many projects include a plan for an environmental literacy component (examples: signage, programs)?

Who are the project funders?

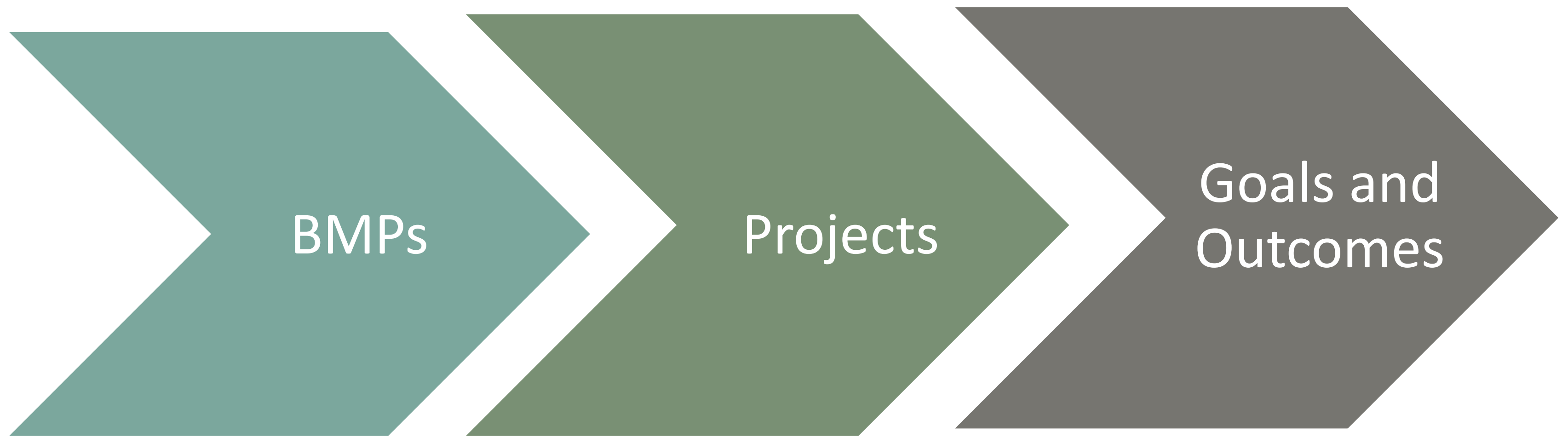
What are the acres of projects supporting Rare Threatened and Endangered (RTE) species, and which ones?

What is the type, number, and extent of management practices implemented on wetlands?

1. **Science:** Integrates multiple levels of project data such as wetland type, land use, community information, supported species, project funders, and more.
2. **Restoration:** Tracks progress toward the Vital Habitats Goal to restore, enhance and protect a network of land and water habitats to support fish and wildlife and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed.
3. **Partnership:** Jurisdictions, Ducks Unlimited, The Nature Conservancy, and other organizations are being asked to provide project data, which will be used for the Chesapeake Bay Progress Outcome reports.

Partnership Using Habitat Tracker

The Habitat Outcome and Attainment Tracking System is a means of collecting and managing the habitat improvement projects implemented in the Chesapeake Bay watershed. A central repository of data from multiple agencies and partners allows a streamlined approach to generate reports needed for ecosystem services tracking and assessments. The Tracking System also facilitates evaluating project implementation goals for trend and targeting analyses.



BMPs

Projects

Goals and Outcomes

Habitat Tracker Integrates with Many Chesapeake Bay Goals

Improved Habitats

Revitalized Communities

Citizen Stewardship, Diversity, Local Leadership

Habitat Tracker Features

- Users upload tables in a standard format with both required and optional data fields.
- Users generate pre-defined reports of practice, programs (funders and voluntary), geography, years, and other parameters. Reports are available as downloadable Microsoft Excel files.
- Allows an upload of data by an administrative user, annually.
- Allows replacement of GIS data including physiographic region, wetland type, and tidal/nontidal areas to update all data attributes that rely on those data.
- All reported data can be parsed by year, state, and HUC-12.

Information and Reporting

A standard form is used to help data submitters identify and report projects that are expected to impact wetlands and black ducks. Reported projects are used to assess progress towards meeting the goals and outcomes established in the 2014 Chesapeake Bay Agreement.

Data include project level information and project goals; with less of a focus on tracking CAST management practices, which are limited to water quality outcomes. Projects include preservation and creation of wetlands and habitat appropriate for black ducks in natural, urban, and agricultural areas.

Fields that are tracked and reported by the Habitat Tracker include:

- Geography and land use
- Project and wetland type
- Public accessibility and recreation
- Flood hazard and climate resiliency data
- Habitat for rare, threatened, or endangered species; at risk/heritage species types
- Environmental literacy components and community information
- Project planning priority type
- Project funders
- Project BMPs and inspections

Contact Information

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habitat-tracker.net

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Phone: (443) 841-2474

Web-based Spatio-temporal Visualization of Water Quality and Habitat Status and Change in Chesapeake Bay

Zhaoying (Angie) Wei[1], Qian Zhang[1], John Wolf[2], Emily Trentacoste[3], Richard Tian[1], Peter Tango[4]

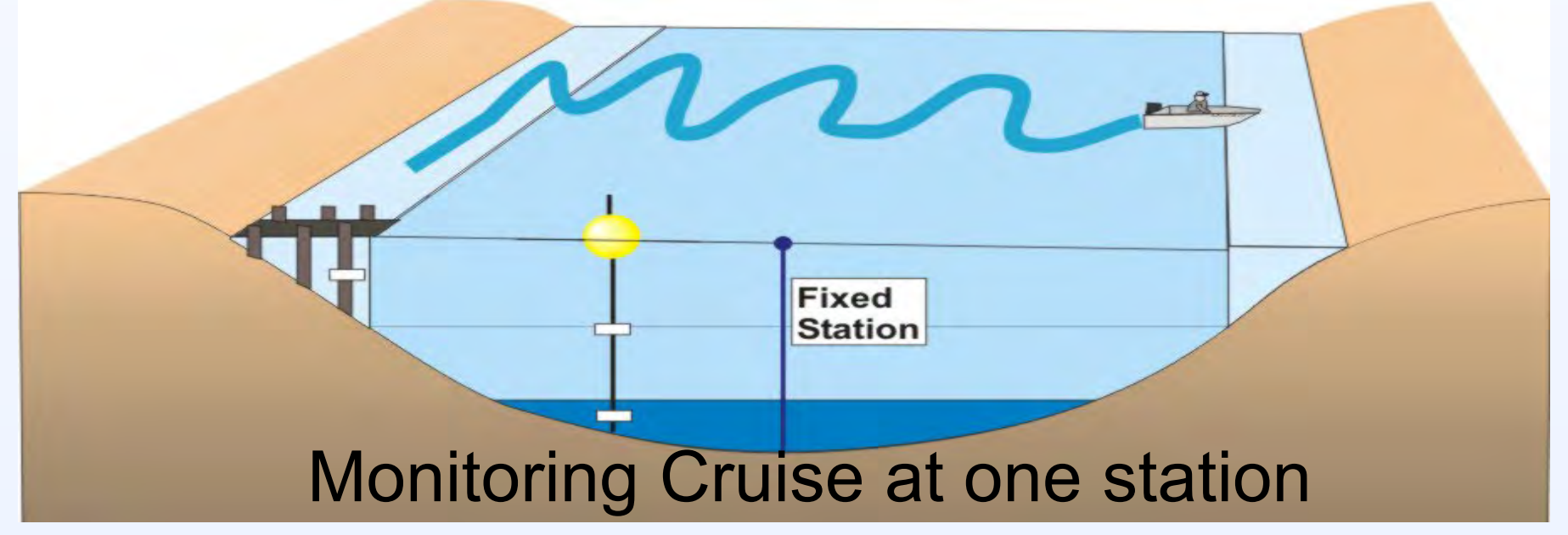
[1]University of Maryland Center for Environmental Science, [2]USGS - Lower Mississippi-Gulf Water Science Center,
[3]USEPA, [4] USGS - MD-DE-DC Water Science Center

Introduction

Spatio-temporal visualization of water quality and living resources data in the Chesapeake Bay has gained popularity in recent years. This web-based 4-dimensional visualization approach provides a good example of utilizing new-generation tools for water quality and habitat depictions and assessments. It shows us how to better integrate, illustrate, and communicate decision-support information from spatio-temporal data.

Chesapeake Bay Monitoring

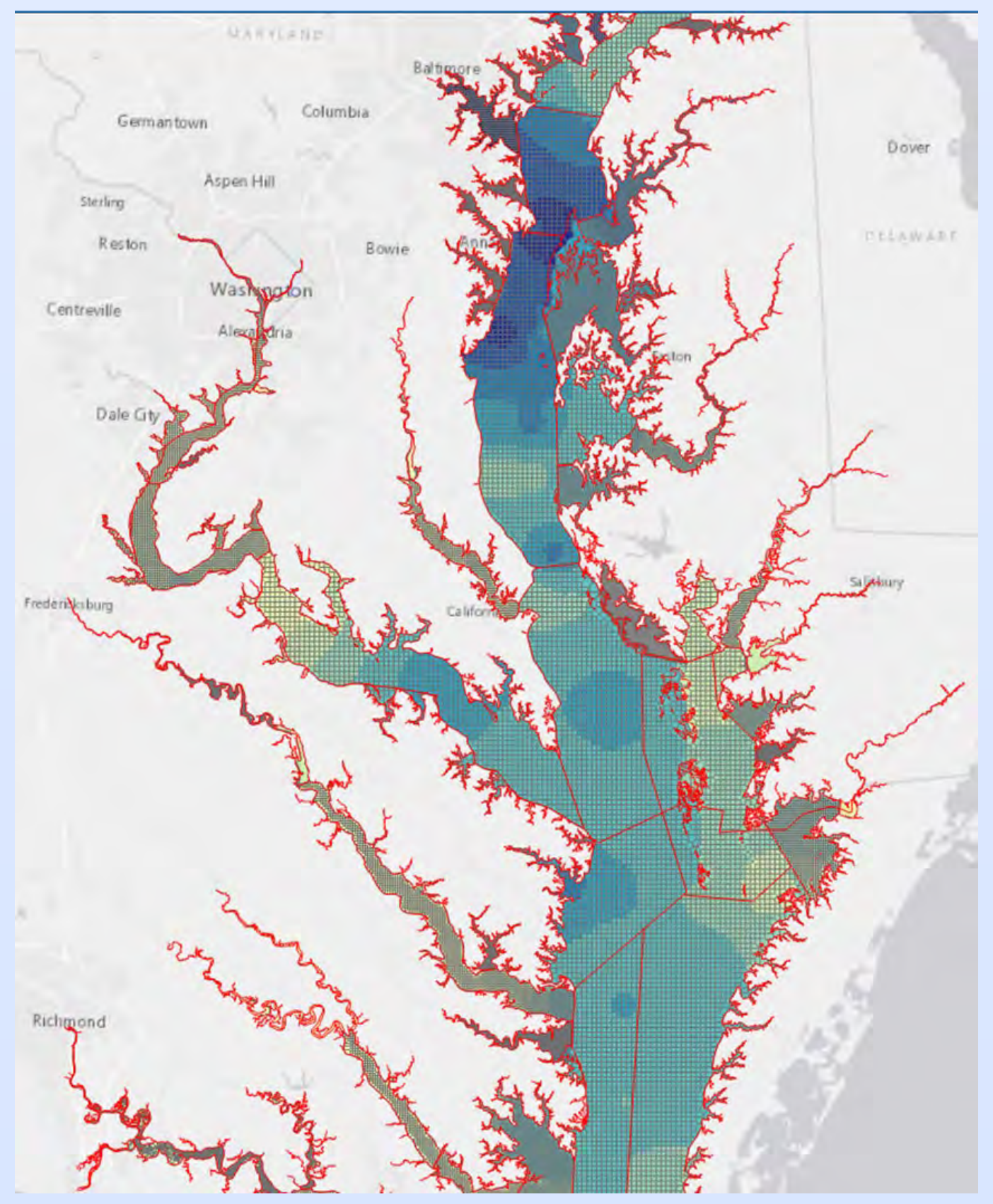
- ☐ Since 1984, MD and VA routinely monitor 19 measured water quality parameters at 49 stations in the Bay's main stem.
- ☐ Cruises are conducted monthly, except 2 cruises per month in June to September.
- ☐ Measurements are taken at one-meter intervals, but every 2 meters below 10 meters.
- ☐ These data are used as input in Chesapeake Bay interpolator.



Monitoring Cruise at one station

Chesapeake Bay Interpolator

- ☐ Cell based interpolator (VOL3D) -current version in use since 2006.
- ☐ Computes water quality concentrations from monitoring data.
- ☐ Cell size 1km x 1km horizontal by 1 m vertical from surface to bottom, in shallow area cell size is 50m x 50m.
- ☐ About 57,000 cells at multiple depths for all 77 segments of the Bay and tributaries. Due to stratification, water quality varies much more vertically than horizontally.

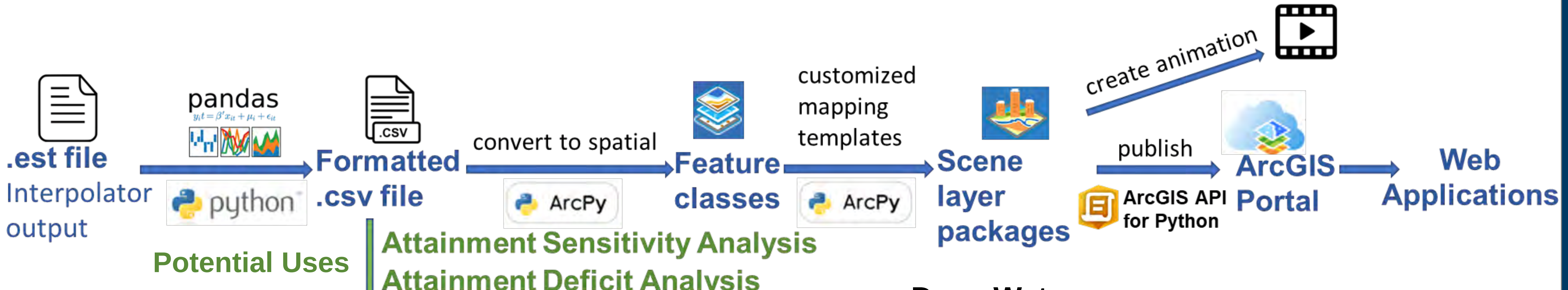


Interpolator cells within monitoring segments

Methodology

In this 4-dimensional visualization for the entire bay, interpolation results from the Chesapeake Bay and Tidal Tributary Interpolator developed by NOAA are utilized as input. We leverage Esri ArcGIS ArcPy 3D mapping capability and open source Python libraries to

(1) restructure the interpolator data
(2) map the data for all depths in 3D scenes at various time steps
(3) generate shareable web scenes and web applications.



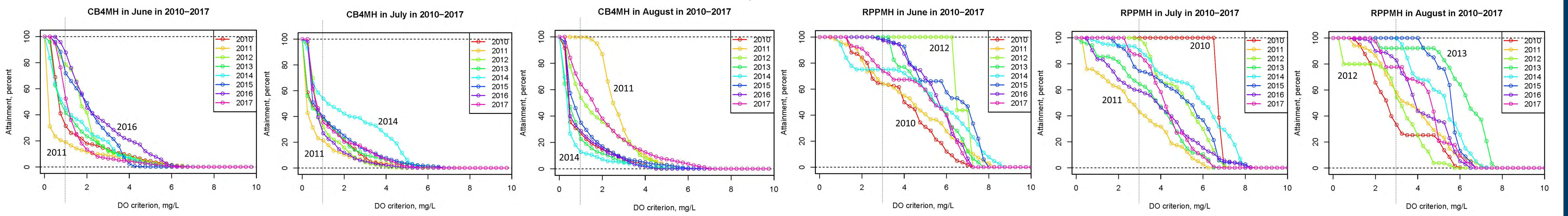
.est file Interpolator output → (pandas, python) → **Formatted .csv file** → convert to spatial (ArcPy) → **Feature classes** → customized mapping templates (ArcPy) → **Scene layer packages** → publish (ArcGIS API for Python) → **ArcGIS Portal** → **Web Applications**

Scene layer packages → create animation

Potential Uses: Formatted .csv file → Attainment Sensitivity Analysis, Attainment Deficit Analysis …

Deep Channel

Deep Water

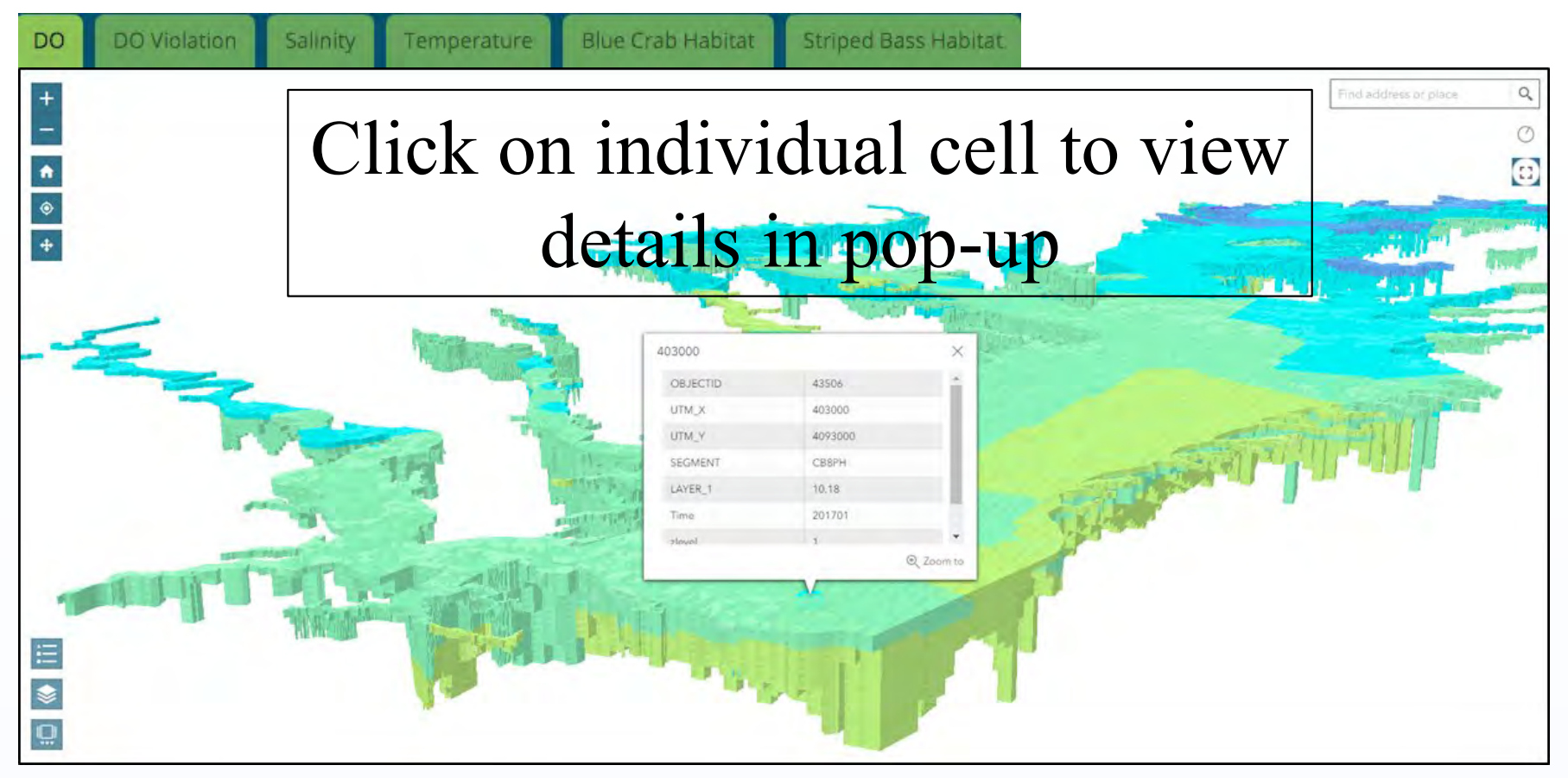


Visualization

We also assess changes in dissolved oxygen violations by comparison to the respective criteria for each designated use of the bay.

https://bit.ly/2IoRqbm

Scan the QR code to launch the web app. It may take a few seconds when first-time launching



Click on individual cell to view details in pop-up

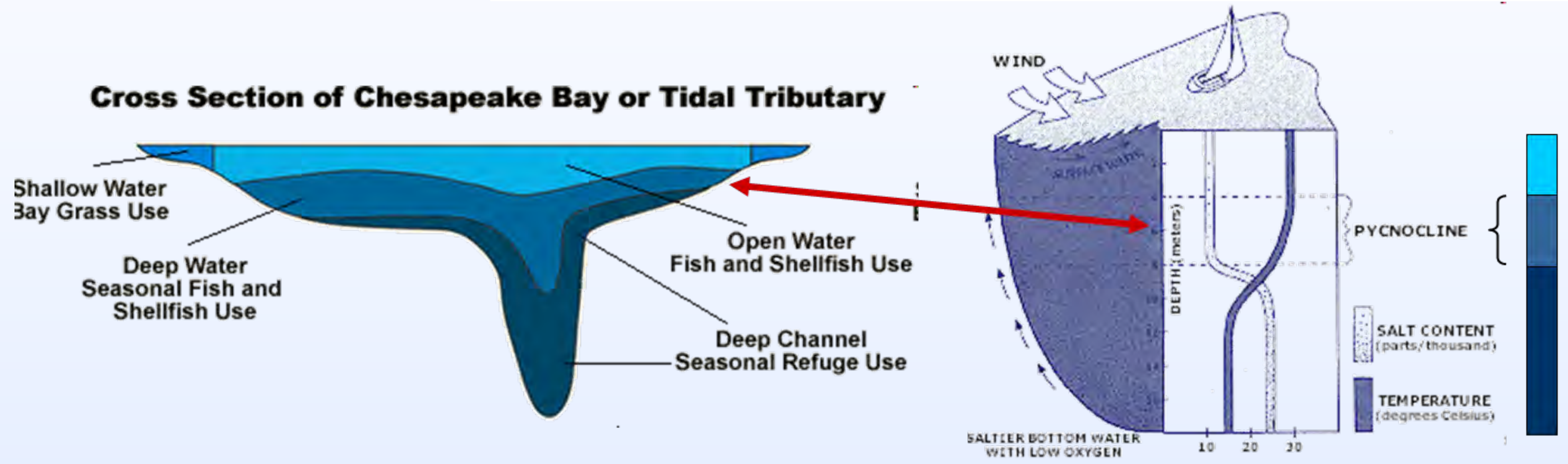
Loop through data of each month using Slides button

Switch on and off layers of different time and depth

Explore from different angles using Navigate button

Water Quality

Designated Use	Season	Threshold	Criteria	Applicable Segments
OW	Year-round	30-day mean	$5\ mg\ L^{-1}$	92
DW	June 1 - Sept. 30	30-day mean	$3\ mg\ L^{-1}$	18
DC	June 1 - Sept. 30	Bi-weekly mean	$1\ mg\ L^{-1}$	10



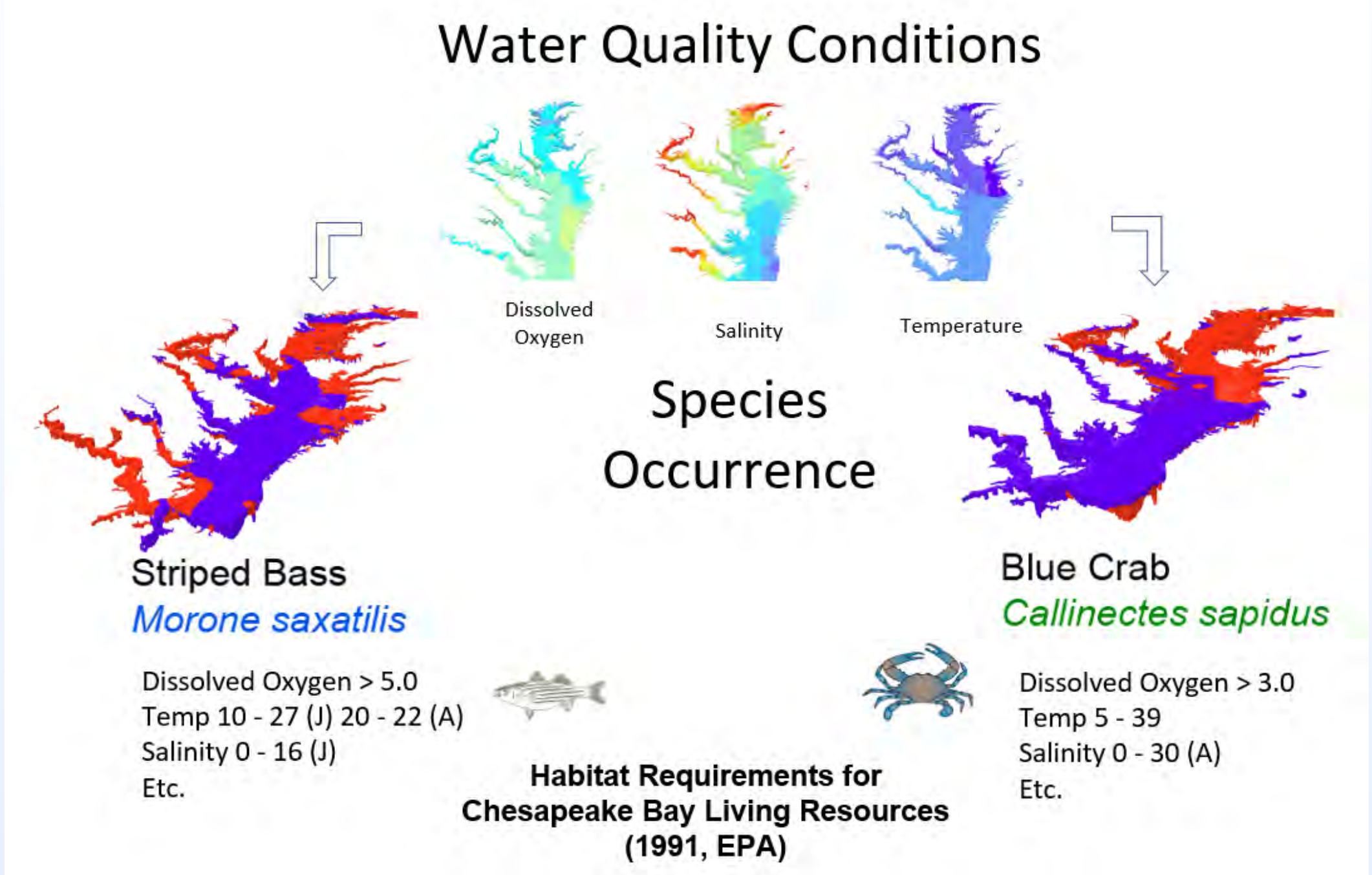
Open Water (OW)

Deep Water (DW)

Deep Channel (DC)

Living Resource Habitat

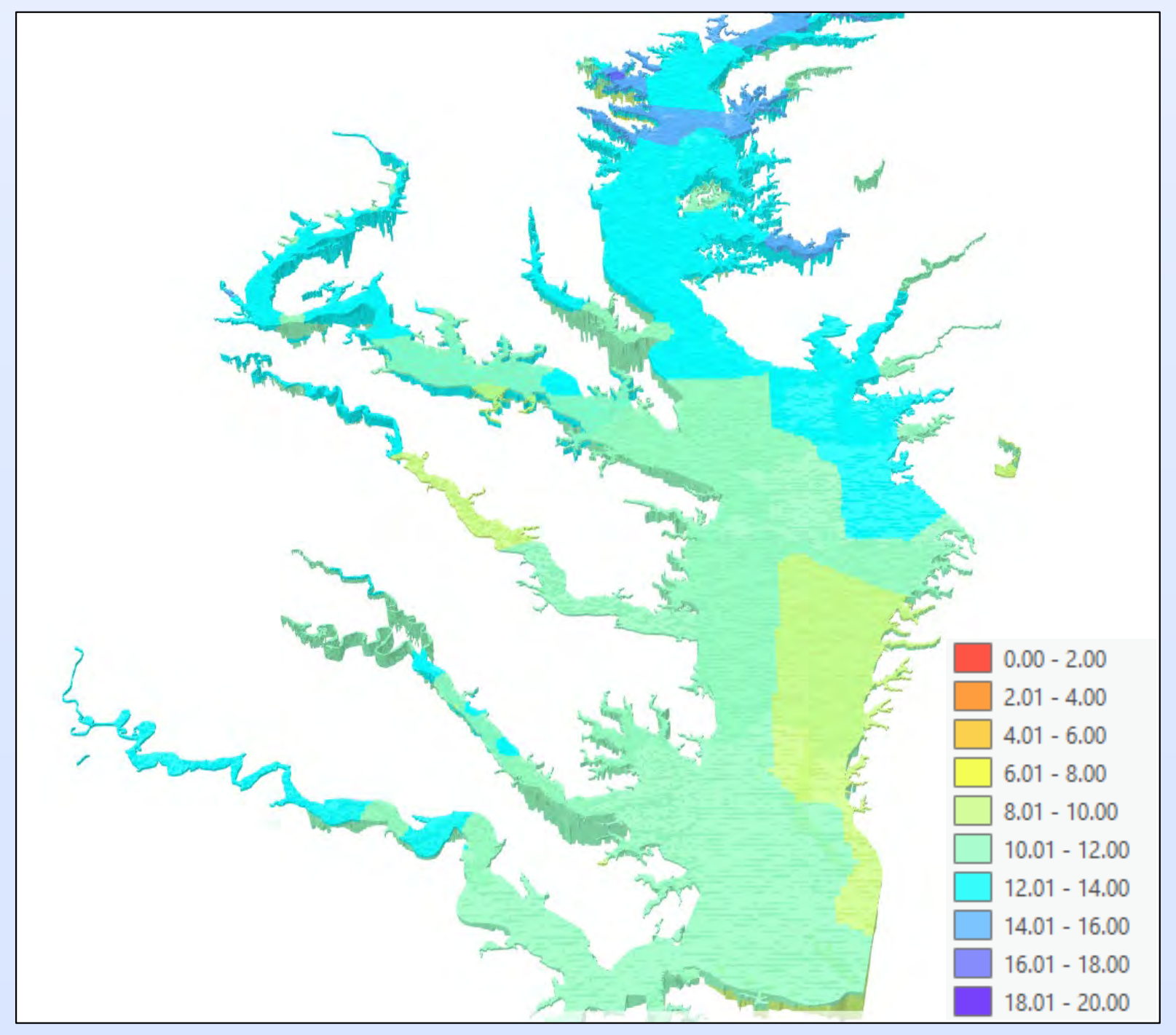
Additionally, habitat status and changes for multiple targeted species are analyzed based on habitat requirements including temperature, salinity and dissolved oxygen.



Striped Bass
Morone saxatilis
Dissolved Oxygen > 5.0
Temp 10 - 27 (J) 20 - 22 (A)
Salinity 0 - 16 (J)
Etc.

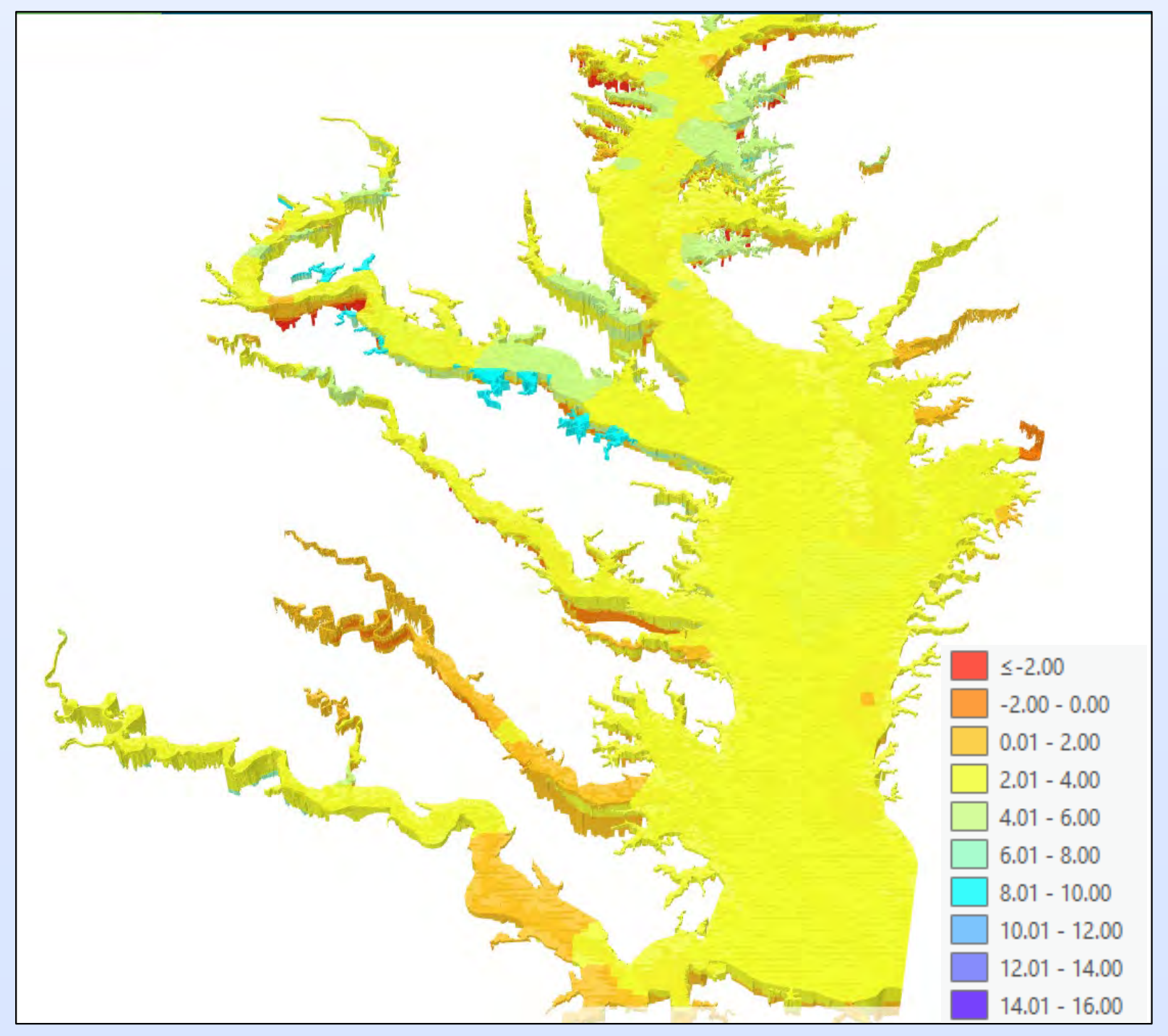
Blue Crab
Callinectes sapidus
Dissolved Oxygen > 3.0
Temp 5 - 39
Salinity 0 - 30 (A)
Etc.

Habitat Requirements for Chesapeake Bay Living Resources (1991, EPA)



🟥	0.00 - 2.00
🟧	2.01 - 4.00
🟧	4.01 - 6.00
🟨	6.01 - 8.00
🟩	8.01 - 10.00
🟩	10.01 - 12.00
🟦	12.01 - 14.00
🟦	14.01 - 16.00
🟪	16.01 - 18.00
🟪	18.01 - 20.00

Monthly Dissolved Oxygen (mg/L)



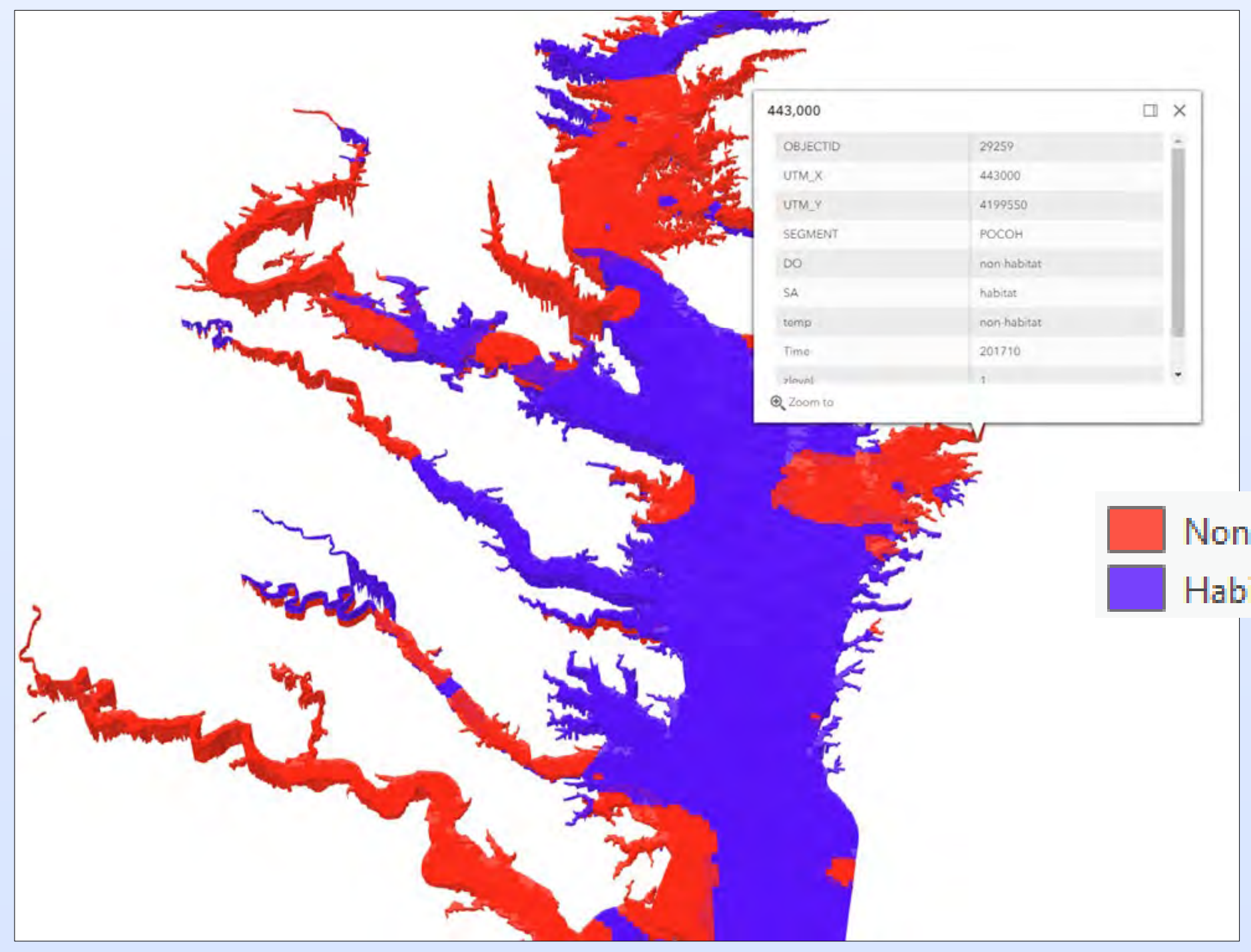
🟥	≤-2.00
🟧	-2.00 - 0.00
🟧	0.01 - 2.00
🟨	2.01 - 4.00
🟩	4.01 - 6.00
🟩	6.01 - 8.00
🟦	8.01 - 10.00
🟦	10.01 - 12.00
🟪	12.01 - 14.00
🟪	14.01 - 16.00

Magnitude of Violation in Dissolved Oxygen (mg/L)

Explore more videos here!

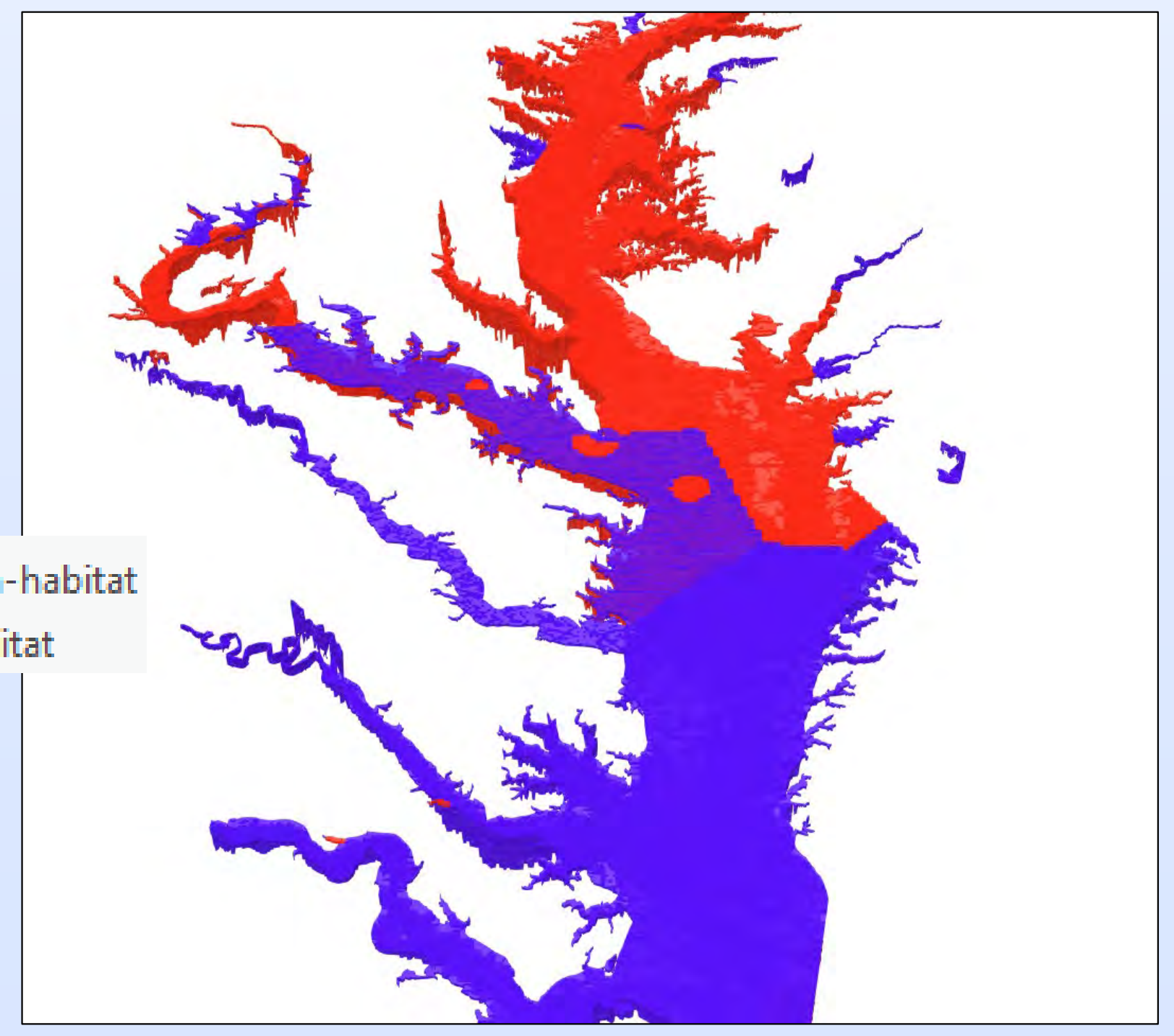
https://bit.ly/31IZXxx

Contact: Zhaoying Wei
zwei@chesapeakebay.net



🟥	Non-habitat
🟪	Habitat

Striped Bass Habitat



Blue Crab Habitat

Chesapeake Bay Watershed Most Effective Basins and Disadvantaged Communities

John Wolf [1], Lee McDonnell [2], Autumn Rose[2], Bailey Bosley [1]

[1] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland, [2] USEPA – Chesapeake Bay Program Office, Annapolis, Maryland

Most Effective Basins

The Chesapeake Bay watershed has been evaluated to determine the river basins likely to have the greatest impact on dissolved oxygen in the deepest waters of the Bay from changes in nonpoint source nitrogen pollution. The Environmental Protection Agency is focusing the implementation of management practices in these "**Most Effective Basins**".

Restoring the Deep Waters of the Mainstem Chesapeake Bay

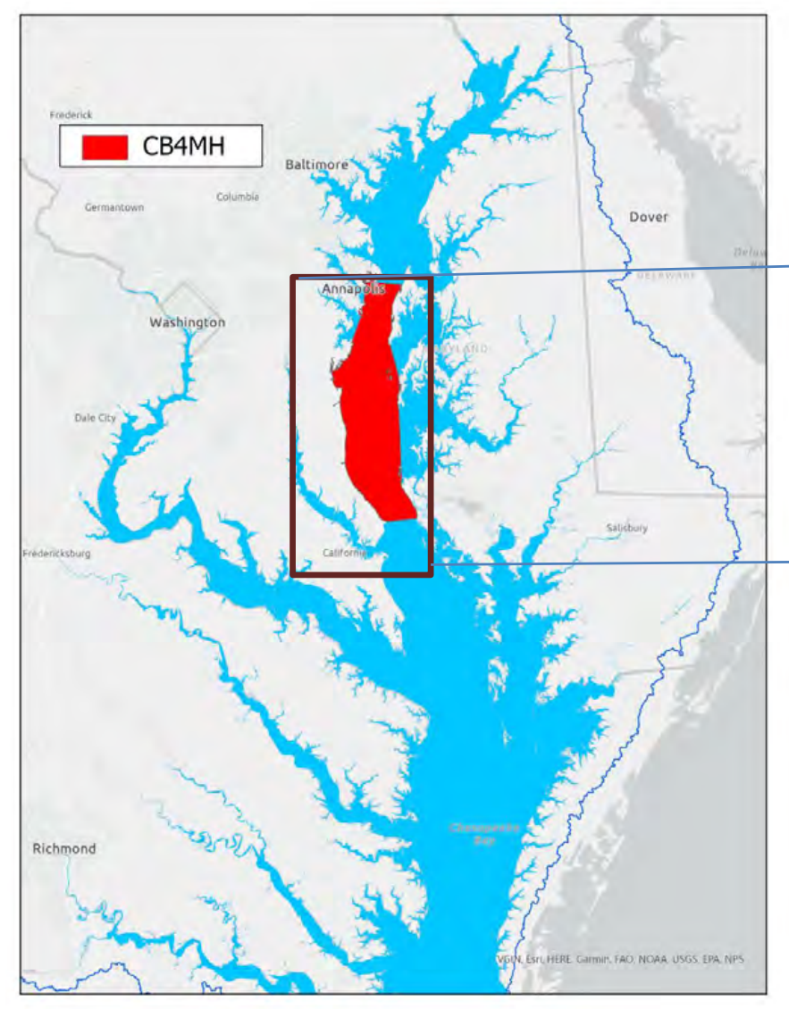


Figure 1. Chesapeake Bay Monitoring Segment CB4MH

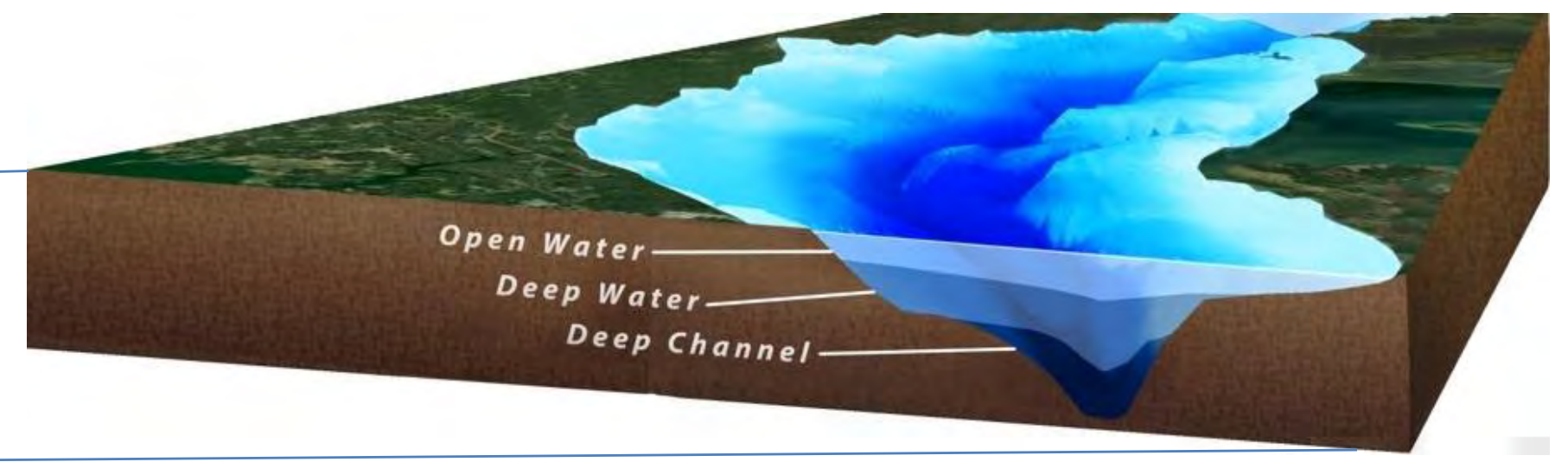


Figure 2. Perspective view of Monitoring Segment CB4MH, showing conceptual delineation of the Deep Water and Deep Channel designated use zones.

The **Chesapeake Bay Pollution Diet** (officially, the Total Maximum Daily Load, or TMDL) is based on restoring conditions in the deepest parts of the mainstem of the Chesapeake Bay. These are represented by the "Deep Water" and "Deep Channel" designated uses.

What is "Load Effectiveness"?

Load effectiveness is a measure of the ability of management practices implemented in a given area (basin) to have a positive impact on dissolved oxygen (DO) in the Bay. Load effectiveness is the combination of three factors: land to water, delivery, and DO response. Each of these factors is described below:

- The *land to water factor* represents **how nitrogen applied to the land moves through the soil and is transported to the water.** It is a measure of the natural propensity of the landscape to deliver nitrogen to waterways.
- The *delivery factor* is an **estimate of the fraction of load reaching a stream**, in a given basin, that will eventually make it to tidal waters.
- The *dissolved oxygen (DO) response factor* is a measure of the Bay's **DO response to nutrient loads** from different areas of the watershed. It is based on estuarine circulation patterns and biogeochemical transformations.

Most Effective Basins – Agriculture

In addition to *load* effectiveness, past analyses of cost per pound of reduction have shown that reducing nitrogen is less costly by far than reducing phosphorus. Furthermore, on average, Best Management Practices (BMPs) placed on agricultural lands have been identified as the most *cost* effective BMPs.

Figure 3. Farmland in Union County, Pennsylvania
Photo Credit: Will Parson, Chesapeake Bay Program

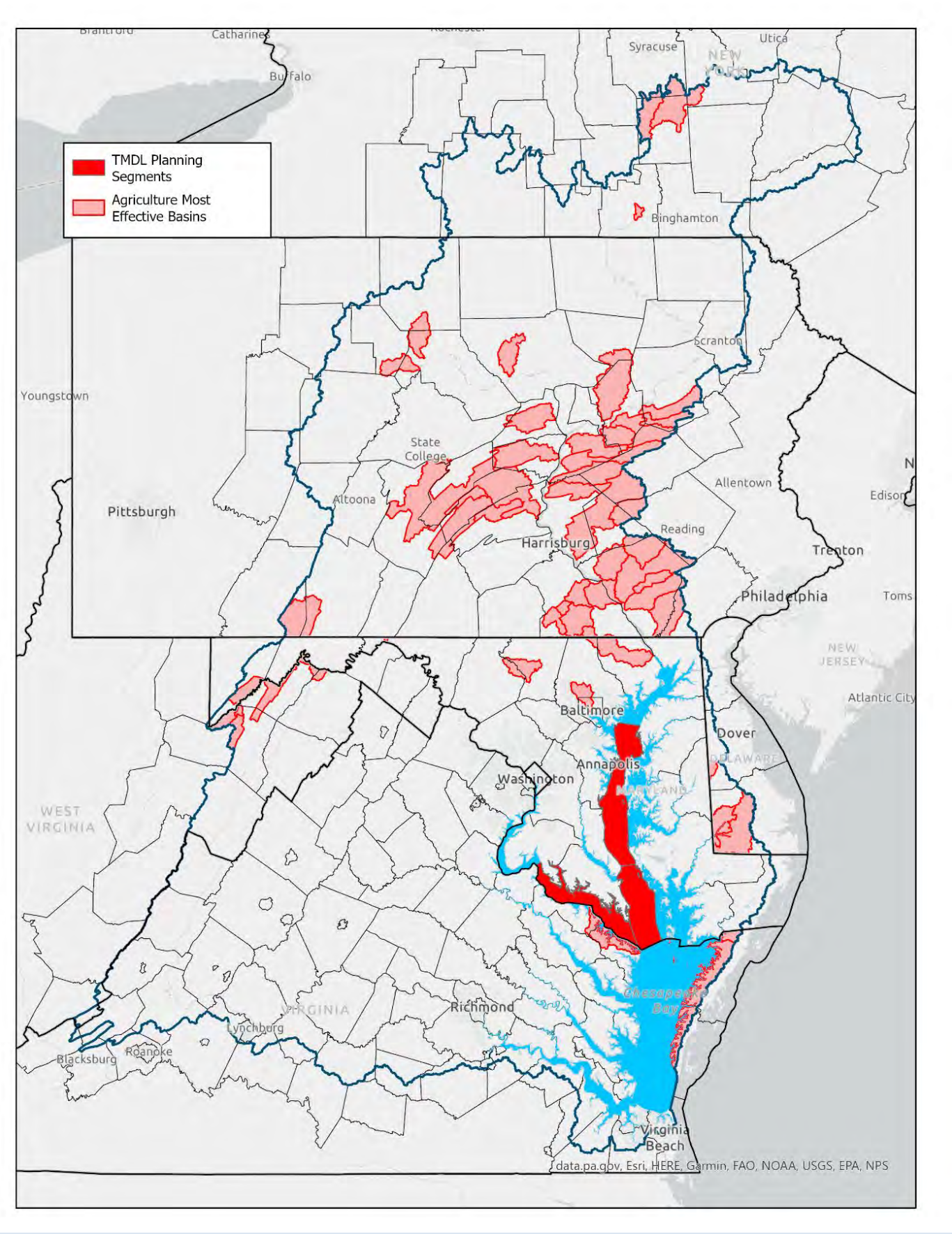


Figure 4. Most Effective Basins (2020), based on nitrogen loads at the State-River basin scale from agricultural sources.

Most Effective Basins – Infrastructure

The Infrastructure Investment and Jobs Act (IIJA), signed into law on November 15, 2021, has authorized significant additional funding for Chesapeake Bay restoration. For Fiscal Year 2022, an additional $15 million is being directed toward areas in the Chesapeake Bay watershed that are most effective for nitrogen reduction from all nonpoint sources.

Figure 5. Breton Bay in St. Mary's County, Maryland
Photo Credit: Will Parson, Chesapeake Bay Program

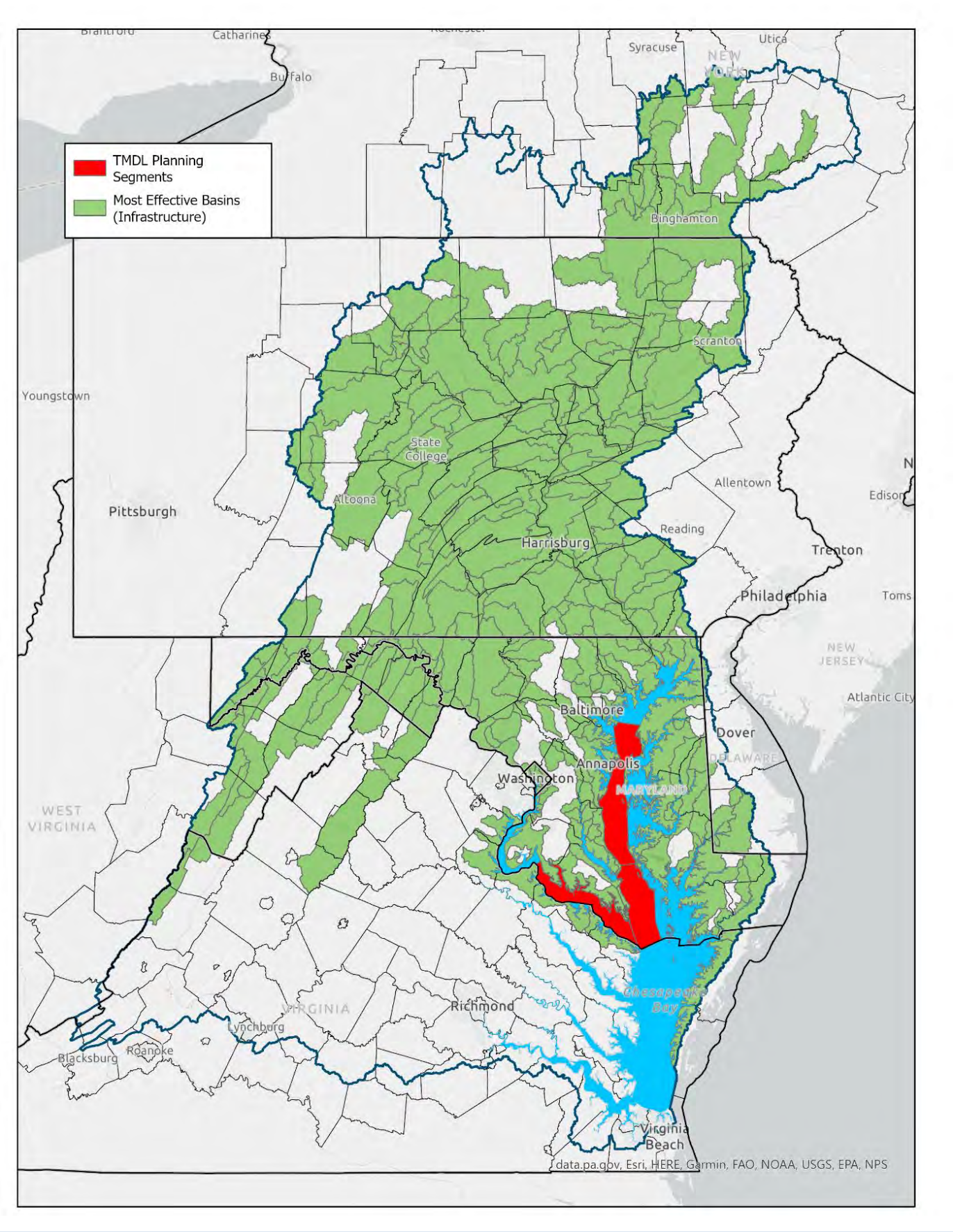


Figure 6. Most Effective Basins (2022) , based on State-River basins with a nitrogen relative effectiveness > 7.0 from all nonpoint sources.

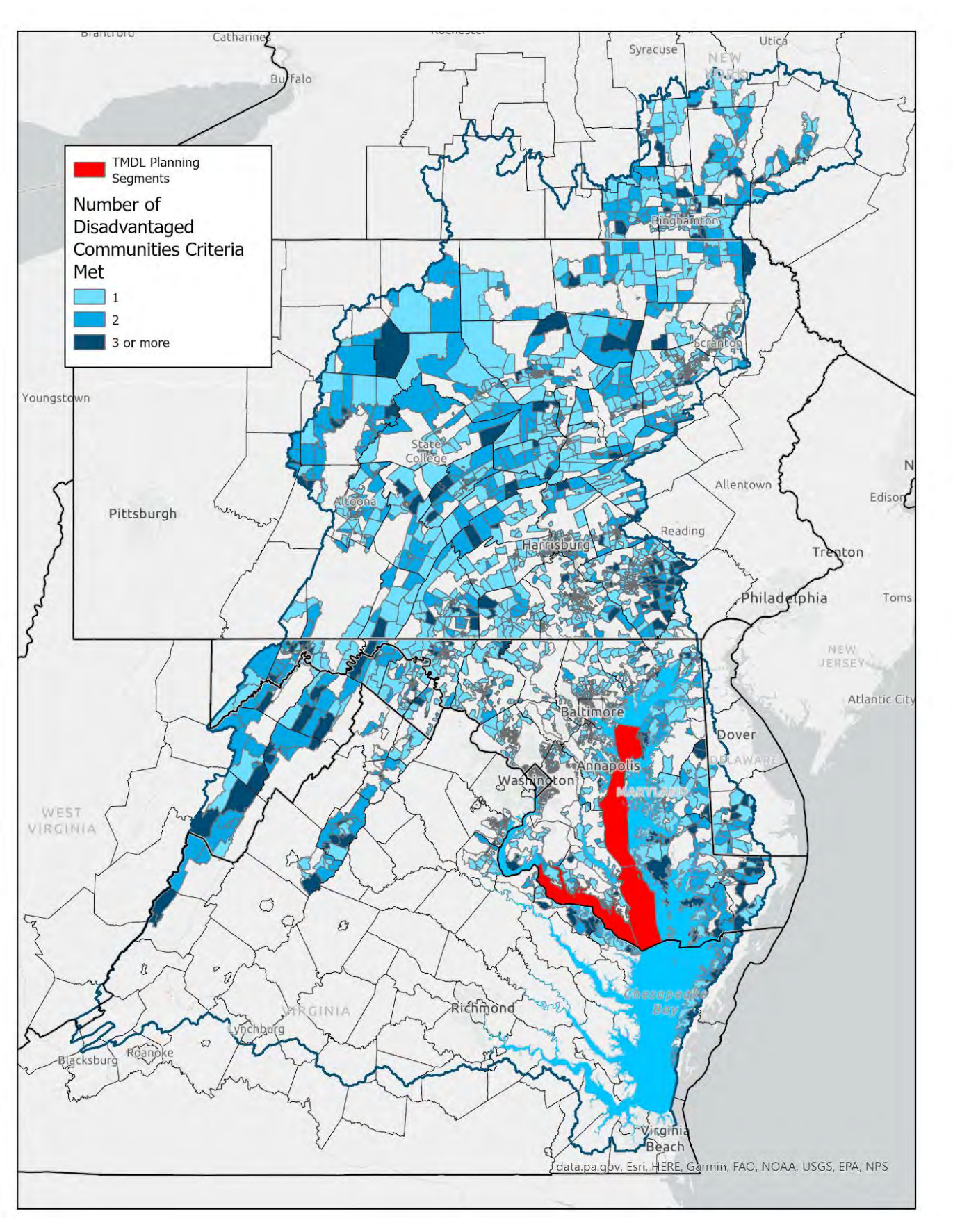


Figure 7. Census block groups containing one or more disadvantaged community criteria within Most Effective Basins (2022).

Disadvantaged Communities

A subset of Most Effective Basins grant funding is being targeted to areas containing one or more **disadvantaged communities**. These include census block groups containing a higher amount of:

- Low-income populations
- Populations under the age of 5
- Populations over the age of 64
- Populations with less than high school education
- Linguistically isolated populations
- Unemployed populations

Figure 8. Middle Branch Park in Baltimore County, Maryland
Photo Credit: Will Parson, Chesapeake Bay Program

For More Information

Chesapeake Bay Program Grant Guidance:

USEPA. 2022. 2022 Chesapeake Bay Program Grant Guidance. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-5/2022%20CBPO%20Grant%20Guidance_May%202022.pdf.

USEPA. 2022. Addendum to the U.S. Environmental Protection Agency Chesapeake Bay Program Office Grant and Cooperative Agreement Guidance: May 19, 2022. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-05/Addendum%20to%20the%202022%20Grant%20Guidance_Final%20May%202022.pdf.

USEPA. 2022. Chesapeake Bay Program Office Most Effective Basins Funding Allocations. Retrieved June 19, 2022, from https://www.epa.gov/system/files/documents/2022-05/Attachment%2018_MEB%20Funding%20Allocations-May%202022_0.pdf.

Most Effective Basins Grant Funding

By Jurisdiction

Figure 9. Most Effective Basins funding allocation among jurisdictions in thousands of dollars [Ag = agriculture, Inf = infrastructure, Gen = general ($ can be applied anywhere within MEBs), Dis = disadvantaged communities ($ must be applied in area containing one or more disadvantaged communities)]

By Funding Source

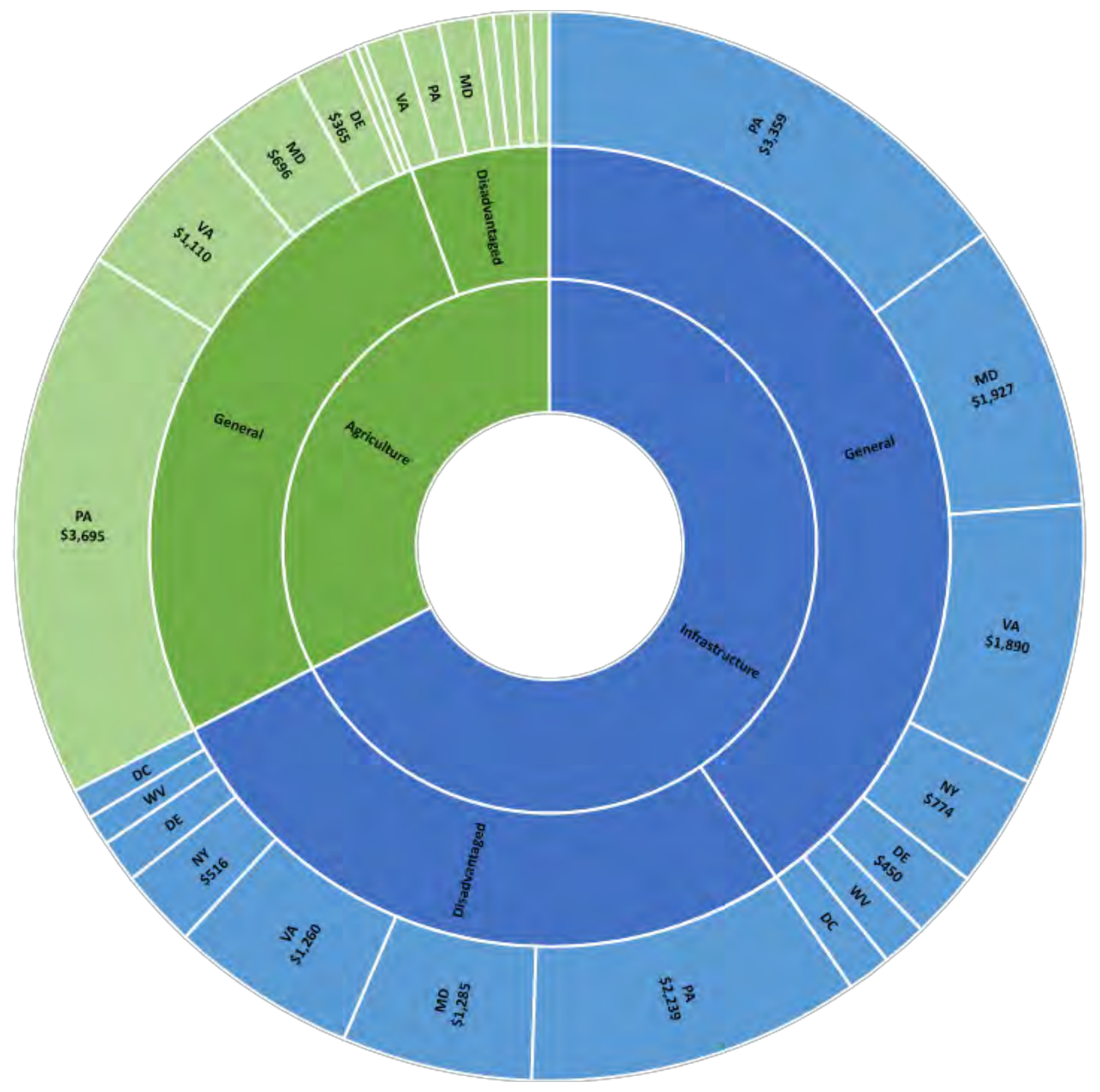


Figure 10. Most Effective Basins funding allocation among funding sources in thousands of dollars [Ag = agriculture, Inf = infrastructure, Gen = general ($ can be applied anywhere within MEBs), Dis = disadvantaged communities ($ must be applied in area containing one or more disadvantaged communities)]

Web Applications

The web applications below provide additional detail and guidance on the interpretation of the Chesapeake Bay Most Effective Basins.

Most Effective Basins and Disadvantaged Communities 2022 Mapping Application
gis.chesapeakebay.net/wip/meb2022/

Most Effective Basins 2022 Story Map Application
gis.chesapeakebay.net/wip/meb2022overview/

Acknowledgments

Thanks to Gary Shenk (USGS), Jeff Sweeney (USEPA), Veronica Hines (Maximus/Attain), and Tim Paris (Maximus/Attain) for contributions to this effort.

Chesapeake Bay Segment Explorer

Zhaoying (Angie) Wei[1], John Wolf[2]

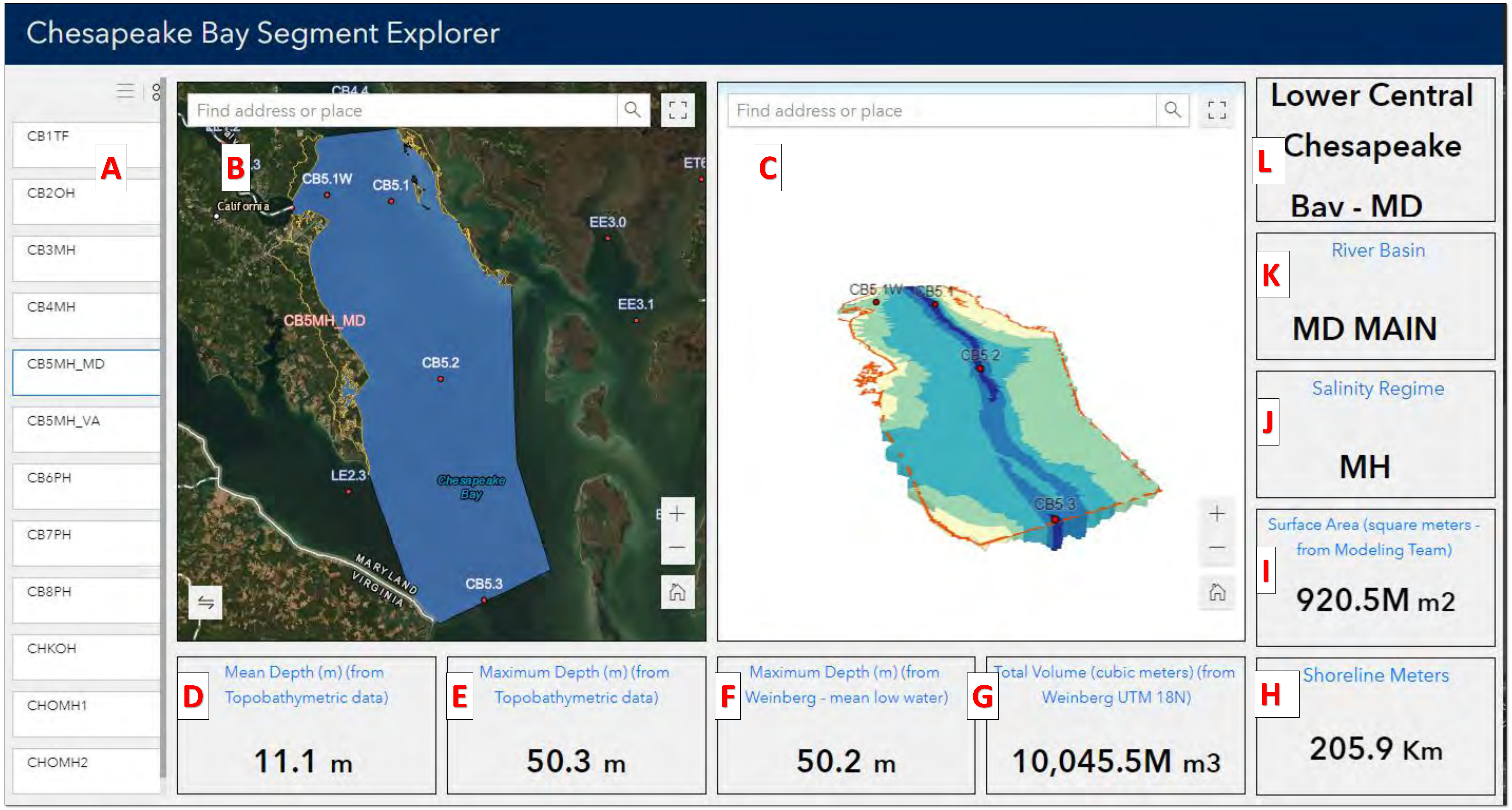
[1] University of Maryland Center for Environmental Science, [2] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Introduction

The Chesapeake Bay Total Maximum Daily Load (TMDL) allocations for nutrients and sediment serve as the basis of comprehensive watershed restoration plans to restore water quality and living resources in the Chesapeake Bay. Water quality standards attainment is evaluated based on a four-dimensional assessment of designated uses in 92 Chesapeake Bay segments[1]. The Chesapeake Bay Segment Explorer is a web application that provides segment-specific physical characteristics as well as both 2D and 3D visualizations of each segment.

3D Visualization and the Chesapeake Bay SCHISM Model

- ☐ The 3D grids used in 3D visualization is constructed based on Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM).
- ☐ SCHISM is a 3D seamless cross-scale model grounded on unstructured grids (UG) for hydrodynamics and ecosystem dynamics.
- ☐ The implementation of the SCHISM grids in Chesapeake Bay is still in progress. This model is currently available in Mainstem, James River and York River segments.
- ☐ For more details on SCHISM, go to http://ccrm.vims.edu/schismweb/



Lower Central Chesapeake Bay - MD

River Basin
MD MAIN

Salinity Regime
MH

Surface Area (square meters - from Modeling Team)
920.5M m2

Mean Depth (m) (from Topobathymetric data)
11.1 m

Maximum Depth (m) (from Topobathymetric data)
50.3 m

Maximum Depth (m) (from Weinberg - mean low water)
50.2 m

Total Volume (cubic meters) (from Weinberg UTM 18N)
10,045.5M m3

Shoreline Meters
205.9 Km

Explanation of the Explorer Interface

The Chesapeake Bay Segment Explorer provides a window into baseline physical characteristics of monitoring segments of the Chesapeake Bay. This Section provides a key to Explorer interface.

A – User selects a Chesapeake Bay segment that populates the other windows in the Explorer application.

B – A two-dimensional map is presented for the chosen segment. The map includes the boundaries of the segment, any tidal water quality monitoring stations found in the segment, and TMDL segmentsheds.

C – A three-dimensional scene depicting the extent of the segment, color-coded by bathymetric depth as represented in the SCHISM model. Both the 2D map and 3D scene are interactive. The 3D scene incorporates vertical exaggeration of 100x.

D – Mean depth of the segment based on high-resolution topobathymetry from CoNED[2].

E – Maximum depth of the segment based on high-resolution topobathymetry from CoNED[2].

F – Maximum depth of the segment from historical Chesapeake Bay soundings (1859 – 2015)

G – Total volume of the segment based on Chesapeake Bay Program high-resolution shoreline and the historical soundings.

H – Th estimated shoreline distance within each segment calculated using Chesapeake Bay Program High resolution shoreline (in Albers Equal Area Projection).

I – Segment surface area provided by the Chesapeake Bay Program Modeling Team.

J – Salinity regime used to segment river basins as follows:

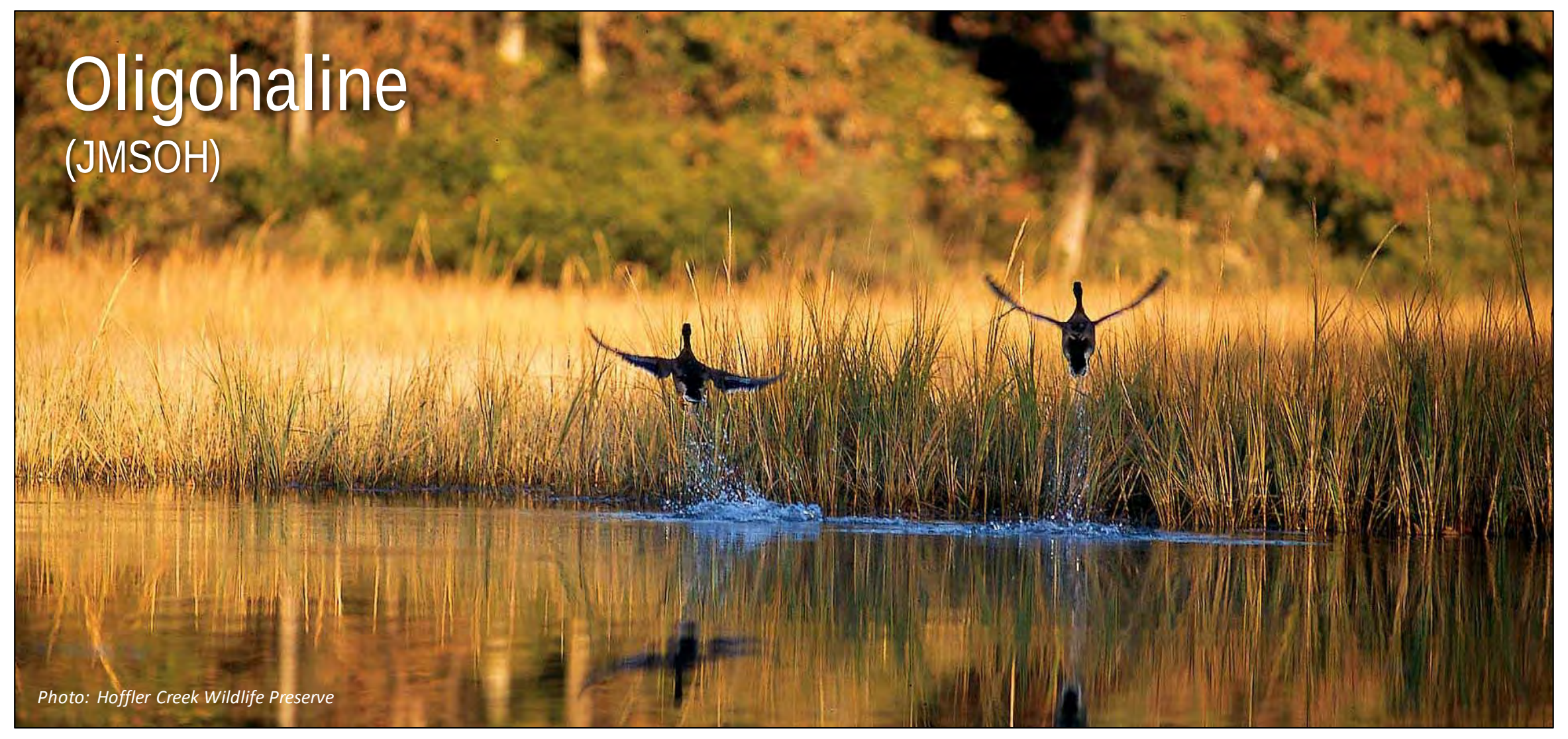
- Tidal Fresh (TF): 0-5 ppt
- Oligohaline (OH): > 0.5-5 ppt
- Mesohaline (MH): > 5-18 ppt
- Polyhaline (PH): > 18 ppt

K – River basin was defined as the major tidal tributaries along with mainstem Chesapeake Bay Segments. Tributaries were segmented from mainstem at the mouth of each river.

L – Name of selected segment.

Salinity Regime Examples


Tidal Fresh
(JMSTF1)
Photo: Chesapeake Bay Gateways Network


Oligohaline
(JMSOH)
Photo: Hoffler Creek Wildlife Preserve


Mesohaline
(JMSMH)
Photo: Envision the James (Chesapeake Conservancy)


Polyhaline
(CB8PH)
Photo: Commonwealth of Virginia

Technology and Future Plans

The Chesapeake Bay Segment Explorer is an ArcGIS Experience Builder application that leverages a 2D web map and a 3D web scene.

Future plans include the potential integration of the segment explorer with water quality standards attainment information currently presented in the Watershed Data Dashboard. (https://gis.chesapeakebay.net/wip/dashboard)

Interactive Web Application

https://bit.ly/3HrawLc

Note: The Chesapeake Bay Segment Explorer is not recommended for mobile devices at present time.

References

1. USEPA (U.S. Environmental Protection Agency). 2005. Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983-2003. 2005 Addendum. EPA 903-R-05-004. CBP/TRS 278-06. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

2. OCM Partners, 2022: 2016 USGS CoNED Topobathymetric Model (1859 - 2015): Chesapeake Bay Region, https://www.fisheries.noaa.gov/inport/item/55321.

USGS Chesapeake Science Workshop
June 2022

Chesapeake Bay Watershed Data Dashboard: Tools to Support & Inform Restoration Management

Jackie Pickford[1], Kaylyn Gootman[2], Ruth Cassilly[3]

Adapted from materials created by Emily Trentacoste[2] & John Wolf[4].

[1]Chesapeake Research Consortium; [2]Environmental Protection Agency; [3]University of Maryland; [4]US Geological Survey.

What is the Watershed Data Dashboard?

The Data Dashboard an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

It consolidates the vast amount of scientific and technical information available to environmental managers and planners in a single cohesive location, making it easier for partners at all levels to get information about their area of interest.

What can you do with the Dashboard?

Some uses of the Dashboard include:

- ➢ Targeting restoration efforts geographically, by sector, or by practice
- ➢ Developing scenarios to run on the Chesapeake Assessment Scenario Tool (CAST)
- ➢ Outreach and communication of water quality information
- ➢ Building local watershed stories to engage with stakeholders

What information does the Dashboard contain?

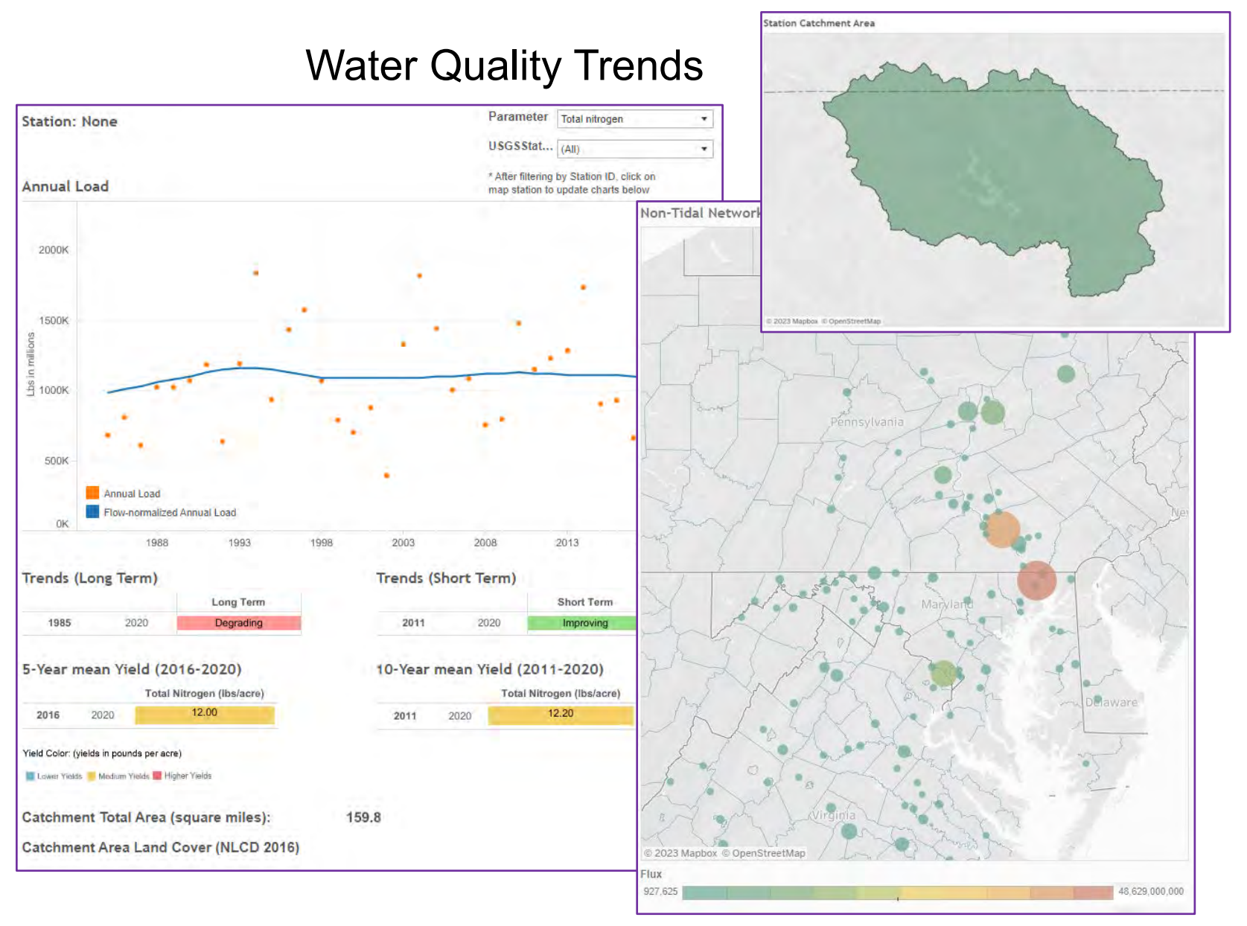
The Dashboard is organized in modules based on the type of information and the questions a planner may be trying to answer. The headings below reflect the modules and their individual sections.

Module: Non-tidal Water Quality (Streams & Rivers)

Water Quality Trends

Information on the amount of nutrients and sediment at the monitoring stations throughout the watershed and trends over time that account for stream flow (flow-normalized).

Water Quality Trends



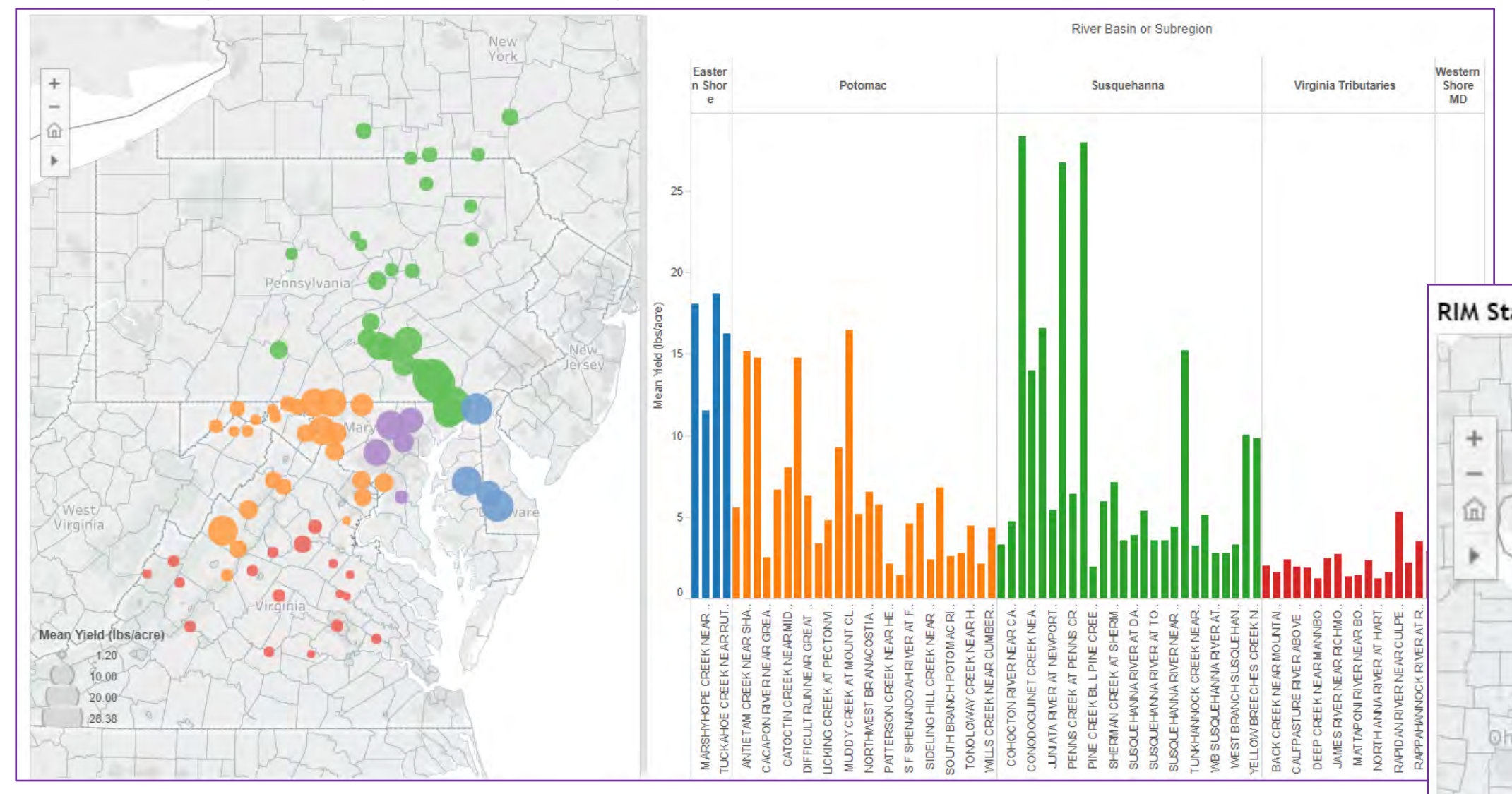
What can I do with this information?

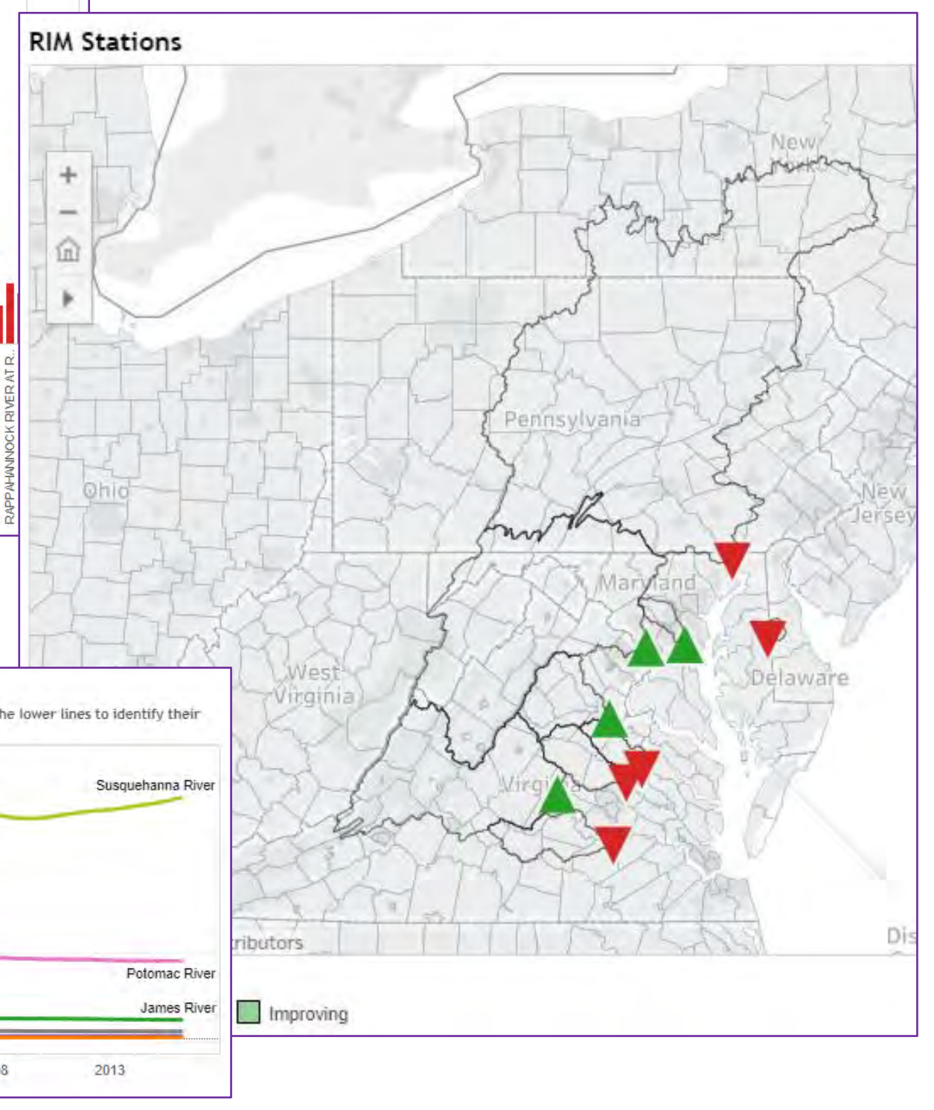
- **Learn the status** of nutrient and sediment levels in streams and rivers in your area of interest.
- **Compare** the amount of nutrients and sediment **between streams and rivers** across the region.
- **Identify changes over time** in nutrient and sediment levels in streams and rivers.
- **Assess progress** by determining if nutrient and sediment conditions are improving or degrading.
- **Target or prioritize watersheds** for restoration efforts by identifying those with high amounts of nutrients and sediment, especially relative to size.
- **Explore the tidal connection** by reviewing the amounts of nitrogen and phosphorus that directly enter the Bay tidal waters from its nine major rivers.
- **Understand important drivers of water quality** such as watershed characteristics like size and land-cover/land-use.

Comparing Watersheds

Provides the average amount of nutrients and sediment at monitoring stations accounting for watershed size (lbs pollutant/acre/year watershed), allowing for easy comparison across the region and within sub-regions.

Comparing Sub-region Monitoring Trends

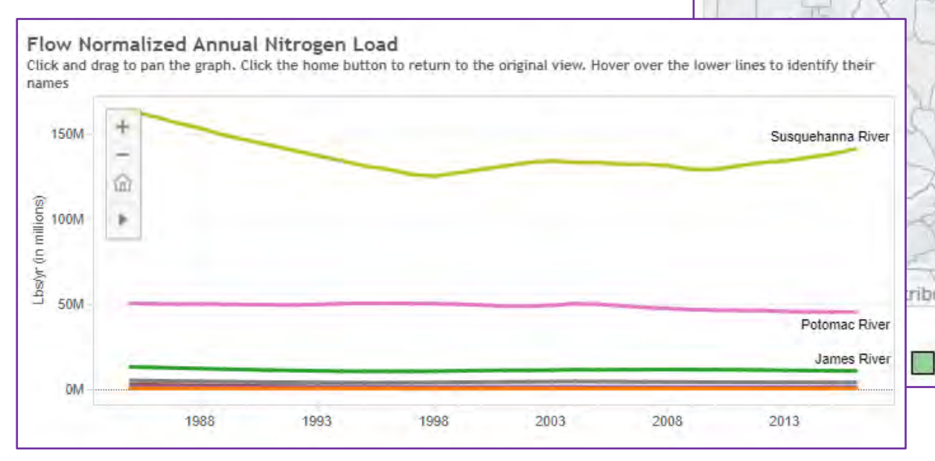




River Contributions to Tidal Waters

Trends accounting for stream flow (flow-normalized) of nitrogen and phosphorus in the nine major rivers at locations where they flow directly into the Bay's tidal waters.

Stream Flow Nitrogen Trends



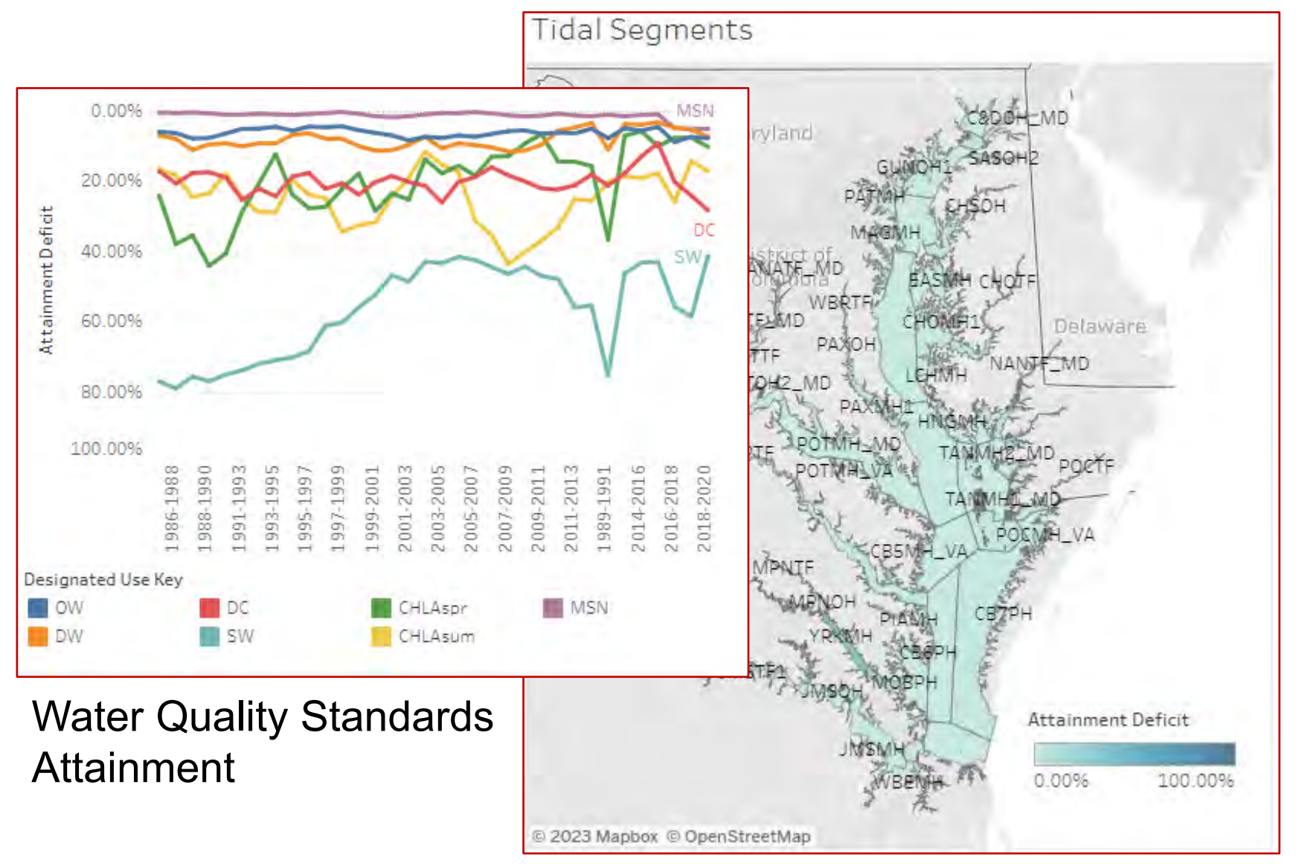
Check it Out Yourself!

http://gis.chesapeakebay.net/wip/dashboard

Module: Tidal Water Quality & Living Resources

Water Quality Standards Attainment

Information on attainment of water quality standards for protecting aquatic life in tidal areas. 'Attainment deficit' depicts how far away non-attaining areas are from meeting standards.

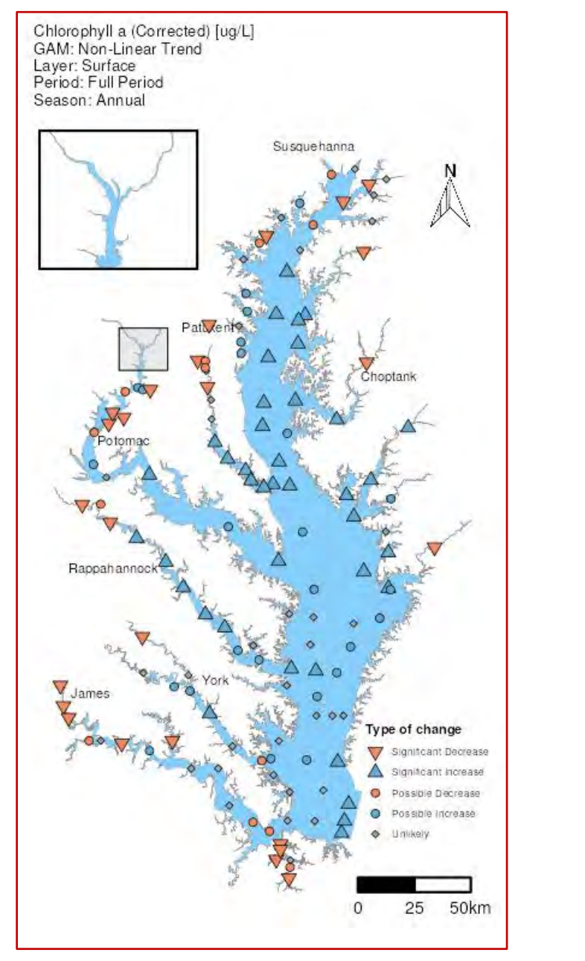


Water Quality Standards Attainment

What can I do with this information?

- **Learn the status** of water quality and living resources in your tidal area of interest.
- **Identify changes over time** in water quality standards, water quality and living resources.
- **Assess progress** by determining if conditions are improving or degrading, and by comparing to goals.
- **Target or prioritize** areas for management actions by identifying tidal areas in need of restoration and identifying effective upstream watersheds for efforts.
- **Explore management options** by understanding specific influences on submerged aquatic vegetation in tidal areas, or identifying influential wastewater treatment plants.
- **Understand important drivers** of water quality and living resources such as influential areas of the watershed and wastewater treatment plants discharging to tidal waters.

Tidal Water Quality Monitoring



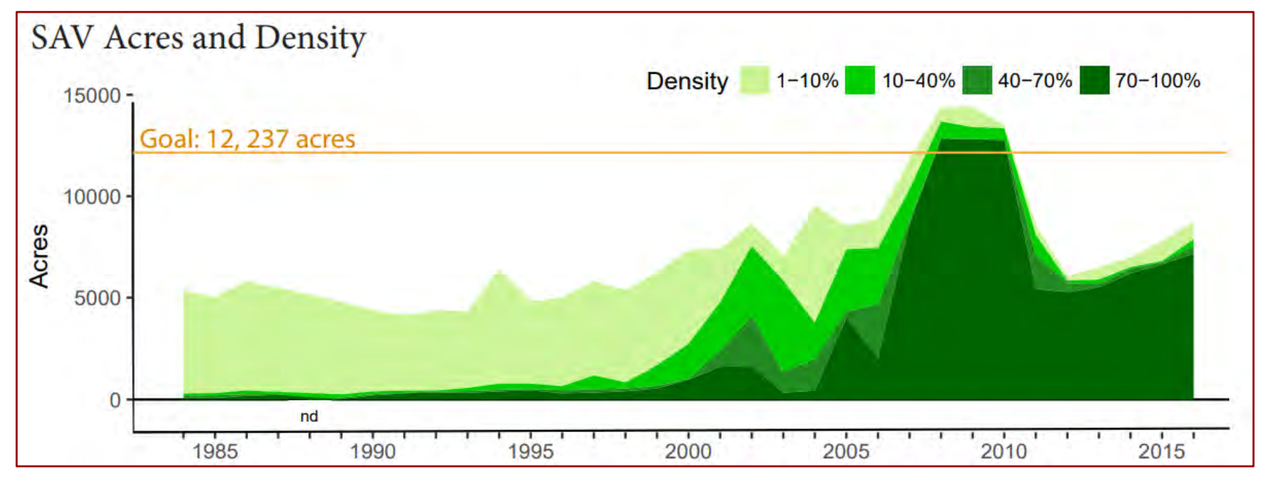
Tidal Water Quality Monitoring

Water quality monitoring data and trends at the Bay's tidal monitoring stations. These parameters include secchi depth for water clarity, concentrations of nitrogen, phosphorus, suspended sediment and dissolved oxygen, and temperature.

Submerged Aquatic Vegetation

Provides fact sheets with annual acreage and density data for submerged aquatic vegetation for different areas of the tidal waters with similar vegetation populations, and timelines of events that influence, contribute to, or explain the changes.

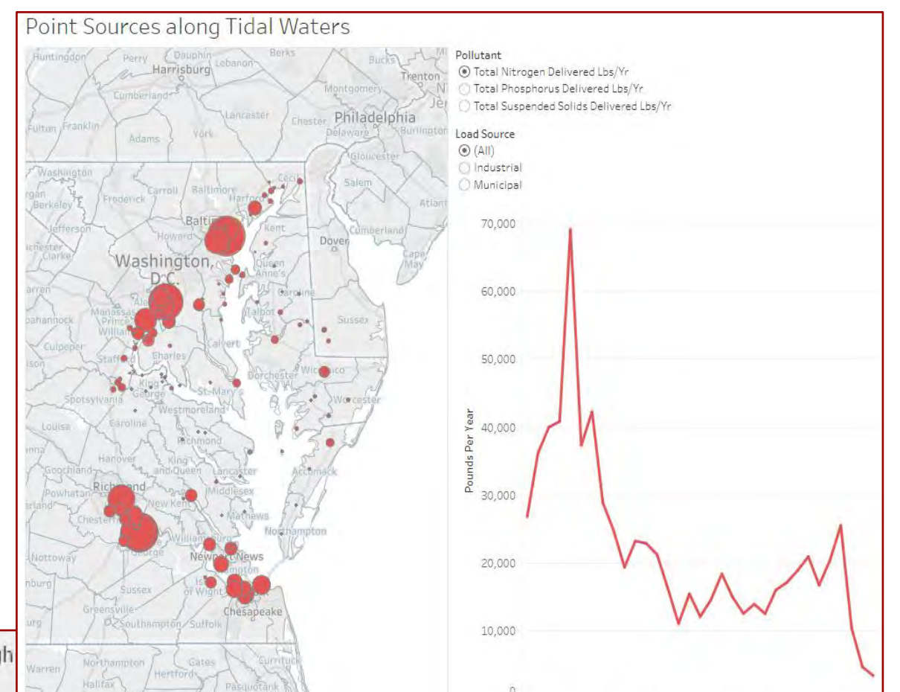
SAV Segment: Susquehanna Flats (CB1TF2 and NORTF)



Wastewater Treatment Plant Discharges

Locations of wastewater treatment plants that discharge directly to tidal waters, and discharges of nitrogen and sediment over time from these plants.

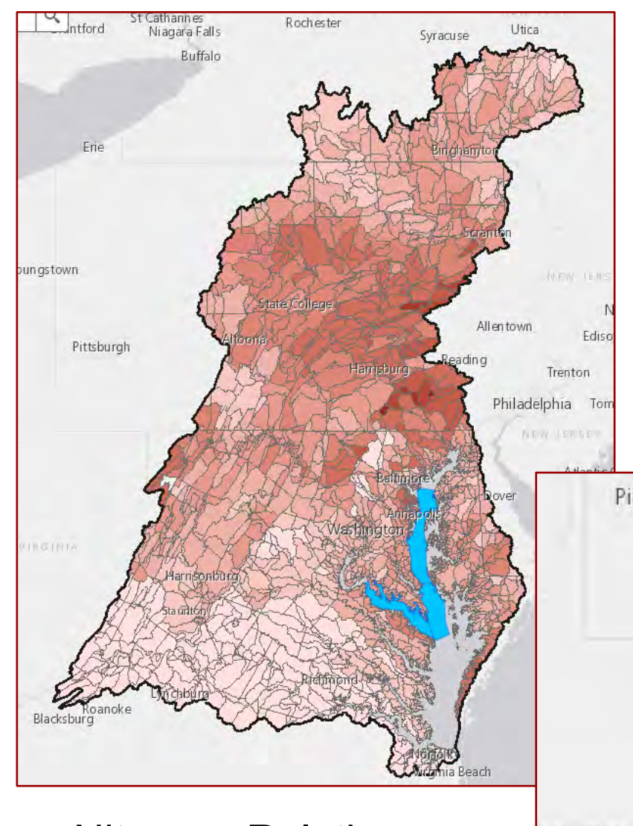
Point Sources Along Tidal Waters



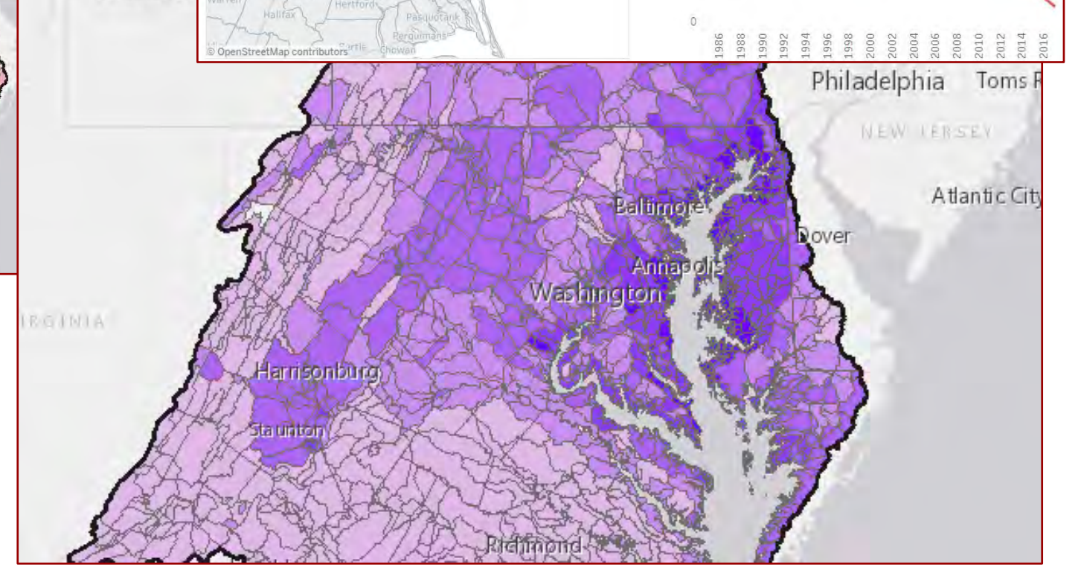
Most Effective Watersheds Influencing Bay

Provides maps that demonstrate influence of watershed on the tidal waters, including:

- ➢ The estimated effectiveness of different parts of the watershed on improving dissolved oxygen in the main stem of the Bay (relative effectiveness).
- ➢ The estimated proportion of locally generated pollution that makes it to the Bay's tidal waters (delivery factors).
- ➢ The discrete watersheds of the 92 Bay TMDL tidal segments.



Nitrogen Relative Effectiveness

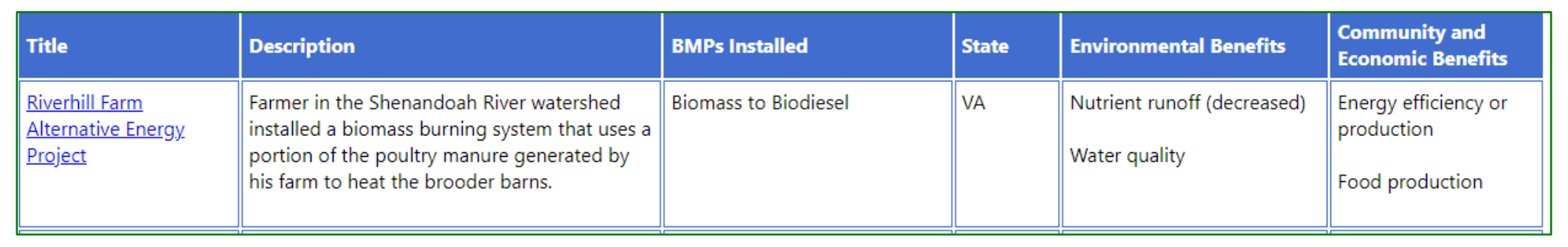


Phosphorus Delivery Factors

Module: Prioritizing Other Benefits

Beyond Environmental Benefits Database and Search Tool

Search for case studies in the Chesapeake Bay watershed by location, BMP, environmental benefit and community and economic benefit, etc.



Title	Description	BMPs Installed	State	Environmental Benefits	Community and Economic Benefits
Riverhill Farm Alternative Energy Project	Farmer in the Shenandoah River watershed installed a biomass burning system that uses a portion of the poultry manure generated by his farm to heat the brooder barns.	Biomass to Biodiesel	VA	Nutrient runoff (decreased) Water quality	Energy efficiency or production Food production

Beyond Environmental Benefits Database

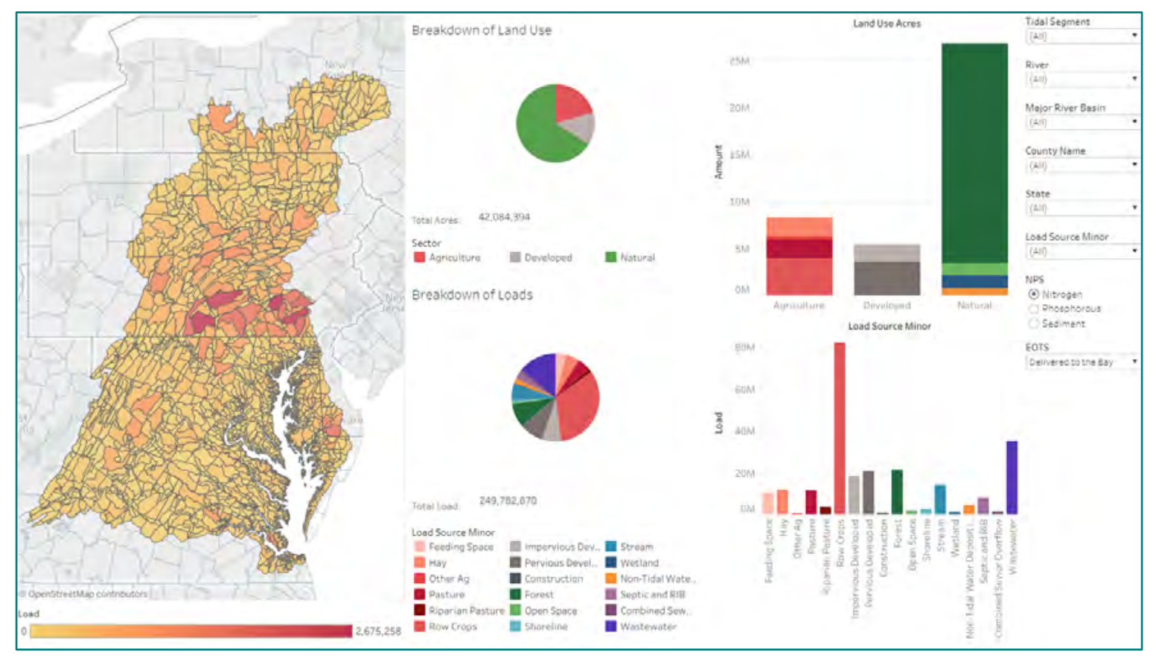
Co-benefits of Water Quality BMPs

Provides information on co-benefits associated with water quality best management practices (BMPs).

Module: Targeting Restoration Efforts

Understanding Sources

Information on land use and estimated nutrient and sediment loads at different geographies and scales across the Chesapeake Bay watershed from the most recent Progress run of the Phase 6 Watershed Model.



Understanding Sources of Nutrient and Sediment Loads

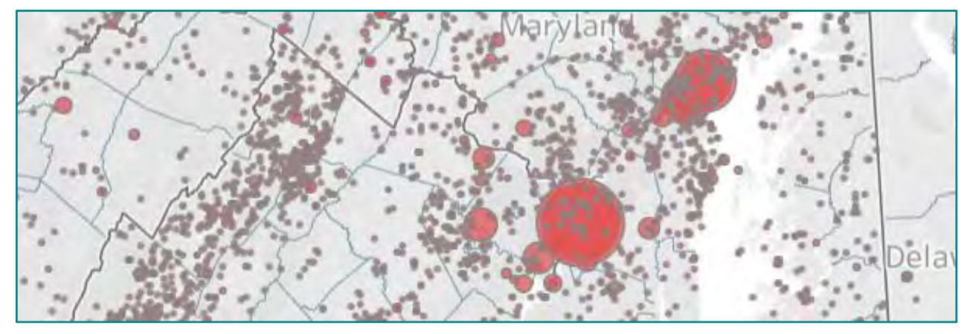
What can I do with this information?

- **Learn the sources** of nutrients and sediment in your area of interest.
- **Understand important drivers** of water quality including landscape features that influence streams and the Bay.

Wastewater Treatment Plants

Locations of wastewater treatment plants throughout the Chesapeake Bay watershed and annual nutrient and sediment discharges reported from 2020.

Point Sources and 2020 Nitrogen Loads

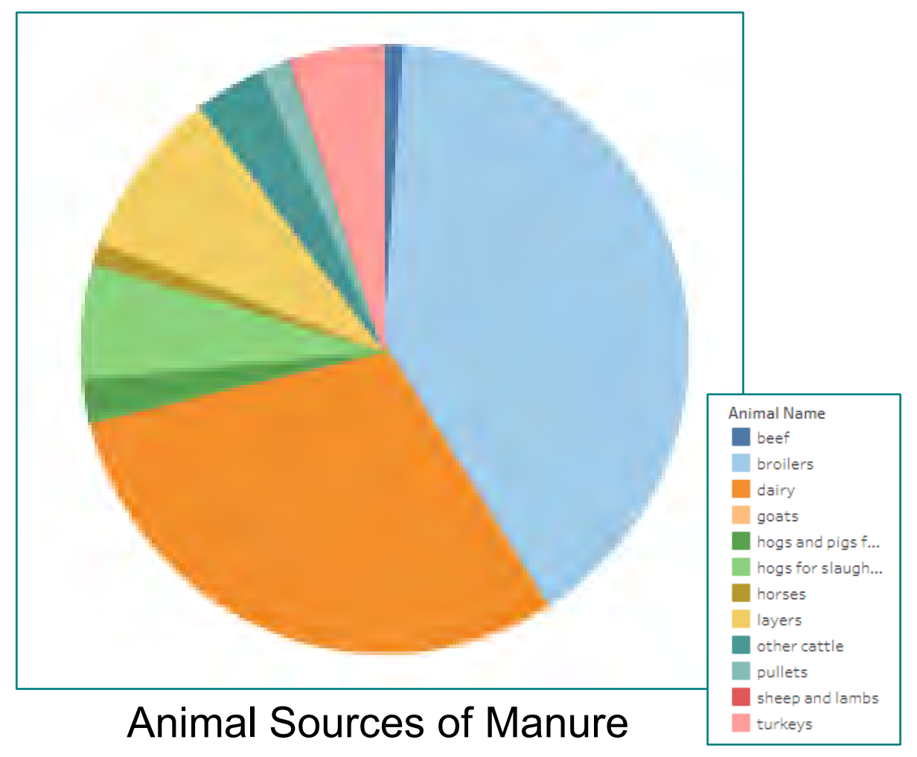


Nutrient Application Management

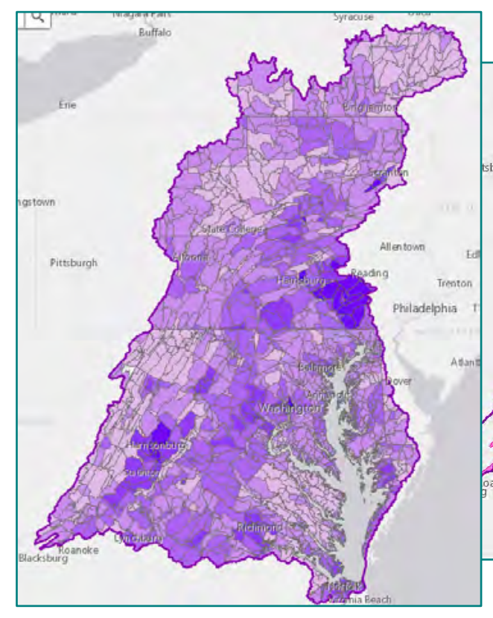
Provides estimates of nutrient application across the Chesapeake Bay watershed by county and by nutrient source (fertilizer, manure, biosolids), and animal sources of manure.

Geographic Targeting

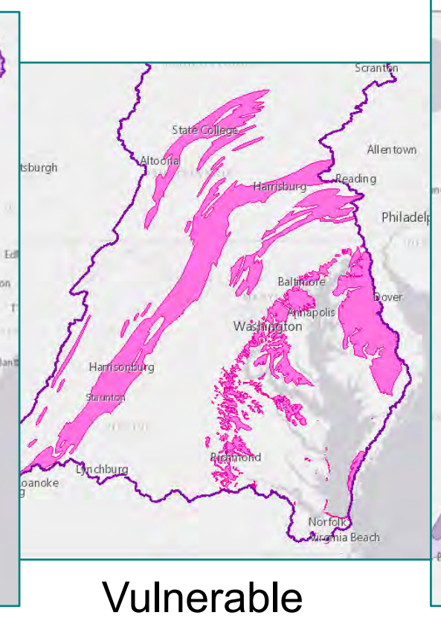
Provides spatial information across the watershed that can be utilized to geographically identify areas for restoration.



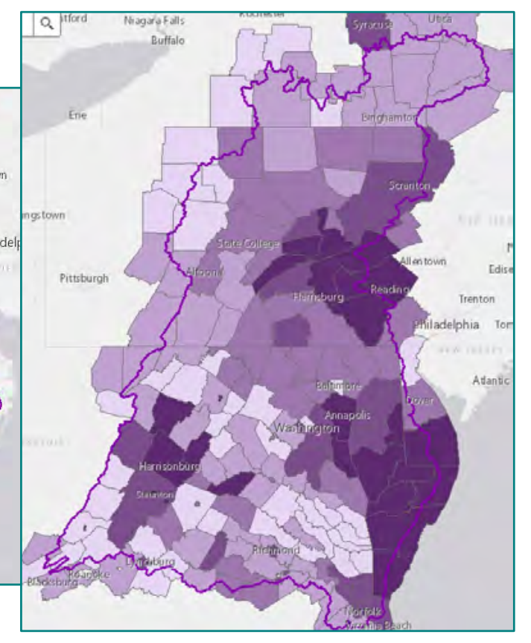
Animal Sources of Manure



Highest Loading Areas (Phosphorus)

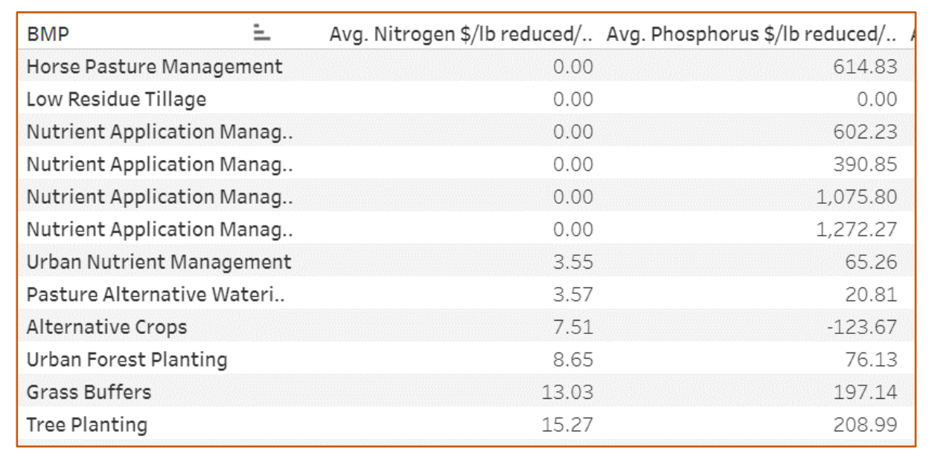


Vulnerable Groundwater



Estimated Soil Phosphorus Content on Agricultural Lands

Module: Management Practices



BMP	Avg. Nitrogen $/lb reduced/..	Avg. Phosphorus $/lb reduced/..
Horse Pasture Management	0.00	614.83
Low Residue Tillage	0.00	0.00
Nutrient Application Manag..	0.00	602.23
Nutrient Application Manag..	0.00	390.85
Nutrient Application Manag..	0.00	1,075.80
Nutrient Application Manag..	0.00	1,272.27
Urban Nutrient Management	3.55	65.26
Pasture Alternative Wateri..	3.57	20.81
Alternative Crops	7.51	-123.67
Urban Forest Planting	8.65	76.13
Grass Buffers	13.03	197.14
Tree Planting	15.27	208.99

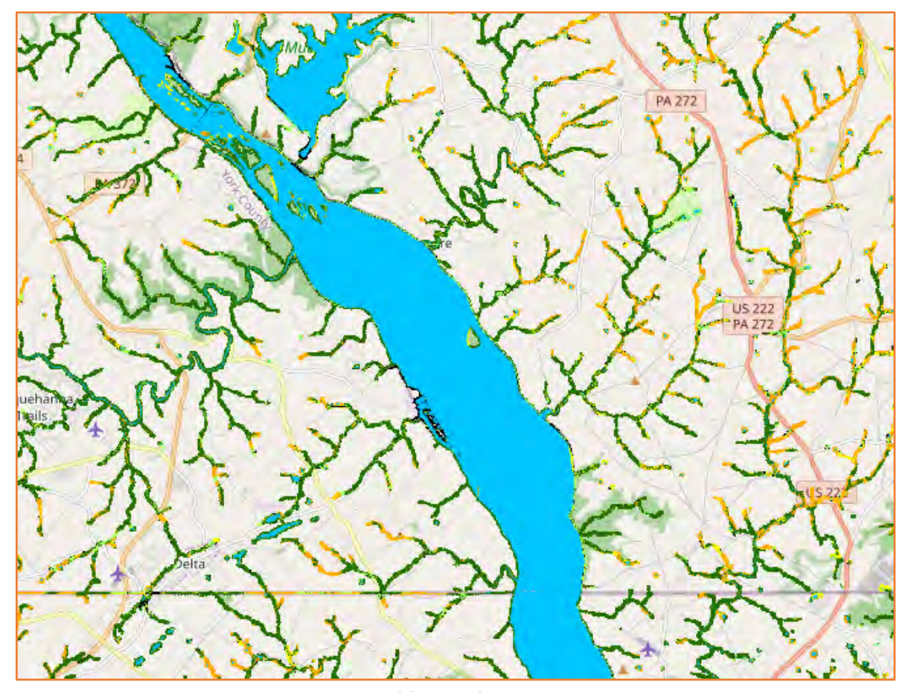
Practice Cost ($) per lb Nutrient Reduction

Management Practice Implementation

Provides information on the current reported implementation (2020 Progress), cost-effectiveness, and pollution reduction efficiency of Chesapeake Bay Program best management practices (BMPs) in each county.

What can I do with this information?

- **Learn the status** of implementation of different management practices by county across the Chesapeake Bay watershed
- **Assess progress** by determining how much of the available area for different management practices has implementation
- **Target or prioritize** areas for management practices by identifying areas that have less implementation.
- **Explore management options** by learning about the cost-effectiveness and pollution reduction effectiveness of each management practice.
- **Choose management practices** to use in scenarios on the Chesapeake Assessment Scenario Tool (CAST).
- **Identify opportunities** for implementation of riparian buffers at different geographic scales.



Riparian Buffer Opportunities

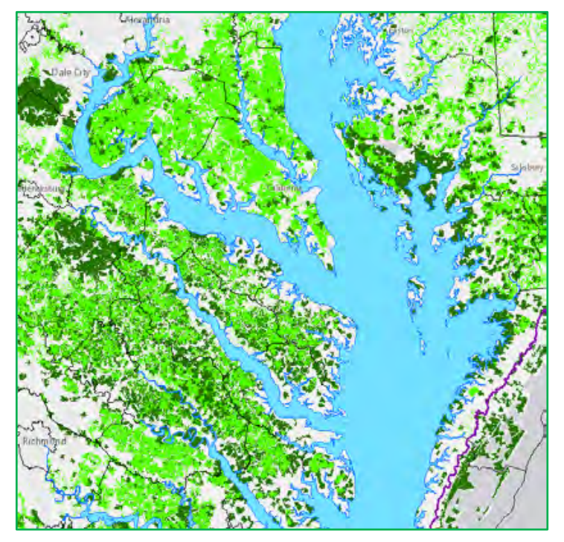
Riparian Buffer Opportunities & Locations

Provides information on the estimated acres of land available for riparian buffer implementation by different geographies based on high-resolution land use data. Contains map displaying boundary of riparian corridor along streams available for grass and buffer implementation and conservation.

Module: Land Policy and Conservation

Planning for Urban Growth & Development

Provides information relevant to growth and development including land use (2013 high-resolution) and current county-level zoning data (if available). Provides information to help identify opportunities across the watershed for Forest Conservation, Agriculture Conservation, and Growth Management.



Forest Conservation Opportunities

What can I do with this information?

- **Assess potential** for growth and development across the Chesapeake Bay watershed.
- **Explore management options** related to smart growth and land conservation practices.
- **Identify** geographic areas with potential for implementation of smart growth or conservation measures.
- **Target or prioritize** areas for management actions based on the likelihood of growth and potential for conservation.

Plastic Pollution: An Emerging Issue That Should Be Considered By The Chesapeake Bay Program For 2025 And Beyond

Kelly Somers, US EPA Region 3; Kristin Saunders, UMCES; Matt Robinson, US EPA Region 3; Bob Murphy, Tetra Tech

The Problem with Plastics

Research in the Chesapeake Bay indicates this emerging problem is extensive and could impact human health and the environment

- 100% of samples (n=30) collected by Bikker et al. (2020) in the Chesapeake Bay mainstem contained microplastics. Highest concentrations found in urban and suburban tributaries.
- Murphy et al. (2022) surveyed the Anacostia and Potomac Rivers and found microplastics in all trophic levels with the dominant particle type being fiber. 23% of fish collected (n=200) had microplastics in their stomach contents.
- Lopez et al. (2021) showed through modeling that the Chesapeake Bay could serve as a major sink for plastic pollution.

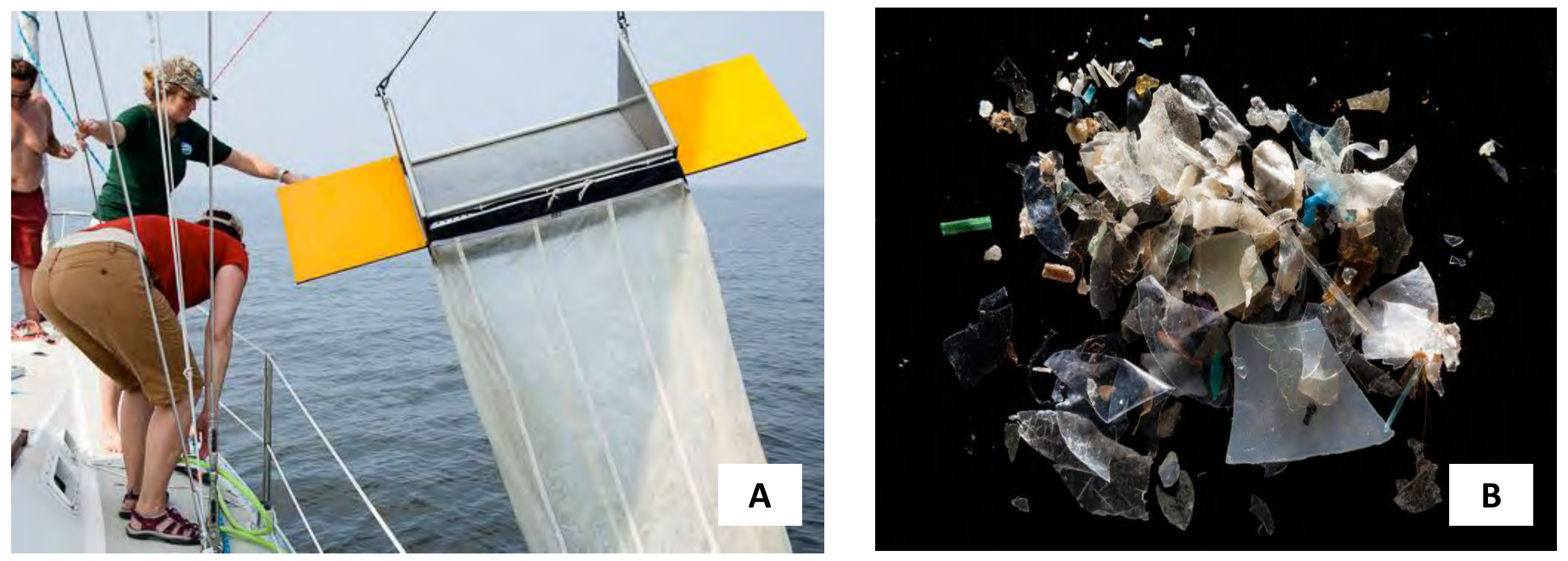


Figure 1 – (A) Sampling for microplastics with manta trawl in Chesapeake Bay; (B) Microplastics collected from the Magothy River (Photos: Will Parson, Chesapeake Bay Program Office)

The Plastic Pollution Action Team

- The Plastic Pollution Action team was formed in response to a 2019 STAC led workshop assessing the state of knowledge, data gaps and relationships to management.
- The Plastic Pollution Action Team reports to the Chesapeake Bay's Management Board with support from the STAC and the STAR
- The PPAT is multi-disciplinary group of experts that have representation from the federal, state, local, NGO, private and academia sectors.
- The PPAT seeks to reduce the presence and impacts of plastic pollution on the CB.
- The PPAT meets periodically to:
  - discuss updates on ecological risk research being conducted;
  - provide guidance to research supporting PPAT goals;
  - Update as needed the science strategy to address questions and research gaps discovered during execution of ecological risk research;
  - Discuss current source reduction efforts or policies;
  - Report out to CBP groups for feedback as requested including MB, STAR, STAC, Goal Implementation Teams, the Integrated Monitoring Networks Workgroup, and Toxics Workgroup

New and Ongoing PPAT Work

The PPAT will continue to provide technical oversite to new and ongoing projects in 2023-2024.

1. Development of ecological risk assessment of plastic pollution exposure in Striped Bass (*Morone saxatilis*) in the Chesapeake Bay and its tributaries.
2. Develop a monitoring and analytical reference guide and monitoring strategy for plastic pollution in the Chesapeake Bay watershed.
3. Develop a source reduction strategy for plastic pollution in the Chesapeake Bay watershed.

Results from Ecological Risk Assessment

Microplastics have been found to impact feeding, respiration, growth, and immune response in coastal fish species. Since 2020, The PPAT has been developing an ecological risk assessment (ERA) examining the impacts of microplastics on Striped Bass (*Morone saxatilis*). The PPAT chose to focus on this endpoint given its role as an apex predator in the Chesapeake Bay and its importance as a recreational and commercial fishery species.

There are three phases to the development of the ERA:

Phase 1: Development of quantitative food web models to identify the most important prey species to Striped Bass

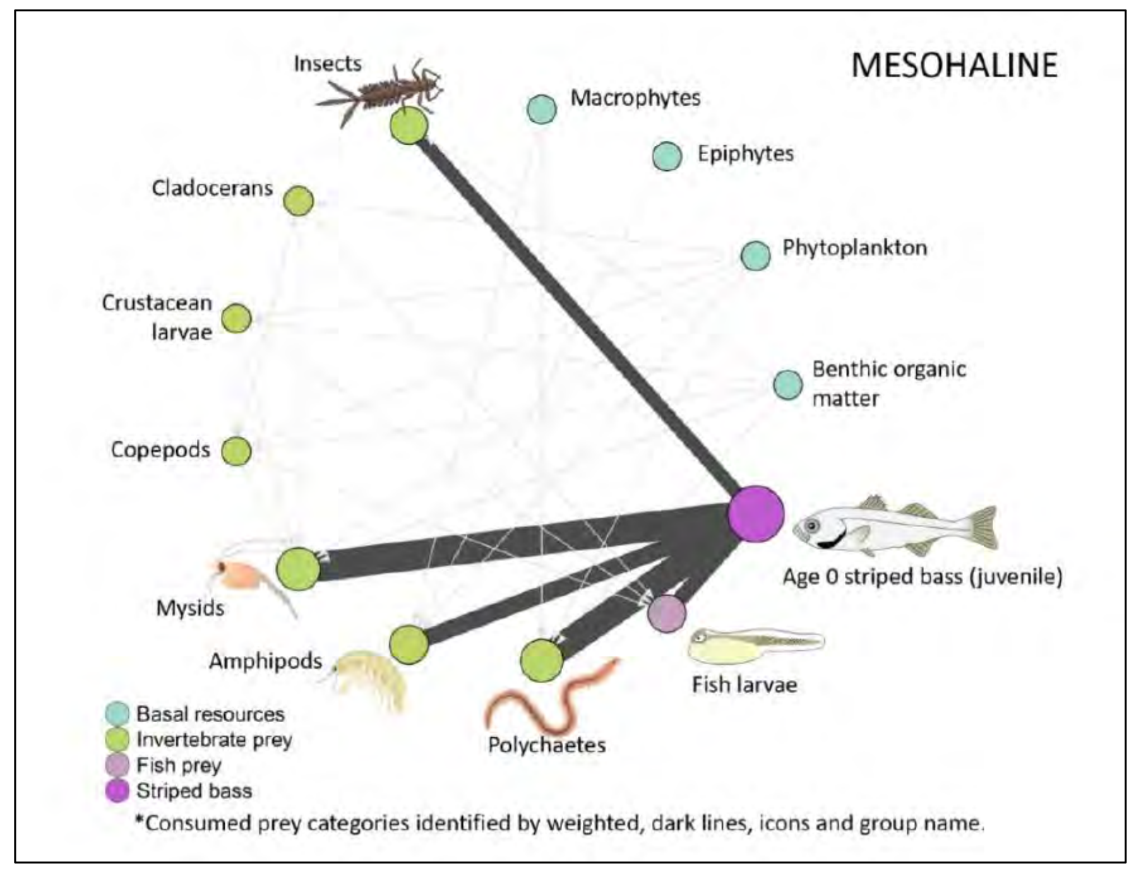


Figure 2 – Quantitative food web model developed by Murphy et. al (2021) for Striped Bass in the mesohaline portion of the Potomac River. Similar models were developed for other salinity zones throughout the river and the bay mainstem.

Phase 2: Literature review to identify which prey species have been found to contain microplastic

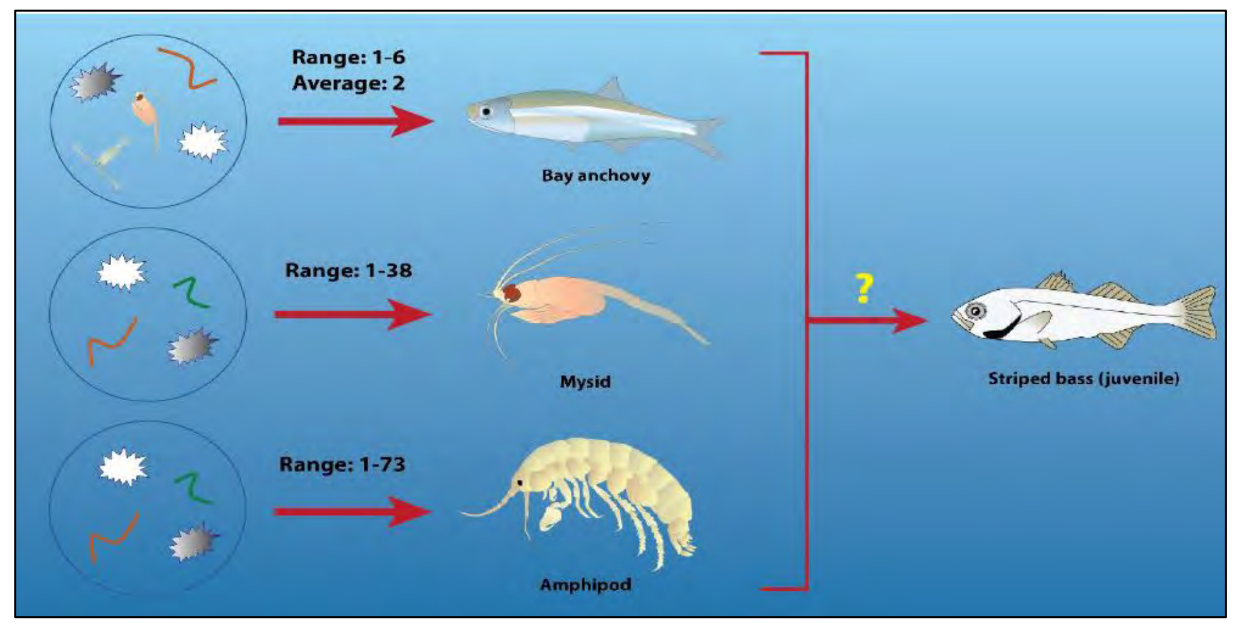
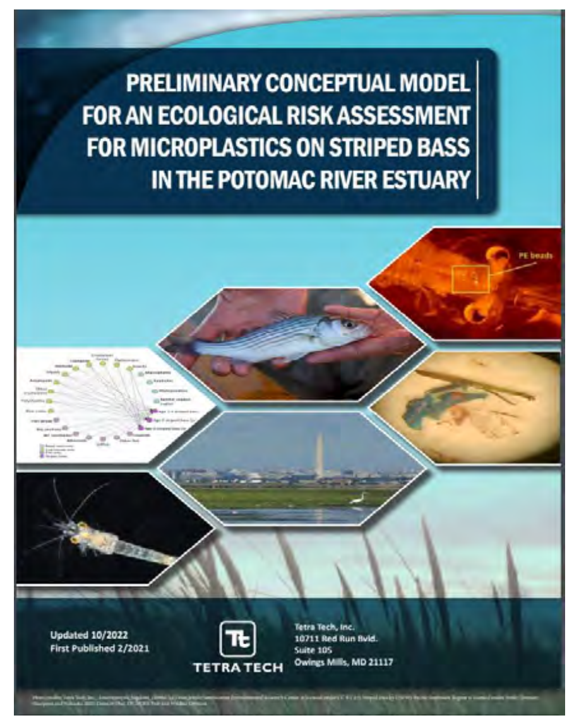


Figure 3 – Graphic displaying major prey species for Striped Bass identified by the semi - quantitative food web models. A literature review of studies performed outside the CB has shown these species to be contaminated with microplastics (Murphy et. al 2022).

Phase 3: Contextualize the risk – Determine through experimentation the physiological impacts of microplastic consumption on Striped Bass.

Next Steps: EPA Region III is working with Tetra Tech and the Chesapeake Biological Lab to sample one prey species in the Chesapeake Bay, mysid shrimp, for microplastics and conduct feeding experiments with Striped Bass in the lab to determine impacts from eating prey contaminated with microplastics.

PPAT Supported Publications



PRELIMINARY CONCEPTUAL MODEL FOR AN ECOLOGICAL RISK ASSESSMENT FOR MICROPLASTICS ON STRIPED BASS IN THE POTOMAC RIVER ESTUARY

Updated 10/2022
First Published 2/2021

TETRA TECH

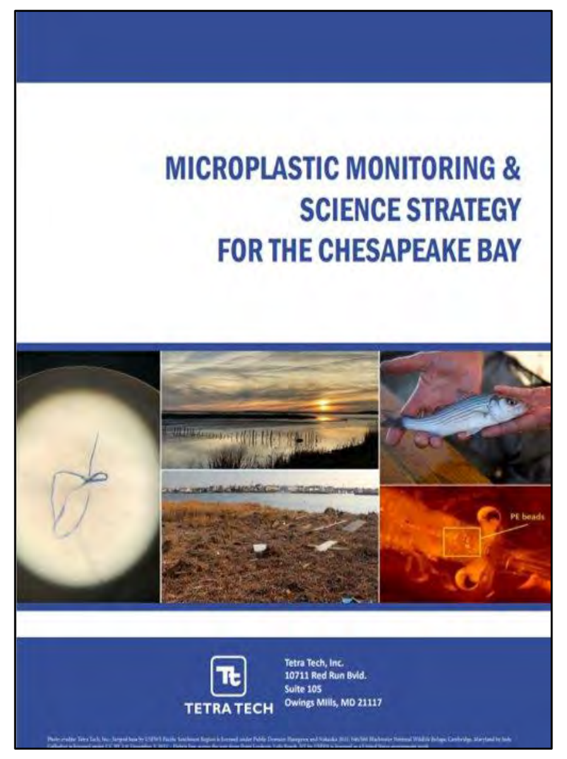
Tetra Tech, Inc.
10711 Red Run Blvd.
Suite 105
Owings Mills, MD 21117

Potential Linkages between Microplastics and 2014 Chesapeake Bay Watershed Agreement Outcomes

Tetra Tech, Inc.
August 1, 2022

TETRA TECH

Prepared by:
Paige Hobaugh
Bob Murphy



MICROPLASTIC MONITORING & SCIENCE STRATEGY FOR THE CHESAPEAKE BAY

TETRA TECH

Tetra Tech, Inc.
10711 Red Run Blvd.
Suite 105
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The Plastic Pollution Action Team has provided technical oversite and review of the reports which were funded by the EPA R3 Water Division and completed through a contract with Tetra Tech. Copies of all documents can be found on the PPAT webpage: https://www.chesapeakebay.net/who/group/plastic-pollution-action-team

1. Preliminary Conceptual Model for an Ecological Risk Assessment (ERA) for Microplastics (MP) on Striped Bass in the Potomac River Estuary (Published 2/2021; Updated 10/22).
2. Microplastic Monitoring and Science Strategy for the Chesapeake Bay
3. Uniform Size Classification and Concentration Unit Terminology for Microplastics.
4. Linkages Report on Microplastics and Chesapeake Bay Agreement Goals.

Integrating Plastic Pollution into Chesapeake Bay Goals

- **Plastic pollution is a pervasive problem in the Chesapeake Bay and could impact human health and living resources**
- **Strategic investment in research Is needed**
  - More research and understanding is needed on the impacts of plastics on Chesapeake Bay living resources and human health.
- **Monitoring and management is an important next step**
  - Implementation of the science strategy will put us on a path for understanding the impacts of plastic pollution on Striped Bass and other ecosystem endpoints
  - CBPO should support the development and implementation of a plastics monitoring program to determine extent of plastic pollution and types of plastics (i.e. polymers) found in the watershed. This will assist with future source reduction efforts.
- **Source reduction planning has been requested by the PSC**
  - The PPAT was directed by the PSC in 2021 to develop a Source Reduction Strategy for Plastics in the Chesapeake Bay and watershed.
- **Integrating plastics as a contaminant of concern in 2025 and beyond is recommended**
  - CBPO should include plastics as an emerging contaminant of concern in future planning efforts to better protect human health and the environment
- **CBPO should continue to support the Plastic Pollution Action Team**
  - Continuing to support resources towards the PPAT will be a strategic investment on the Bay and its watershed

https://www.chesapeakebay.net/who/group/plastic-pollution-action-team

Rising Water Temperature in Chesapeake Bay and Watershed

Management Responses to Ecological Impacts

Watershed Recommendations

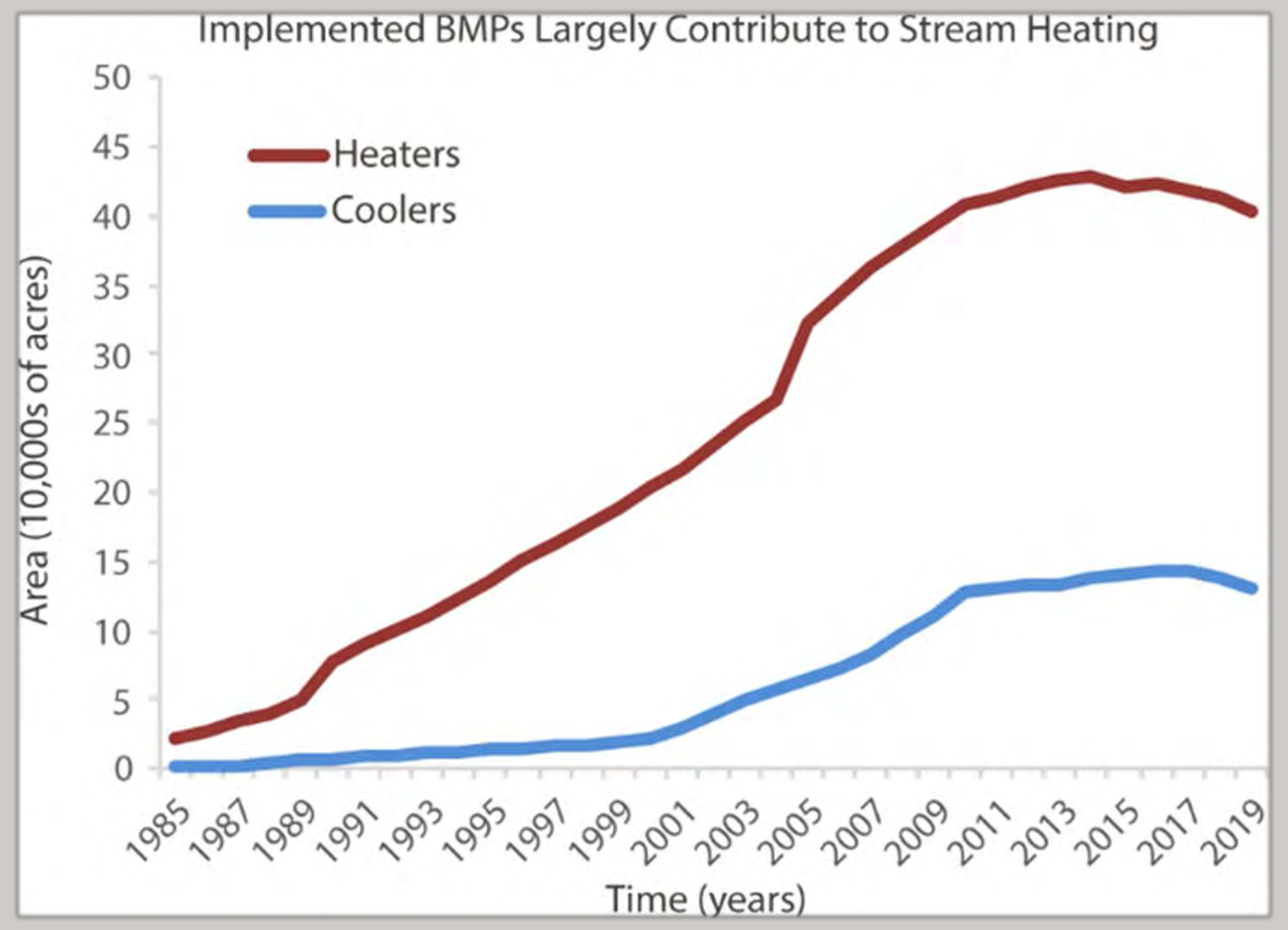
Moderate water temperatures through cooling strategies

Protect Coldwater fisheries

- Accelerate conservation actions like:
  - Maintain and increase intact forested watersheds to protect the Coldwater streams now supporting healthy and vulnerable aquatic life (e.g., brook trout).
  - Continue analyses and mapping/modeling to identify stream reaches with thermally resilient groundwater inputs for targeting habitat restoration efforts.

Restore Aquatic Habitats in Urban Streams and Rural Watersheds

- Strategically conserve and restore aquatic habitats which:
  - Improves connectivity between healthy forested habitats
  - Provides access to thermal refugia.



Modernize Water Quality Standards (WQS)

- Update current WQS to strengthen capabilities to address climate-related rising water temperatures and drive targeted protection and restoration strategies.

Enhance "Cooler" Reduce "Heater" Best Management Practices

- Minimize the extent that some water quality BMPs further heat waterways.
- Use cooler BMPs (e.g., forest buffers, good agricultural stewardship practices, stormwater infiltration) to reduce the amount of heated runoff.

Drivers and Ecosystem-Level Impacts

Nontidal Waters in the Watershed

Water temperatures are rising in the Chesapeake Bay Watershed

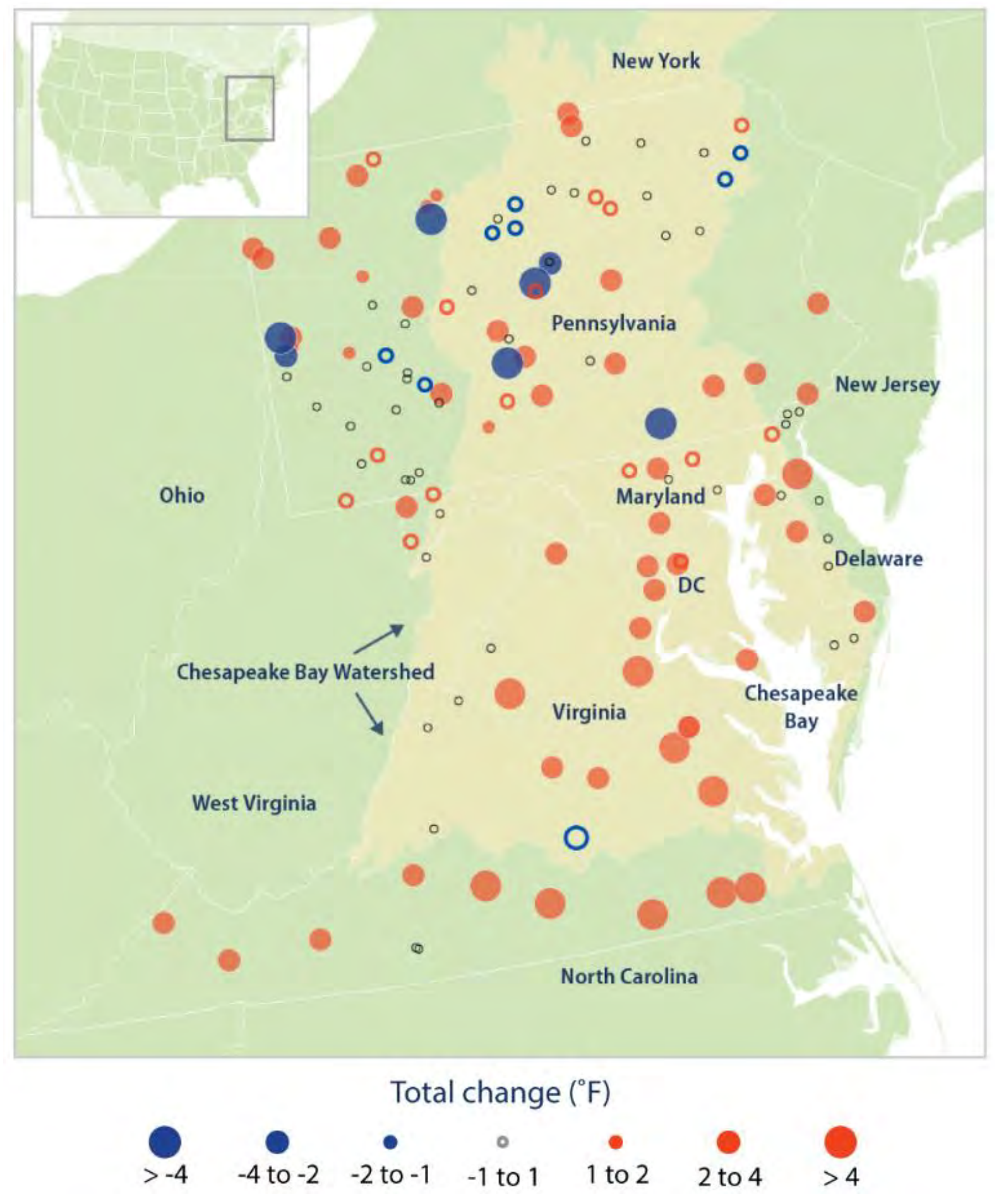
- Land use has a significant impact on temperatures of stream flow and precipitation-induced runoff from land surfaces.
- Trees and riparian forests play a central role in stream temperature moderation.

Water temperatures can affect sensitive species

- Economically and ecologically important aquatic species (e.g., brook trout) are negatively impacted by warming water temperatures and extreme heat events.

Stream temperature monitoring is critical

- Monitoring and analysis strategies need updating in the light of climate and land use change.
  - E.g., higher-frequency monitoring during critical periods to understand impacts.

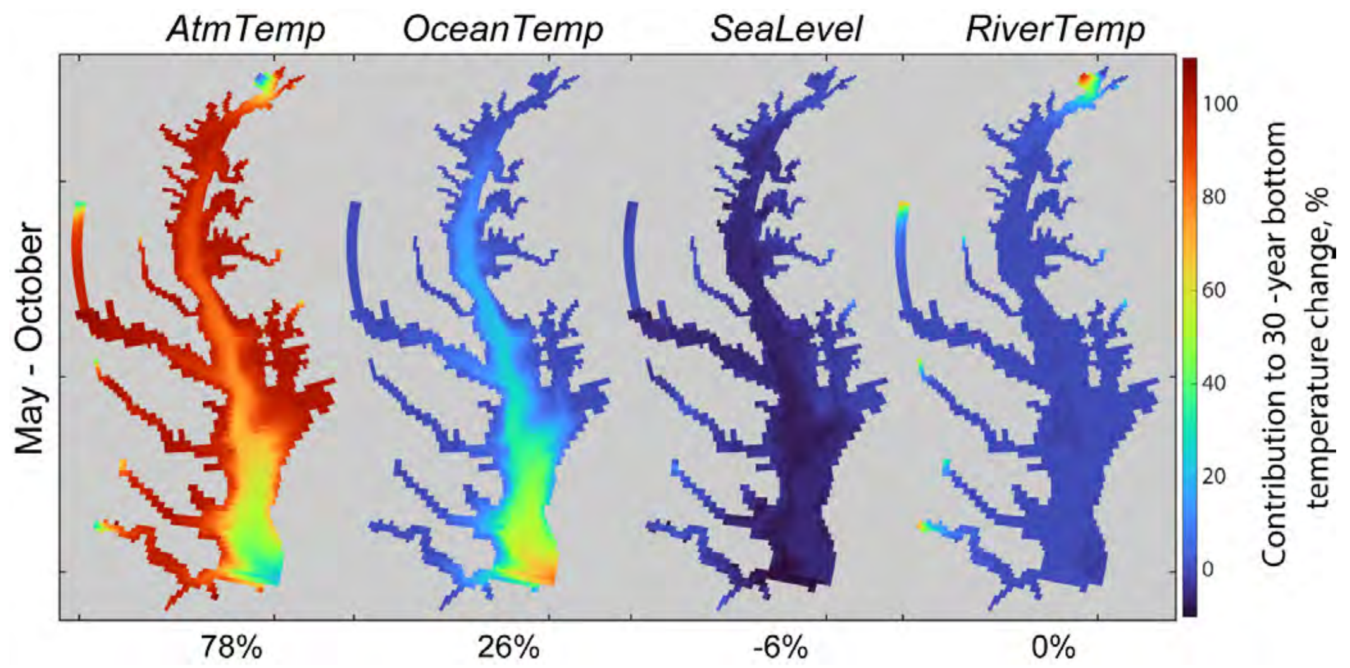


Rice, K. C., & Jastram, J. D. (2015). Rising air and stream-water temperatures in Chesapeake Bay region, USA. *Climatic Change*, *128*, 127-138.

Tidal Bay and Tributaries

Tidal water temperatures are rising in the Bay

- Changes in tidal water temperatures are primarily driven by global atmospheric forcing (e.g., increasing air temperatures) and the warming ocean boundary.



Hinson, K. E., Friedrichs, M. A., St-Laurent, P., Da, F., & Najjar, R. G. (2022). Extent and causes of Chesapeake Bay warming. *JAWRA Journal of the American Water Resources Association*, *58*(6), 805-825.

Species	Impacts
Blue Crab 	➕ Higher productivity; reduced winter mortality ➖ Reduced habitat; increased predation
Eastern Oyster 	➕ Longer spawning season; more food ➖ Additional stressors on vulnerable populations
Striped Bass 	➕ Increased growth rates ➖ Seasonal shifts; unsuitable temps; reduced habitat

Ecological implications

- Key species are predicted to experience negative and positive effects depending on sensitivities, life stage, and habitat requirements in different locations within the estuary.

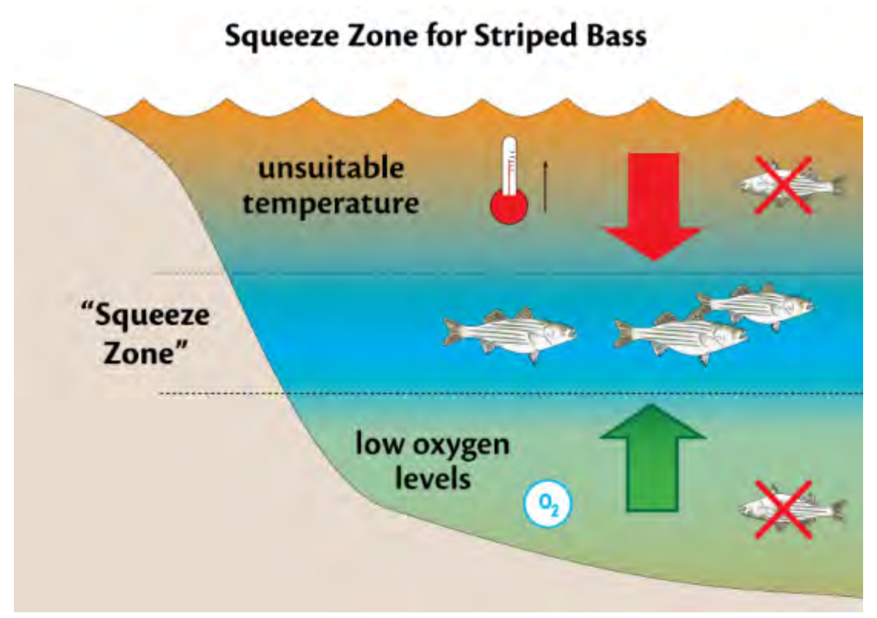


Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Boesch 2008.

- Heat-tolerant widgeongrass will likely be dominant, while eelgrass will likely disappear.
- Northward shifts in key fish species range and changes in Bay habitat suitability (e.g., squeeze zone; loss in marsh and seagrass habitat).
- Species from the south becoming more prevalent.

Tidal Recommendations

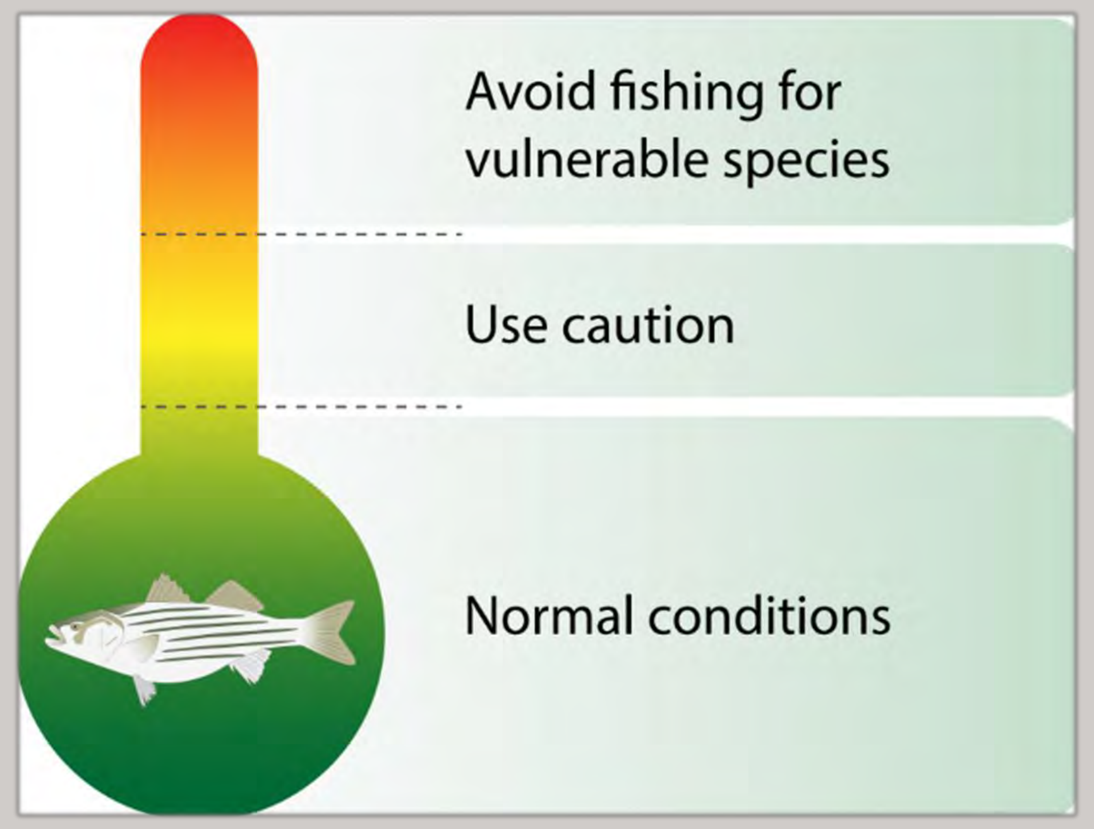
Minimize impacts to the Chesapeake Bay and adapt management

Apply Bay environmental thresholds to inform fisheries management

- Establish fishing guidance based on temperature and dissolved oxygen thresholds to reduce vulnerability on key recreational fish species (e.g., striped bass, summer flounder).
- Engage with fisheries stakeholders to explore incorporation of environmental thresholds influenced by climate change to inform fisheries management in the Bay.

Communicate Temperature Risk

- Better communicate the impacts of rising water temperatures and expected scenarios for existing and future seagrass community structure and Bay fisheries.



Avoid fishing for vulnerable species

Use caution

Normal conditions

Create heat wave alert system

- Collaborate with scientists, resource managers, meteorologists, and communicators to develop a publicly available marine heat wave alert system connected to key fisheries species and seagrass habitat. Consider incorporating other key parameters (e.g., dissolved oxygen, salinity).

Target nearshore projects

- Develop common criteria and metrics to help target, site, and design natural infrastructure projects and implement in the nearshore, where ecological, community, and climate resilience benefits are maximized across multiple habitat types, such as oyster reefs, underwater seagrass beds, and marshes.

Scan to go to the full STAC Rising Water Temperature Workshop Report

Scan to go to the UMCES Workshop Summary

Moving Forward

Increase Trees
Better communicate the benefits of conserving mature trees and don't just rely on new tree planting.

Updated Standards
State water quality standards need to address climate-related changes to water temperature.

Adapt Fisheries
Future management and monitoring of fisheries must adapt as fisheries change with rising water temperatures.

Prioritize BMPs
Implement cooling BMPs/natural infrastructure that reduce heated runoff from developed areas, farms, & forests.

Target Restoration
Factor rising water temperatures into our tools for targeting the lands to conserve and where to apply BMPs.

Communicate
Help people to understand why water temperatures are rising and what they can do about it.

Land-sea opportunities
Consider shorelines/nearshore environments for restoration and habitat protection of at-risk species.

STAC Report Authors &Acknowledgements

Thank you to our STAC workshop steering committee members: Bill Dennison, co-chair, UMCES (Member, CBP STAC; and co-chair, CBP STAR Team); Rebecca Hanmer, co-chair USEPA retired (Chair, CBP Forestry Workgroup); Rich Batiuk, USEPA retired (CoastWise Partners); Frank Borsuk, USEPA Freshwater Fisheries Biologist; Katherine Brownson, U.S. Forest Service; Matthew Ernhart, Stroud Water Research Center (Member, CBP Citizens Advisory Committee); Scott Phillips, USGS (co-chair, CBP Scientific, Technical Assessment, and Reporting Team); Julie Reichert-Nguyen, NOAA CBO (Coordinator, CBP Climate Resiliency Workgroup); Renee Thompson, USGS (Coordinator, CBP Healthy Watersheds Goal Implementation Team); Bruce Vogt, NOAA CBO (Coordinator, CBP Sustainable Fisheries Goal Implementation Team).

Chesapeake Tree Cover Status & Change Fact Sheets

Chesapeake Tree Canopy Network

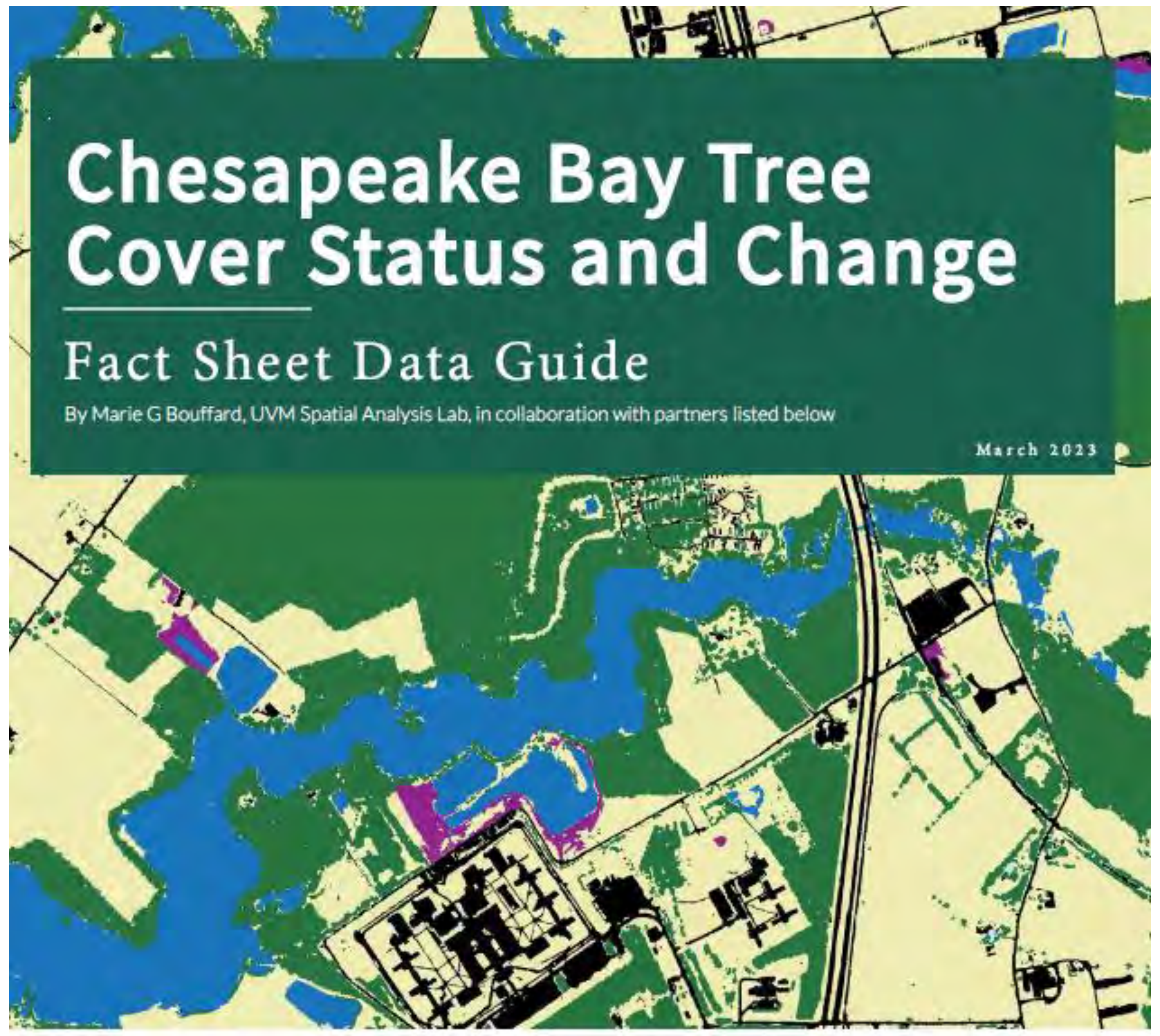
Chesapeake Bay Program
Science. Restoration. Partnership.

Why do trees matter?

Trees provide numerous public benefits in the form of ecosystem services. Ecosystem services refer to all the ways we benefit from the services that healthy natural systems provide, such as improved air quality, reduced stormwater runoff, carbon sequestration, temperature regulation, and wildlife habitat.

Why map tree cover?

It is important to map and monitor tree cover change over time to detect trends that can inform management decisions. This information can be used to improve access to ecosystem services, decide where new trees should be planted, and ensure healthy tree cover for future generations.

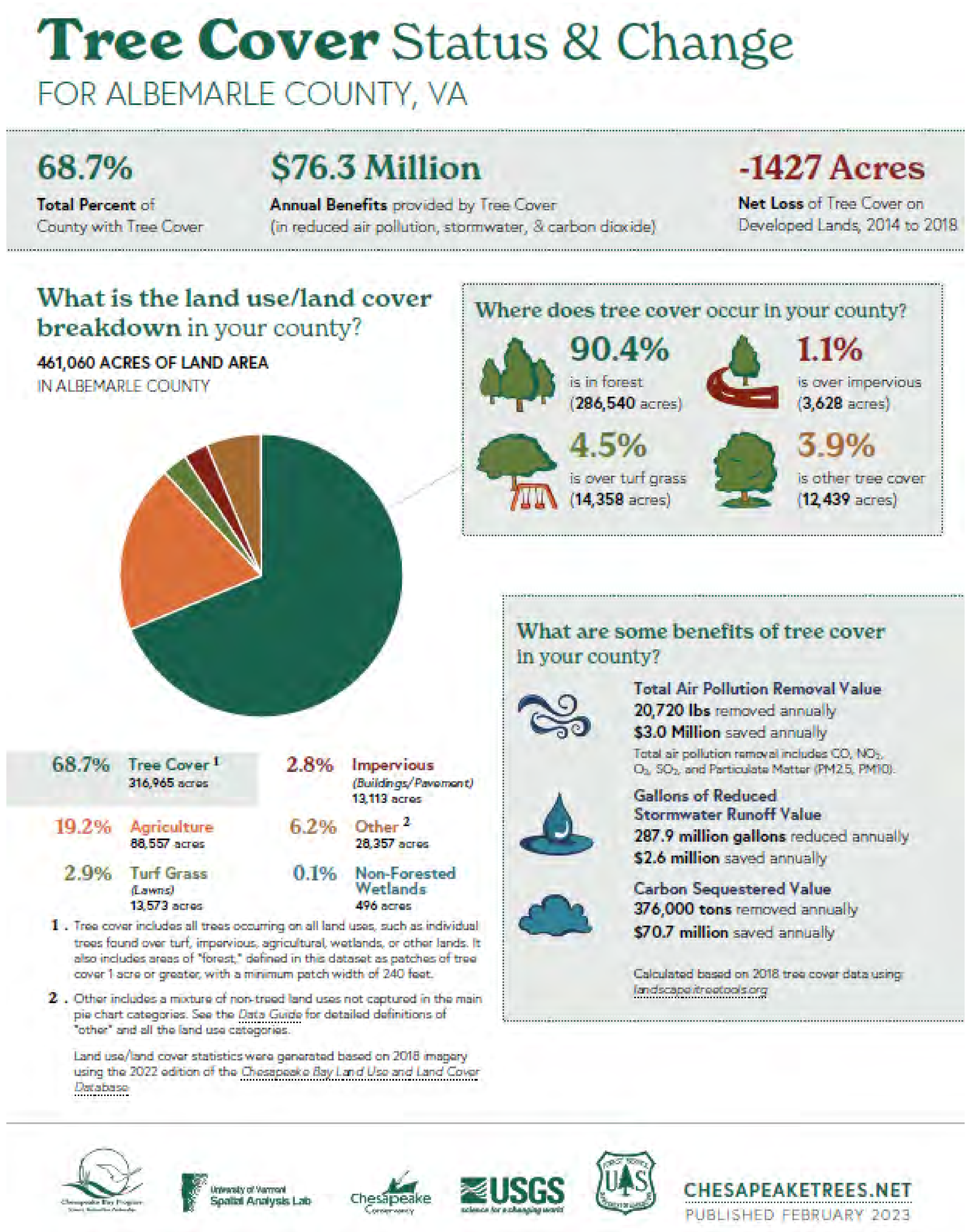


Chesapeake Bay Tree Cover Status and Change

Fact Sheet Data Guide

By Marie G Bouffard, UVM Spatial Analysis Lab, in collaboration with partners listed below

March 2023



Tree Cover Status & Change

FOR ALBEMARLE COUNTY, VA

68.7%	**$76.3 Million**	**-1427 Acres**
Total Percent of County with Tree Cover	**Annual Benefits** provided by Tree Cover (in reduced air pollution, stormwater, & carbon dioxide)	**Net Loss** of Tree Cover on Developed Lands, 2014 to 2018

What is the land use/land cover breakdown in your county?

461,060 ACRES OF LAND AREA
IN ALBEMARLE COUNTY

68.7%	**Tree Cover** [1] 316,965 acres	2.8%	**Impervious** *(Buildings/Pavement)* 13,113 acres
19.2%	**Agriculture** 88,557 acres	6.2%	**Other** [2] 28,357 acres
2.9%	**Turf Grass** *(Lawns)* 13,573 acres	0.1%	**Non-Forested Wetlands** 496 acres

1 . Tree cover includes all trees occurring on all land uses, such as individual trees found over turf, impervious, agricultural, wetlands, or other lands. It also includes areas of "forest," defined in this dataset as patches of tree cover 1 acre or greater, with a minimum patch width of 240 feet.

2 . Other includes a mixture of non-treed land uses not captured in the main pie chart categories. See the *Data Guide* for detailed definitions of "other" and all the land use categories.

Land use/land cover statistics were generated based on 2018 imagery using the 2022 edition of the *Chesapeake Bay Land Use and Land Cover Database*

Where does tree cover occur in your county?

90.4% is in forest (**286,540** acres)	**1.1%** is over impervious (**3,628** acres)
4.5% is over turf grass (**14,358** acres)	**3.9%** is other tree cover (**12,439** acres)

What are some benefits of tree cover in your county?

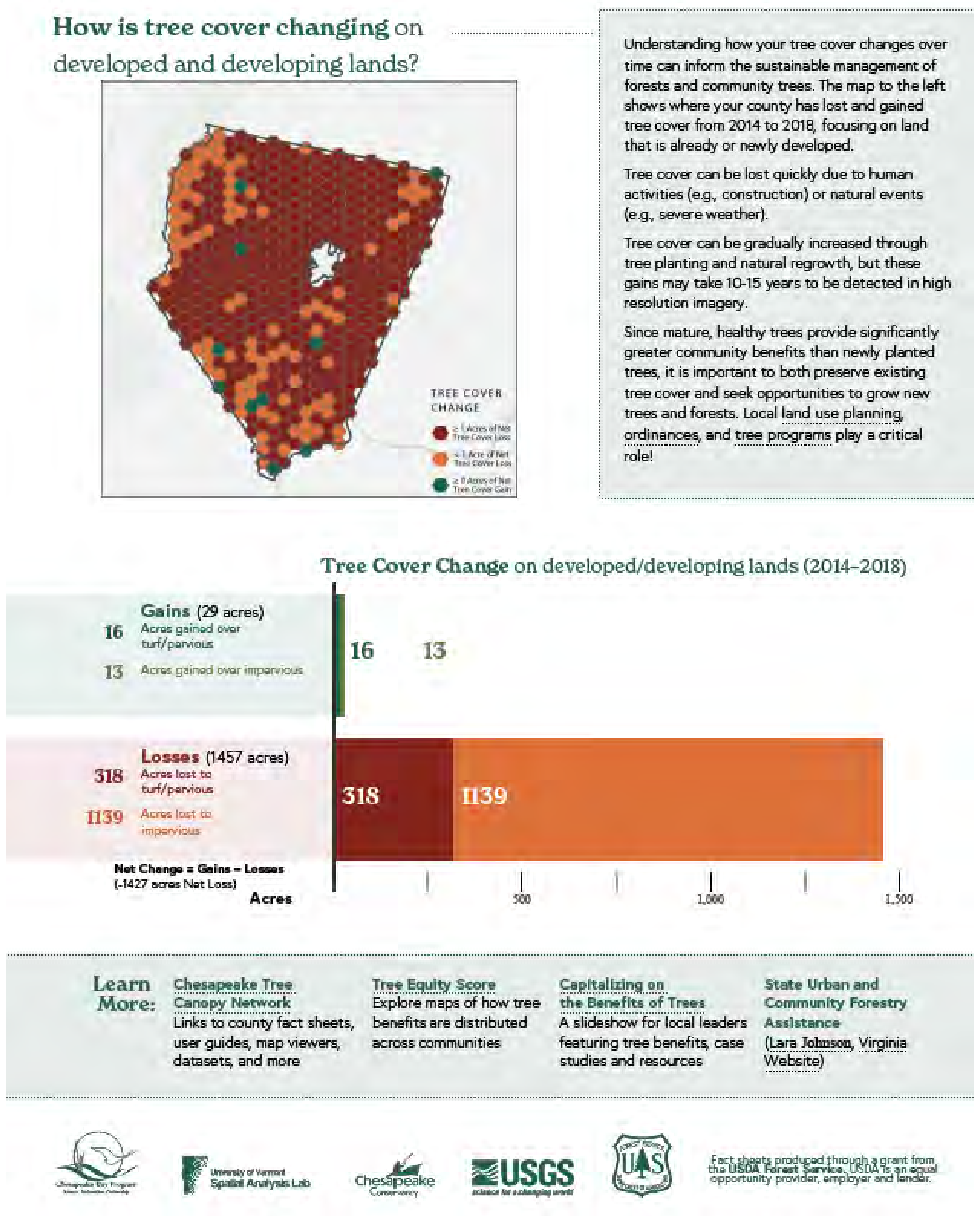
Total Air Pollution Removal Value
20,720 lbs removed annually
$3.0 Million saved annually
Total air pollution removal includes CO, NO_2, O_3, SO_2, and Particulate Matter (PM2.5, PM10).

Gallons of Reduced Stormwater Runoff Value
287.9 million gallons reduced annually
$2.6 million saved annually

Carbon Sequestered Value
376,000 tons removed annually
$70.7 million saved annually

Calculated based on 2018 tree cover data using: landscape.itreetools.org

CHESAPEAKETREES.NET
PUBLISHED FEBRUARY 2023



How is tree cover changing on developed and developing lands?

Understanding how your tree cover changes over time can inform the sustainable management of forests and community trees. The map to the left shows where your county has lost and gained tree cover from 2014 to 2018, focusing on land that is already or newly developed.

Tree cover can be lost quickly due to human activities (e.g., construction) or natural events (e.g., severe weather).

Tree cover can be gradually increased through tree planting and natural regrowth, but these gains may take 10-15 years to be detected in high resolution imagery.

Since mature, healthy trees provide significantly greater community benefits than newly planted trees, it is important to both preserve existing tree cover and seek opportunities to grow new trees and forests. Local land use planning, ordinances, and tree programs play a critical role!

Tree Cover Change on developed/developing lands (2014–2018)

Gains (29 acres)
16 Acres gained over turf/pervious
13 Acres gained over impervious

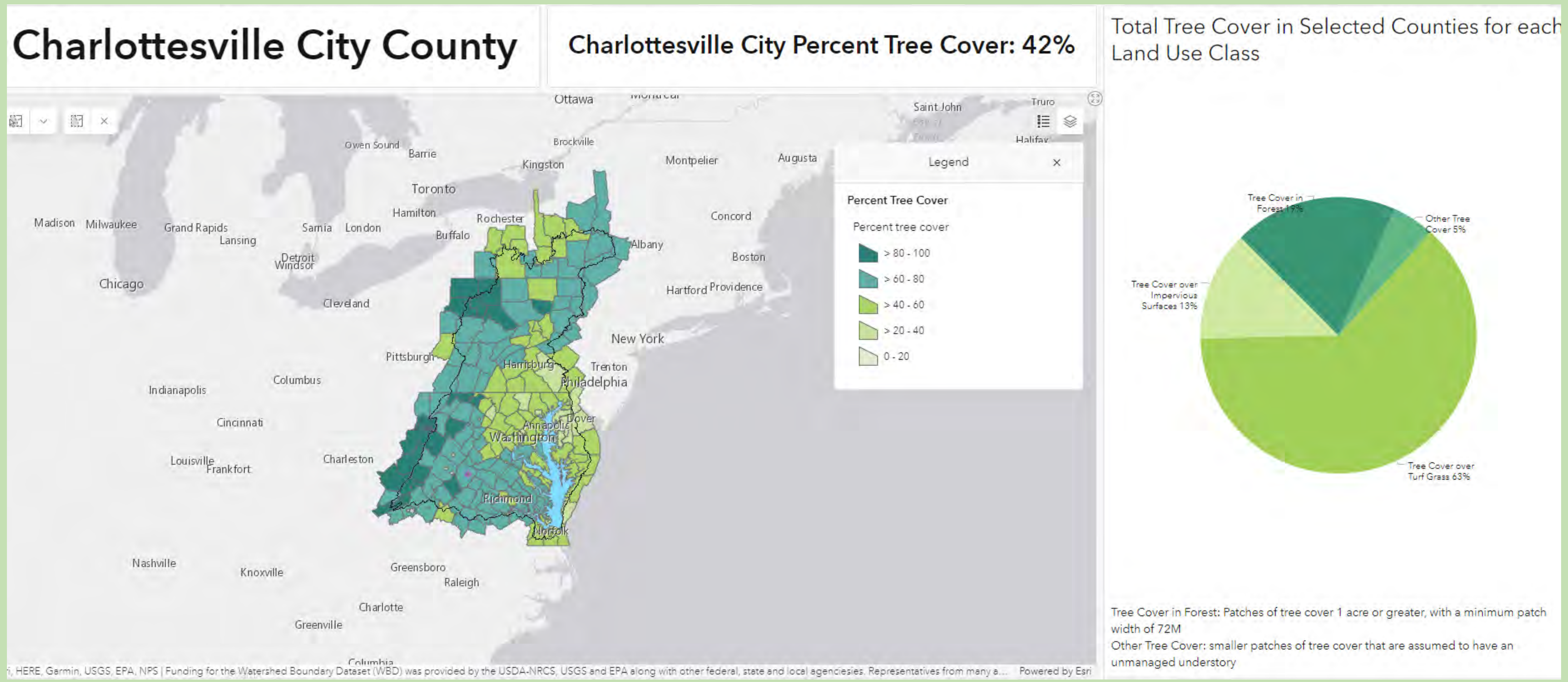
Losses (1457 acres)
318 Acres lost to turf/pervious
1139 Acres lost to impervious

Net Change = Gains – Losses
(-1427 acres Net Loss)

Learn More:	**Chesapeake Tree Canopy Network** Links to county fact sheets, user guides, map viewers, datasets, and more	**Tree Equity Score** Explore maps of how tree benefits are distributed across communities	**Capitalizing on the Benefits of Trees** A slideshow for local leaders featuring tree benefits, case studies and resources	**State Urban and Community Forestry Assistance** (Lara Johnson, Virginia Website)

Fact sheets produced through a grant from the USDA Forest Service. USDA is an equal opportunity provider, employer and lender.

Coming Soon: State of Chesapeake Forests Storymap



Charlottesville City County

Charlottesville City Percent Tree Cover: 42%

Total Tree Cover in Selected Counties for each Land Use Class

Tree Cover in Forest: Patches of tree cover 1 acre or greater, with a minimum patch width of 72M
Other Tree Cover: smaller patches of tree cover that are assumed to have an unmanaged understory

i, HERE, Garmin, USGS, EPA, NPS | Funding for the Watershed Boundary Dataset (WBD) was provided by the USDA-NRCS, USGS and EPA along with other federal, state and local agenciesies. Representatives from many a… Powered by Esri

Find your County Tree Cover Fact Sheet!

SCAN ME

Access the Fact Sheet Data Guide

SCAN ME

Data downloadable here (excluding hydrography):
https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/

High-Resolution Mapping Across the Chesapeake Bay Watershed

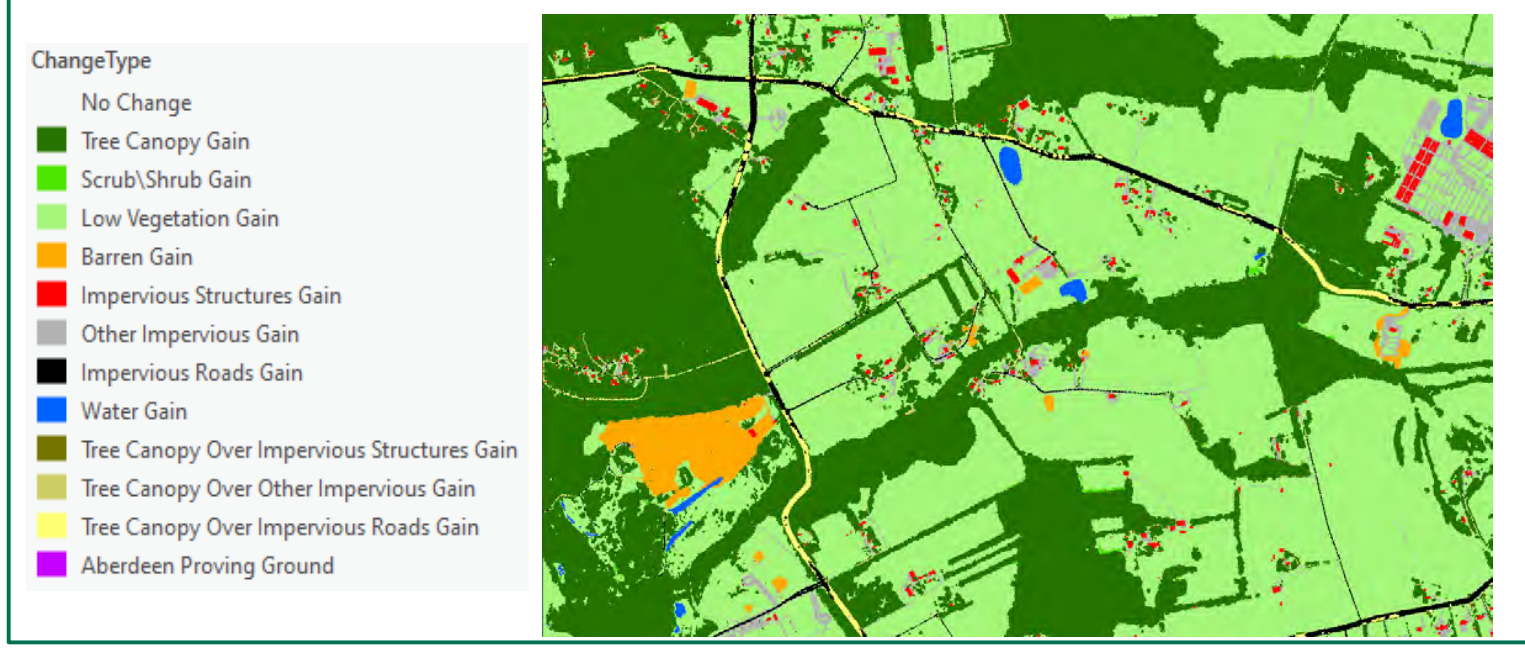
Sarah M. McDonald[1], Labeeb Ahmed[1], Matthew Baker[4], Peter R. Claggett[1], Jacob Czawlytko[2], Elliott Kurtz[2], Sean MacFaden[3], Patrick McCabe[2], Emily Mills[2], **Jarlath O'Neill**-Dunne[3], David Saavedra[2], Kelly Schulze[3], Rachel Soobitsky[2], Katie Walker[2]

1 Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Chesapeake Bay Program Office, Annapolis, MD 21403
2 Chesapeake Conservancy, Annapolis, MD 21403
3 University of Vermont Spatial Analysis Laboratory, Burlington, VT 05405
4 University of Maryland, Baltimore County, Baltimore, MD 21250

Mapping 1-Meter Resolution Land Use/Land Cover

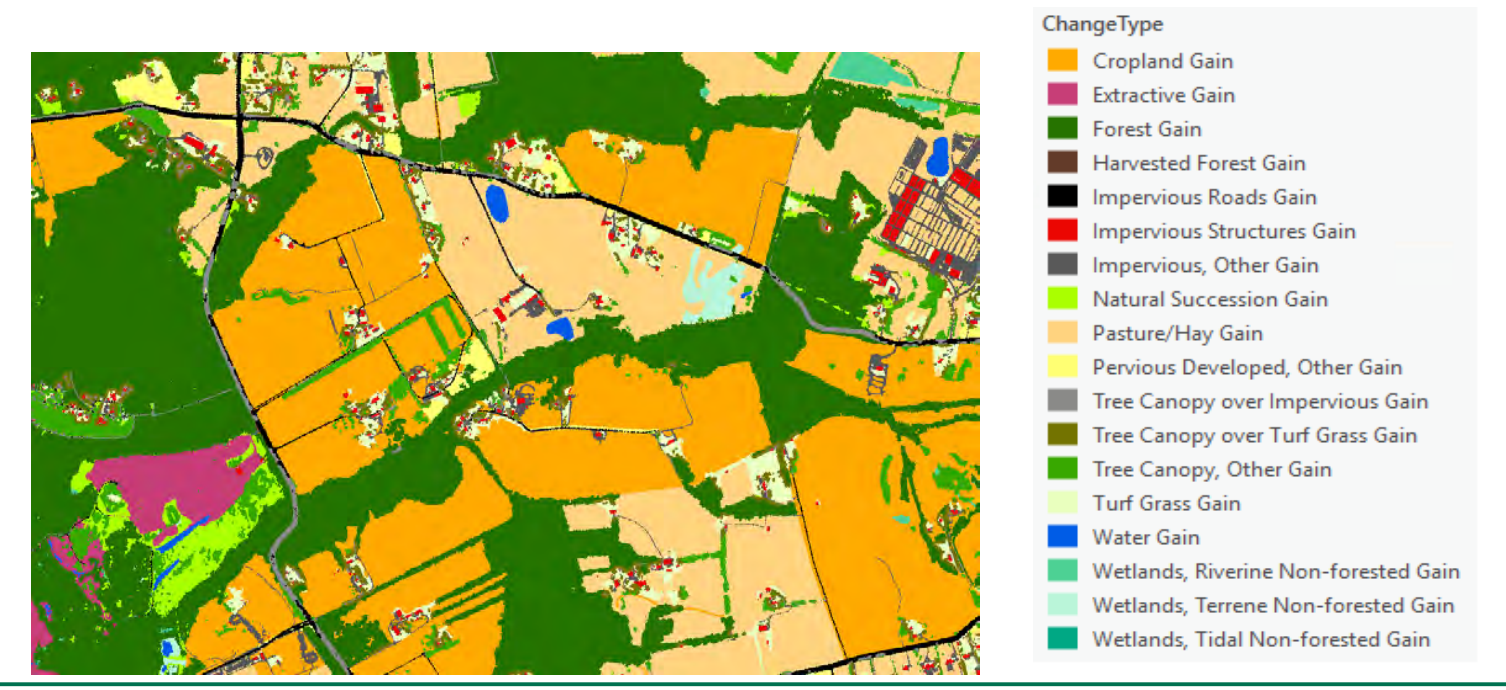
Land Cover

- Describes the physical land surface
- 12 classes mapped by University of Vermont after initial stakeholder review



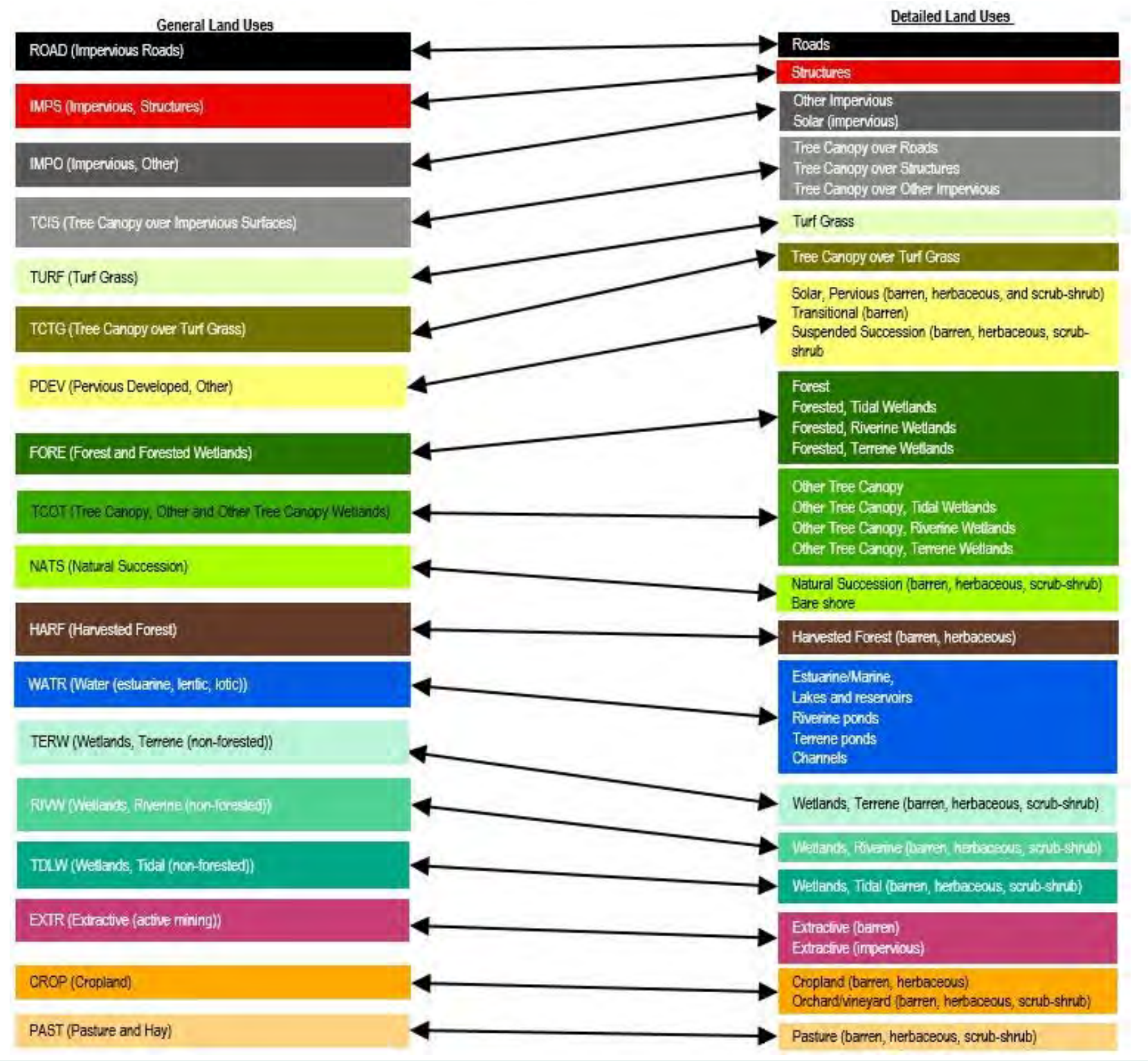
Land Use/Land Cover (LULC)

- Describes how humans manage and use the land
- 54 classes mapped by Chesapeake Conservancy



Unique Data Qualities

- Spatial
  - 1-meter resolution
- Categorical
  - 54 LULC classes, visualized with an aggregated 18-class schema
    - The 18-class schema is tree canopy centric
    - Forested wetlands and tree canopy in wetlands are included in the aggregated *forest* and *tree canopy, other* classes
- Temporal
  - Mapped period ranges from 4 to 5 years
- Extent
  - 206 counties within, intersecting, and adjacent to the Chesapeake Bay Watershed (256,000 square kilometers)
- Accuracy
  - >90% expected accuracy for tree canopy and impervious surfaces



General Land Uses

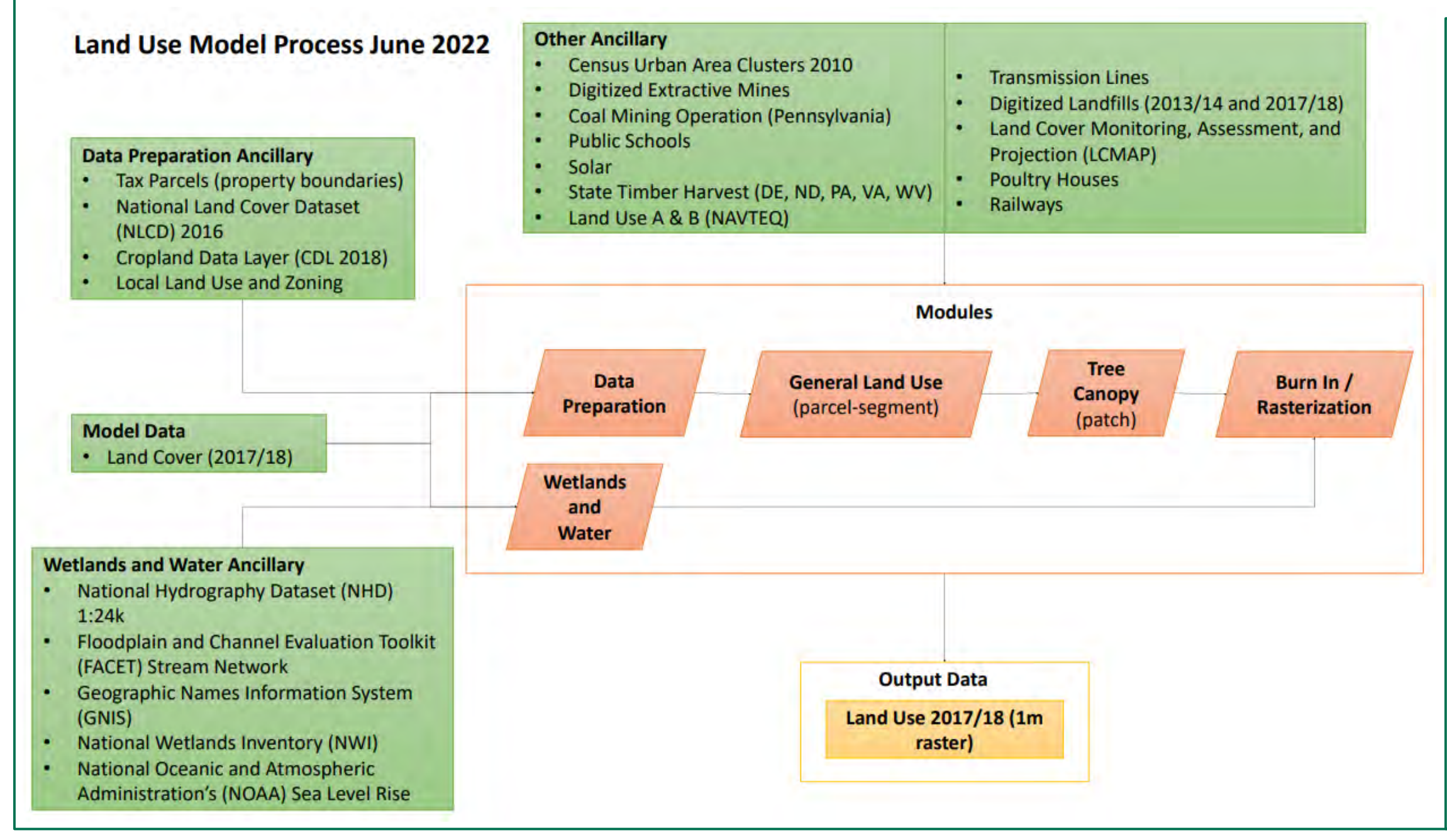
- ROAD (Impervious Roads)
- IMPS (Impervious, Structures)
- IMPO (Impervious, Other)
- TCIS (Tree Canopy over Impervious Surfaces)
- TURF (Turf Grass)
- TCTG (Tree Canopy over Turf Grass)
- PDEV (Pervious Developed, Other)
- FORE (Forest and Forested Wetlands)
- TCOT (Tree Canopy, Other and Other Tree Canopy Wetlands)
- NATS (Natural Succession)
- HARF (Harvested Forest)
- WATR (Water (estuarine, lentic, lotic))
- TERW (Wetlands, Terrene (non-forested))
- RIVW (Wetlands, Riverine (non-forested))
- TDLW (Wetlands, Tidal (non-forested))
- EXTR (Extractive (active mining))
- CROP (Cropland)
- PAST (Pasture and Hay)

Detailed Land Uses

- Roads
- Structures
- Other Impervious
Solar (impervious)
- Tree Canopy over Roads
Tree Canopy over Structures
Tree Canopy over Other Impervious
- Turf Grass
- Tree Canopy over Turf Grass
- Solar, Pervious (barren, herbaceous, and scrub-shrub)
Transitional (barren)
Suspended Succession (barren, herbaceous, scrub-shrub)
- Forest
Forested, Tidal Wetlands
Forested, Riverine Wetlands
Forested, Terrene Wetlands
- Other Tree Canopy
Other Tree Canopy, Tidal Wetlands
Other Tree Canopy, Riverine Wetlands
Other Tree Canopy, Terrene Wetlands
- Natural Succession (barren, herbaceous, scrub-shrub)
Bare shore
- Harvested Forest (barren, herbaceous)
- Estuarine/Marine,
Lakes and reservoirs
Riverine ponds
Terrene ponds
Channels
- Wetlands, Terrene (barren, herbaceous, scrub-shrub)
- Wetlands, Riverine (barren, herbaceous, scrub-shrub)
- Wetlands, Tidal (barren, herbaceous, scrub-shrub)
- Extractive (barren)
Extractive (impervious)
- Cropland (barren, herbaceous)
Orchard/vineyard (barren, herbaceous, scrub-shrub)
- Pasture (barren, herbaceous, scrub-shrub)

Methods

- Land Use/Land Cover (LULC) is mapped using a collection of models, scripted in PostGIS and open-source Python
- The rule-based models are designed to classify polygons composed of land cover image segments unioned with county parcel data
- A plethora of national, state, and local ancillary data are used to inform the rule-based model's LULC determination



Land Use Model Process June 2022

Other Ancillary
- Census Urban Area Clusters 2010
- Digitized Extractive Mines
- Coal Mining Operation (Pennsylvania)
- Public Schools
- Solar
- State Timber Harvest (DE, ND, PA, VA, WV)
- Land Use A & B (NAVTEQ)
- Transmission Lines
- Digitized Landfills (2013/14 and 2017/18)
- Land Cover Monitoring, Assessment, and Projection (LCMAP)
- Poultry Houses
- Railways

Data Preparation Ancillary
- Tax Parcels (property boundaries)
- National Land Cover Dataset (NLCD) 2016
- Cropland Data Layer (CDL 2018)
- Local Land Use and Zoning

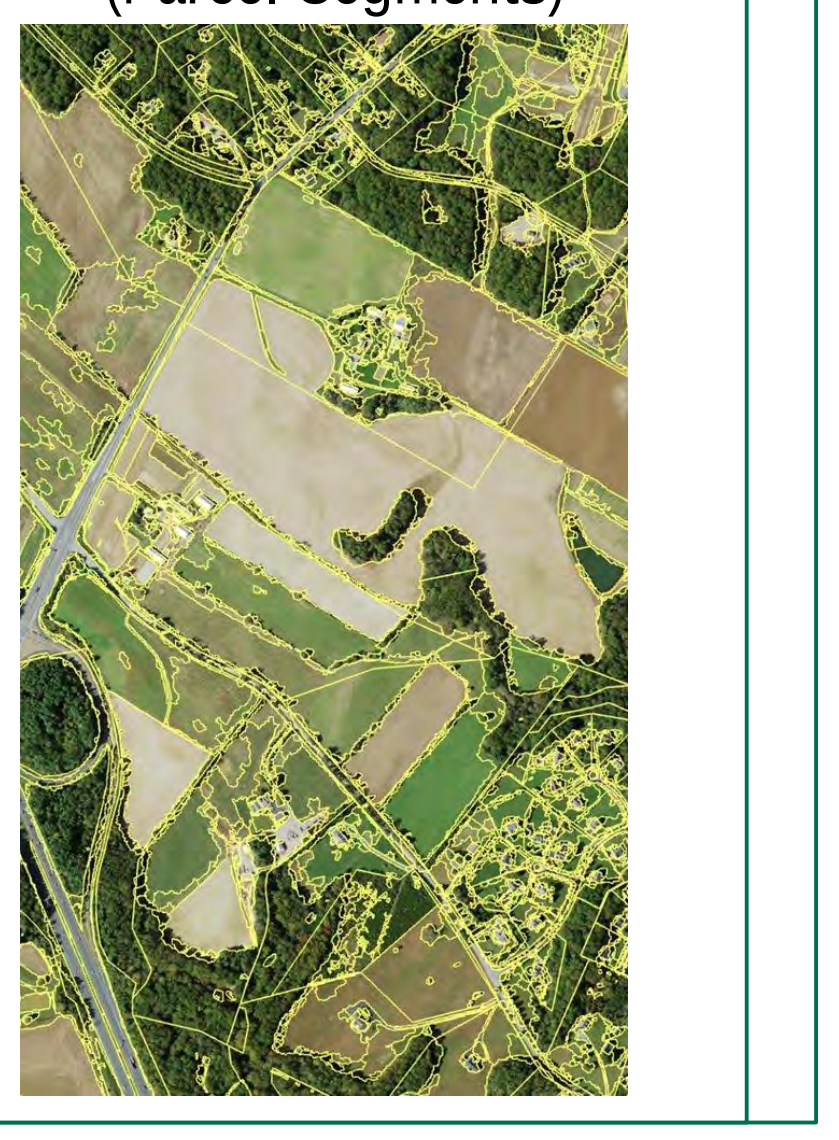
Model Data
- Land Cover (2017/18)

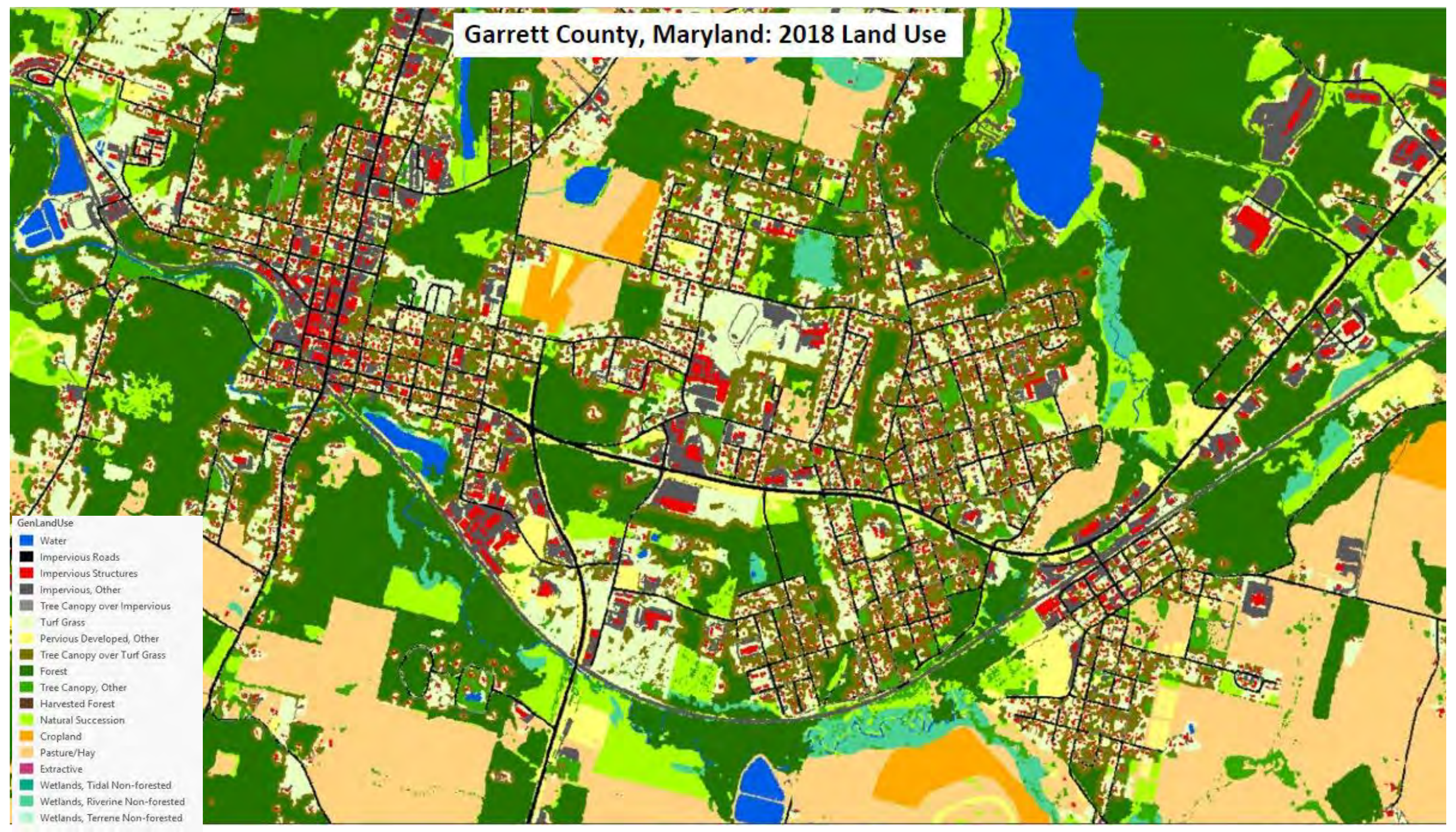
Wetlands and Water Ancillary
- National Hydrography Dataset (NHD) 1:24k
- Floodplain and Channel Evaluation Toolkit (FACET) Stream Network
- Geographic Names Information System (GNIS)
- National Wetlands Inventory (NWI)
- National Oceanic and Atmospheric Administration's (NOAA) Sea Level Rise

Modules
- Data Preparation
- General Land Use (parcel-segment)
- Tree Canopy (patch)
- Burn In / Rasterization
- Wetlands and Water

Output Data
- Land Use 2017/18 (1m raster)

Modelling Scale (Parcel-Segments)





Mapping 1-Meter Resolution Land Use/Land Cover Change

What is the difference between Land Cover Change and Land Use/Land Cover (LULC) Change?

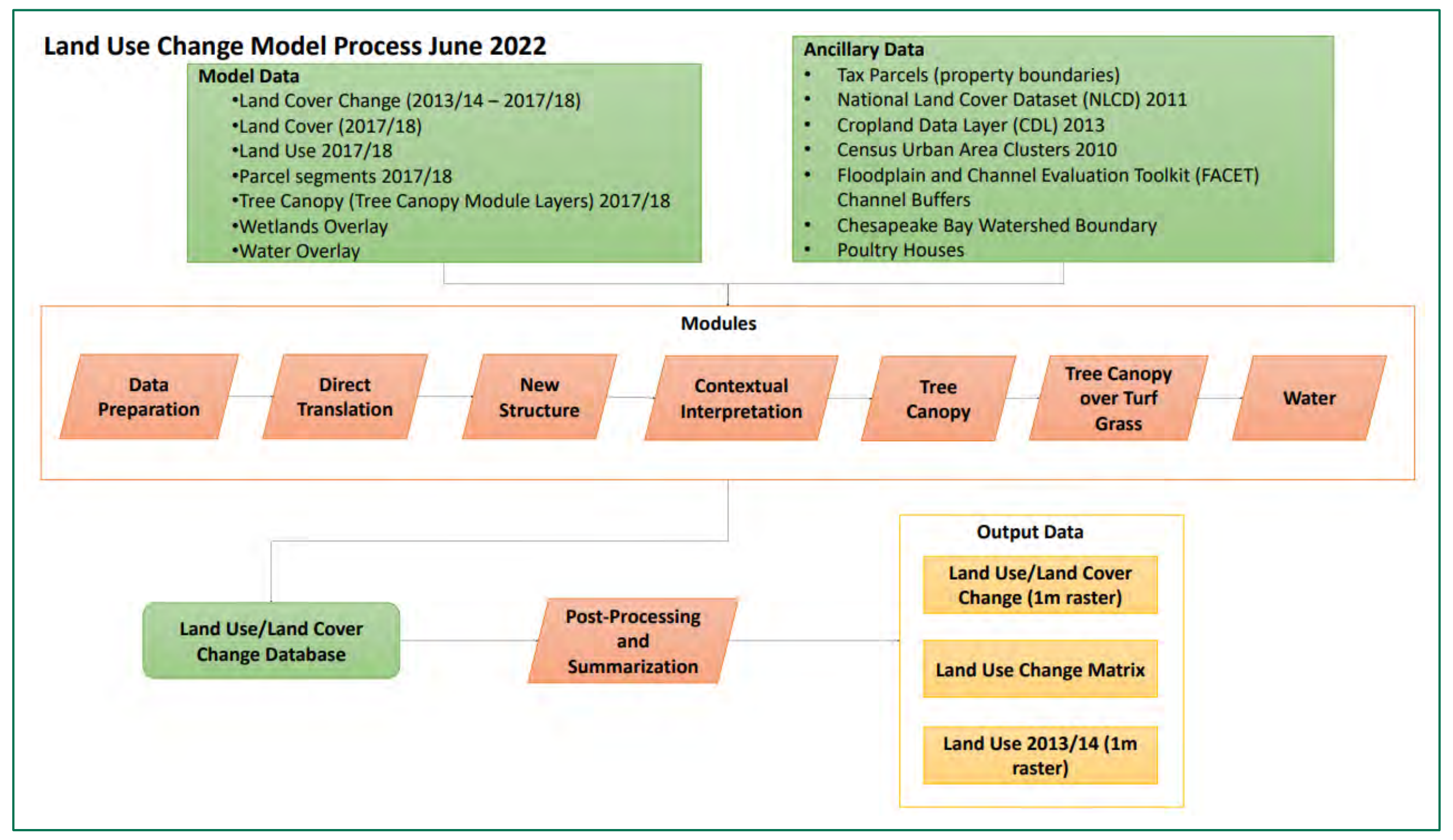
- Land cover change represents change between 12 land cover classes, with 80 transitions mapped across the watershed
- Land use/land cover change represents change between 54 LULC classes, with 974 transitions mapped across the watershed

Methods

- The key driver to mapping Land Use/Land Cover (LULC) change is land cover change
- All land cover change is converted to LULC change
- Land cover change and tax parcels are used to identify areas of land use change not represented as changes in land cover
  - *Low vegetation* in a parcel that became developed in the mapped period (something to *turf grass*)
  - *Tree canopy* in a large forest patch that became fragmented (*forest* to *tree canopy, other*)

Unique model scripted in open-source Python

- Reconcile 1-meter LULC and ancillary data to interpret 2013/14 LULC where LC change occurred
- Create a vector database of LULC information
- Translate vector data to create 1-meter resolution raster of LULC change and change matrices



Land Use Change Model Process June 2022

Model Data
- Land Cover Change (2013/14 – 2017/18)
- Land Cover (2017/18)
- Land Use 2017/18
- Parcel segments 2017/18
- Tree Canopy (Tree Canopy Module Layers) 2017/18
- Wetlands Overlay
- Water Overlay

Ancillary Data
- Tax Parcels (property boundaries)
- National Land Cover Dataset (NLCD) 2011
- Cropland Data Layer (CDL) 2013
- Census Urban Area Clusters 2010
- Floodplain and Channel Evaluation Toolkit (FACET) Channel Buffers
- Chesapeake Bay Watershed Boundary
- Poultry Houses

Modules
- Data Preparation
- Direct Translation
- New Structure
- Contextual Interpretation
- Tree Canopy
- Tree Canopy over Turf Grass
- Water

Land Use/Land Cover Change Database

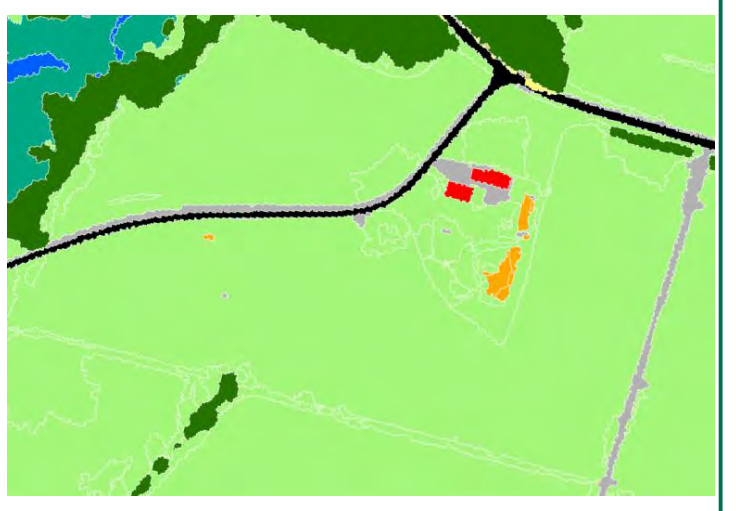
Post-Processing and Summarization

Output Data
- Land Use/Land Cover Change (1m raster)
- Land Use Change Matrix
- Land Use 2013/14 (1m raster)

Why is a Vector Approach Better Suited to Classify LULC and Change?

- Vector image segments identify potential variability in land cover within contiguous patches of a single land cover class. This variability may indicate differences in land use. A purely raster based-approach would not account for this variability.

2018 National Agricultural Imagery Program (NAIP), USDA



2018 Land Cover and 2018 Land Cover Segments (UVM)

Why is a Unique Land Use/Land Cover (LULC) Change Model Required to Accurately Map LULC Change?

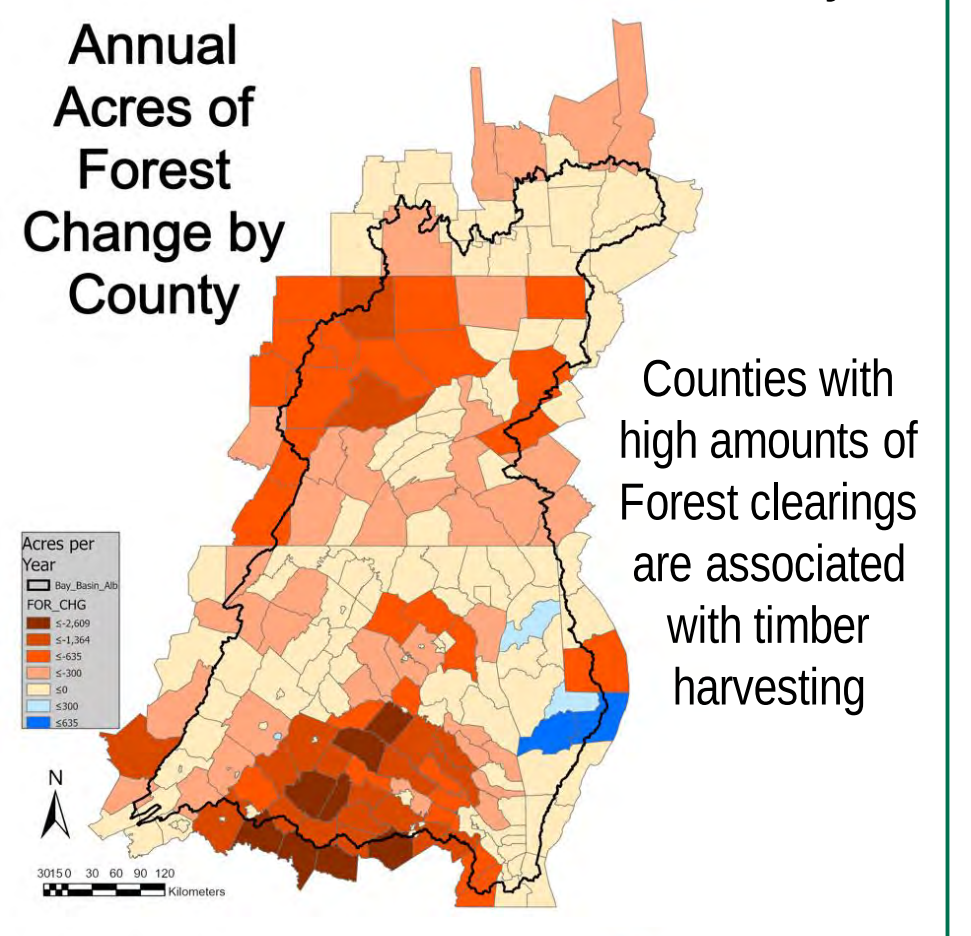
- In a series of LULC datasets, the most recent date is generally most accurate because it leverages the latest ancillary data, imagery, and technological advances. LULC change over an observed 4 to 5-year period only occurs on about 5% of the landscape. To preserve the accuracy of the latest LULC date, only the areas of change need to be updated to represent earlier LULC dates.
- The latest LULC provides the most accurate "end state" context for interpreting the LULC conditions in previous years.
- This approach allows the LULC time series to be adapted to evolving user needs by addressing them in the most recent date of LULC for the entirety of the landscape. Any improvements are held constant back through time by only adjusting the areas of change in the separate change model.

Watershed Trends

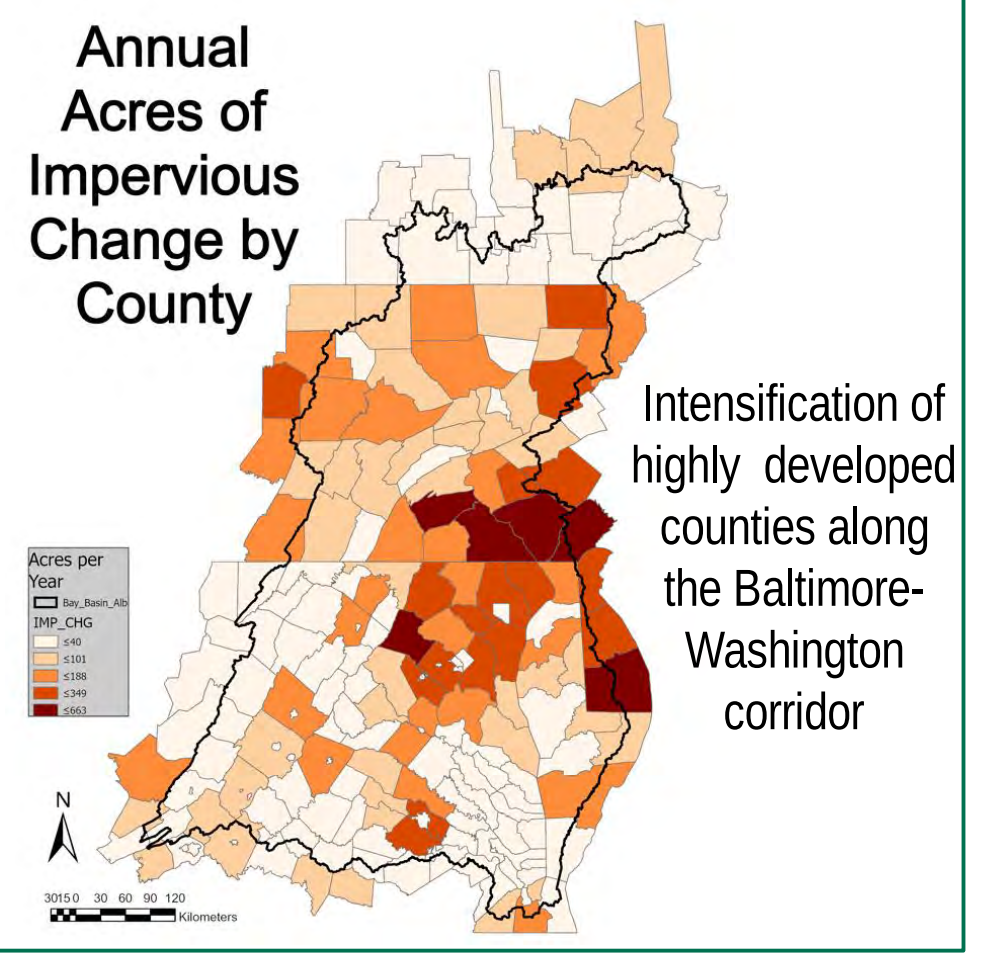
2013/14-2017/18	ROAD	IMPS	IMPO	TCIS	TURF	TCTG	PDEV	FORE	TCOT	HARF	NATS	CROP	PAST	EXTR	TDLW	RIVW	TERW	WATR	Decrease
ROAD	0	14	338	696	74	66	206	138	75	1	17	11	14	4	0	2	0	2	1,657
IMPS	1	0	937	508	277	88	143	7	2	1	37	75	84	2	0	0	0	1	2,165
IMPO	516	3,173	0	1,587	4,334	305	1,288	166	60	102	785	652	1,331	1	21	25	5	35	14,386
TCIS	42	485	690	0	2,446	0	1,599	0	0	181	408	98	184	6	3	7	1	1	6,149
TURF	0	828	5,558	0	0	8,514	1,089	107	106	21	127	3	8	725	0	0	0	0	17,085
TCTG	13	930	4,143	11	11,096	0	783	0	0	93	422	246	539	9	0	0	0	2	18,286
PDEV	1,130	4,377	6,865	0	15,251	49	0	304	33	221	417	142	79	1,270	0	0	0	101	30,241
FORE	1,161	2,764	8,918	732	13,096	28,221	28,107	0	22,046	175,564	81,474	19,557	23,186	4,066	1,381	5,568	193	297	416,330
TCOT	123	952	2,339	0	2,068	2,032	2,341	0	0	788	2,278	3,075	4,566	386	108	250	27	42	21,375
HARF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NATS	63	149	477	0	3,481	371	826	76,425	4,389	4,295	0	546	356	501	0	0	0	1,090	92,968
CROP	500	3,018	8,369	0	4,031	165	2,514	11,299	3,088	1,367	2,069	0	126	1,182	0	0	0	780	38,509
PAST	307	2,253	9,607	0	6,562	185	3,857	13,163	8,984	1,631	4,035	123	0	1,232	0	0	0	402	52,340
EXTR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDLW	2	4	91	0	1	0	0	1,746	162	8	0	0	0	0	0	0	0	73	2,087
RIVW	9	31	104	0	167	0	0	7,499	512	208	0	0	0	20	0	0	0	156	8,707
TERW	2	9	43	0	41	2	28	629	86	11	11	16	5	15	0	0	0	36	933
WATR	2	5	130	0	51	15	65	75	153	0	66	71	73	213	28	22	7	0	975
Increase	3,872	18,991	48,610	3,535	62,975	40,010	42,846	111,558	39,695	184,491	92,147	24,616	30,550	9,634	1,541	5,874	232	3,017	724,192
Totals																			
TotIncrease	3,872	18,991	48,610	3,535	62,975	40,010	42,846	111,558	39,695	184,491	92,147	24,616	30,550	9,634	1,541	5,874	232	3,017	
TotDecrease	1,657	2,165	14,386	6,149	17,085	18,286	30,241	416,330	21,375	0	92,968	38,509	52,340	0	2,087	8,707	933	975	
Net	2,215	16,827	34,224	(2,615)	45,890	21,723	12,605	(304,772)	18,319	184,491	(821)	(13,893)	(21,790)	9,634	(546)	(2,833)	(701)	2,042	

- Timber Harvesting (~260,000 Acres of Tree Canopy cleared for harvesting)
  - ~ 80,000 acres of *natural succession* and *harvested forest* transitioned to *forest* and *tree canopy*
- Development (~130,000 Acres of new development)
  - ~50,000 Acres of new impervious and ~79,000 Acres of new pervious development, including *turf grass*, *tree canopy over turf grass*, solar fields, utility right of ways, and construction
  - ~93,000 Acres of *forest* and *other tree canopy* transitioned to development (including *tree canopy over impervious* and *turf grass*)
  - ~40,000 Acres of Agriculture transitioned to development

Watershed Trends Vary Locally



Counties with high amounts of Forest clearings are associated with timber harvesting

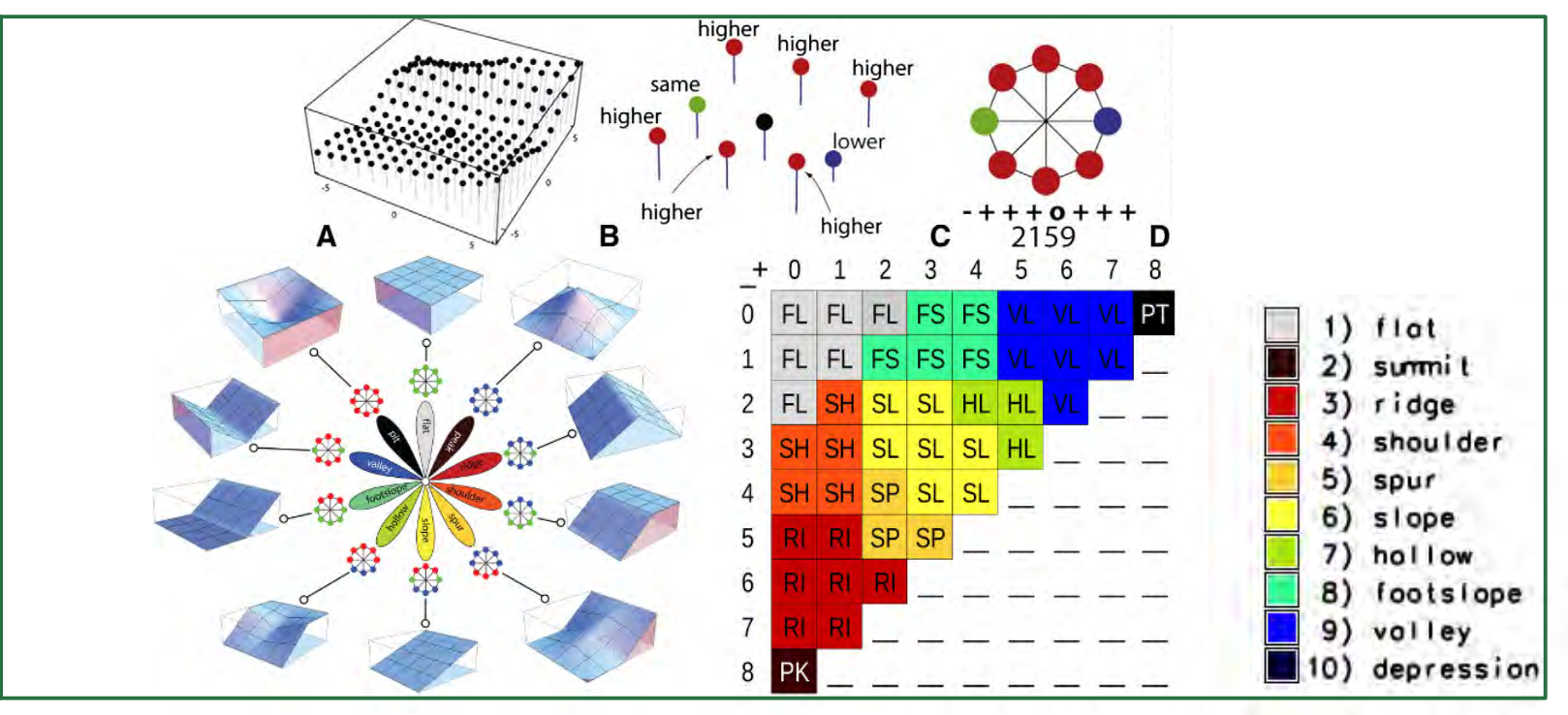


Intensification of highly developed counties along the Baltimore-Washington corridor

Mapping 1-Meter Resolution (Hyper-Res) Hydrography

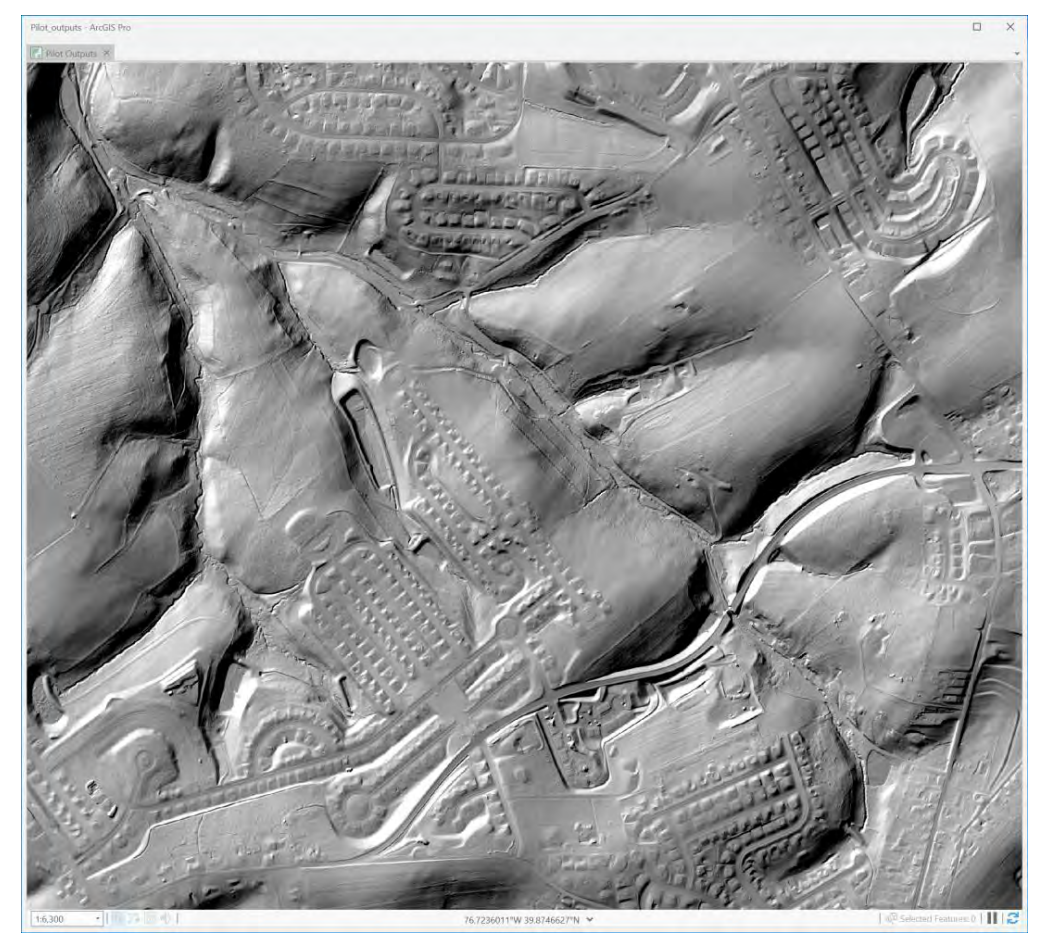
What are Geomorphons?

- Landform classification algorithm by Jasiewicz & Stepinski (2013)
- Evaluates 8 directional position and relative elevation bounding line-of-sight to determine landform
- Classifies pattern rather than degree
- Delineates contiguous features rather than pixels
- Adjustable parameters, host of encoded information

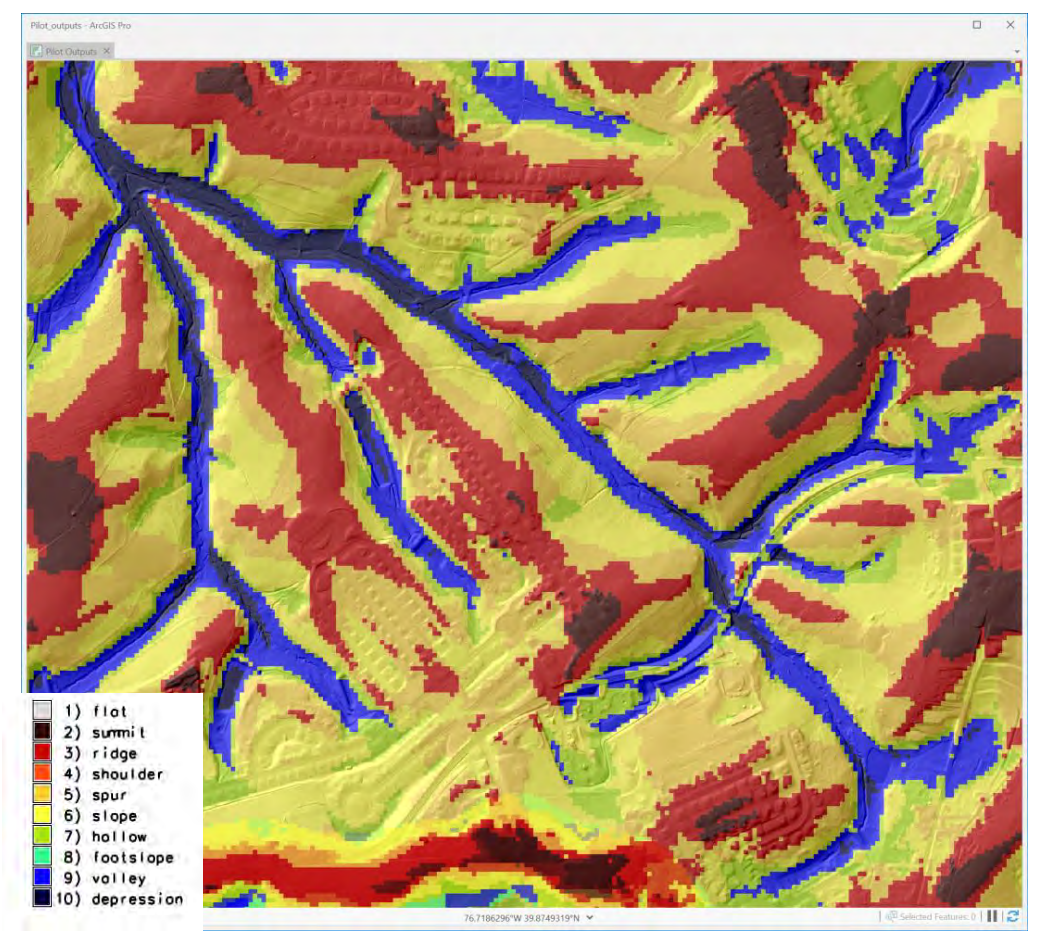


Methods

1. Lidar elevation

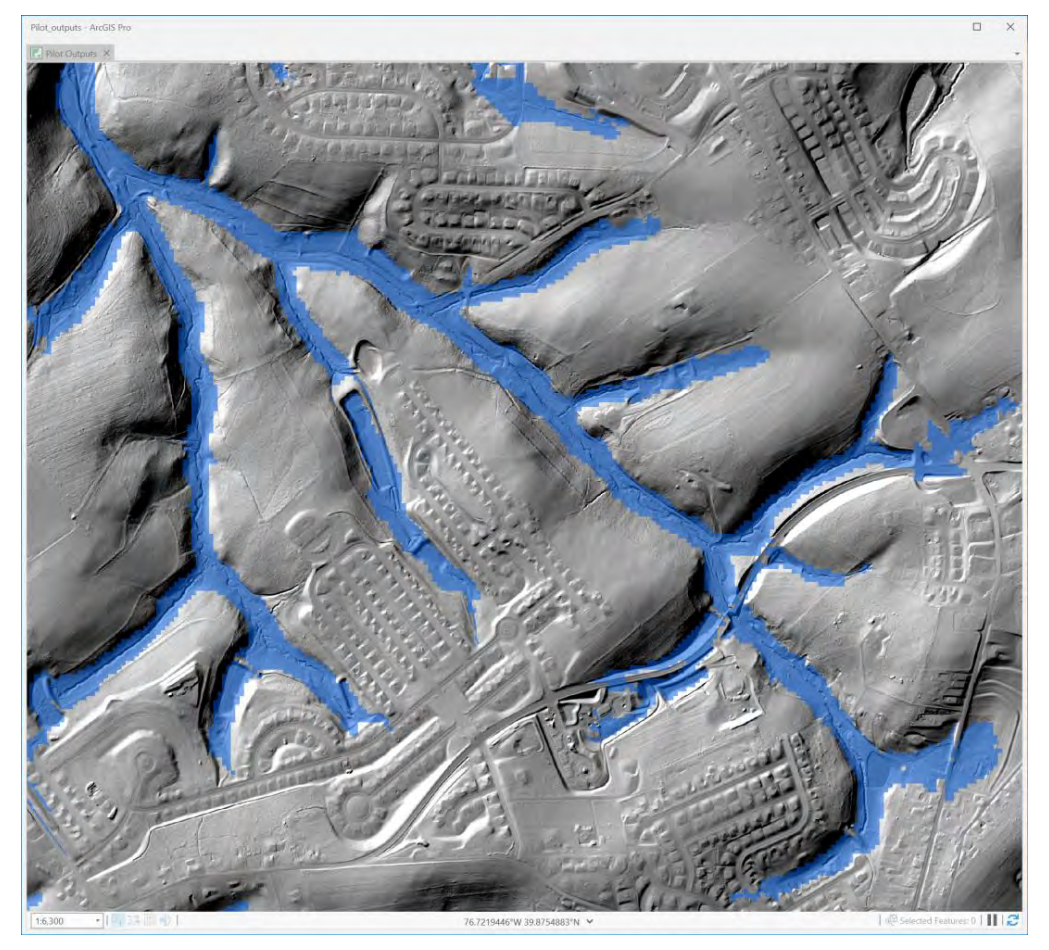


2. Valley-Scale Classification

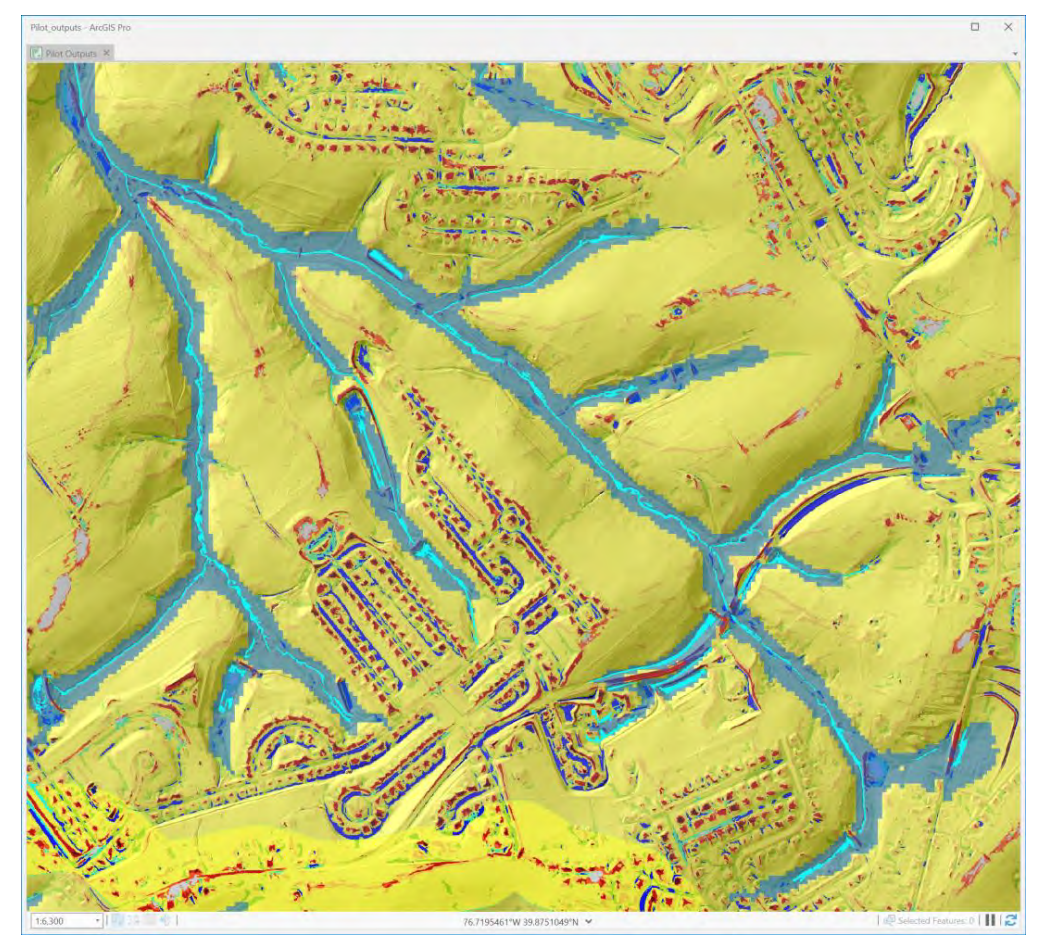


3. Channel-Scale Classification

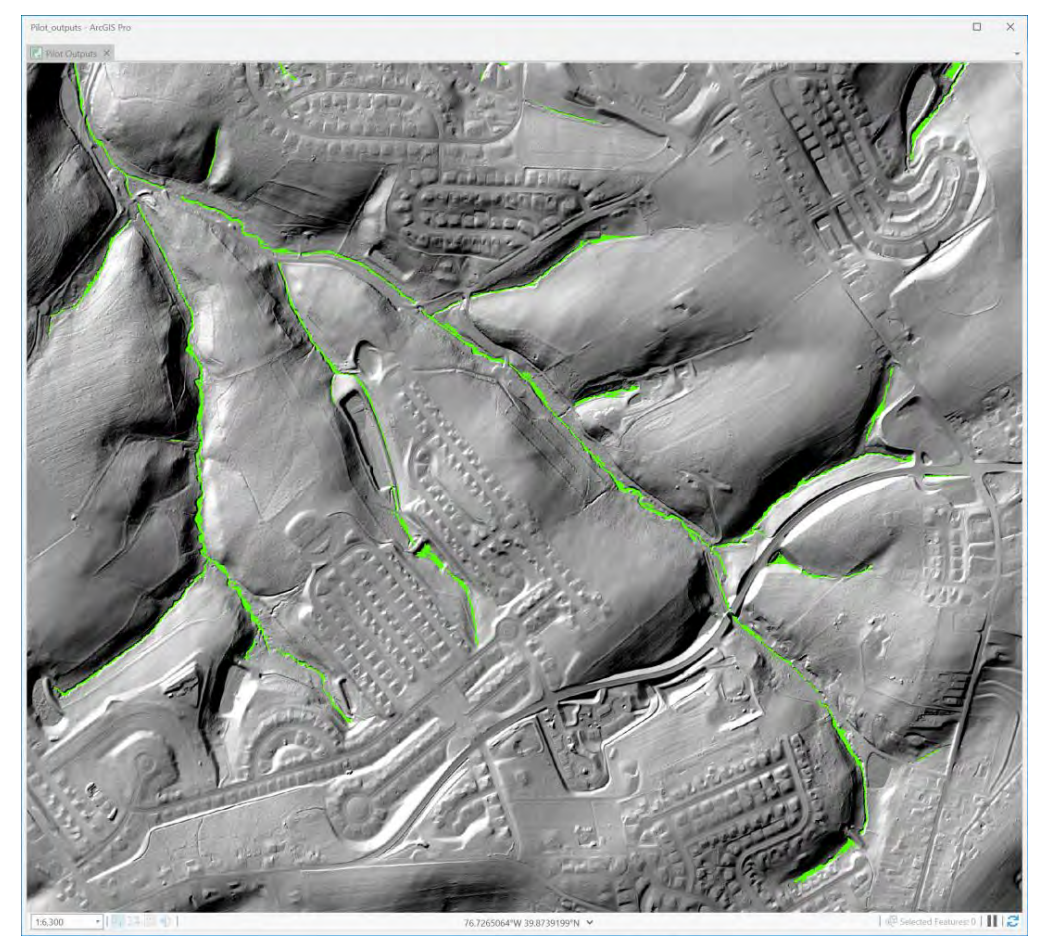
4. Identify Valley Network



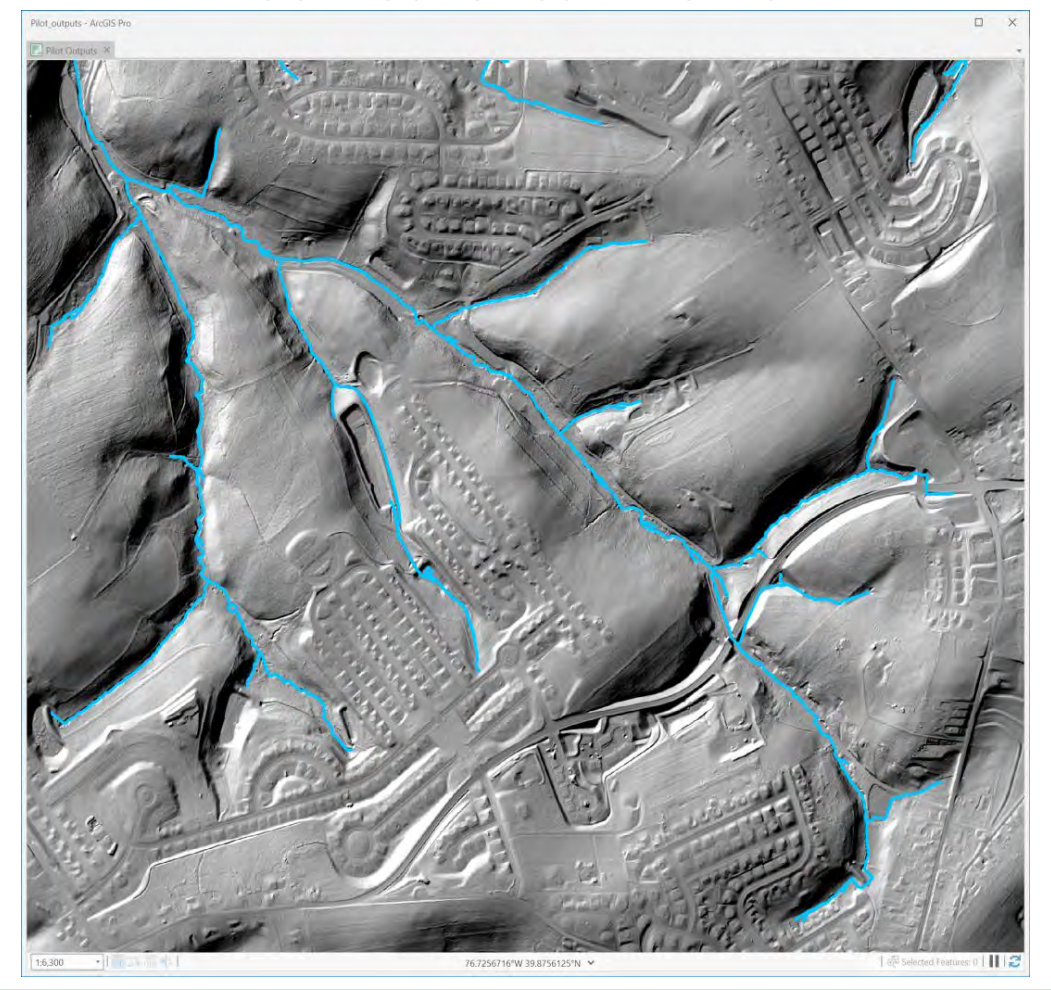
5. Extract Features using valley network



6. Predict Channel Skeleton



7. Connect Stream network



Reach-scale attributes:

- Length and slope
- Width and Bank height
- Stream order
- Essential for temp, hydraulic, WQ modeling
- Others?
- Channel Width, bank height, other attributes detected directly from DEM

Reach Classification:

- Streams
- Rills and gullies
- Roadside ditches
- Agricultural ditches/swales
- Detention features/ponds
- Floodplain depressions
- Other (e.g., anthropogenic features, crevice, slide scars, washes)

How Does this Approach Compare to the National Hydrography Dataset (NHD)?

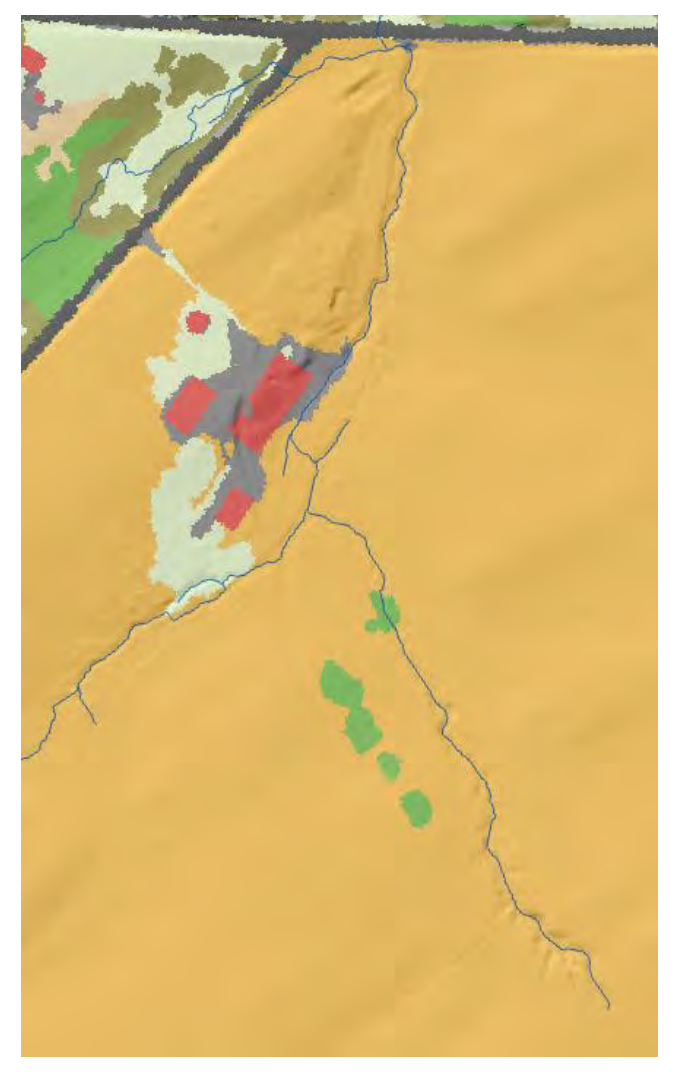
- The Hyper-Res Streams (blue) are more precise than NHD streams (red)
- The Hyper-Res is better suited for precise applications, such as riparian area and other local analyses
- The Hyper-Res streams is assigned attributes not present in NHD

2013 LULC

2013 LULC + LULC Change + Hyper-Res Hydrography

2013 LULC + Hyper-Res Hydrography

2017 LULC + Hyper-Res Hydrography



Title

Authors

[1] USGS - Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Land Use

- LC vs LU
- List of anci used to convert to LU
- Process diagram
- Final lu image

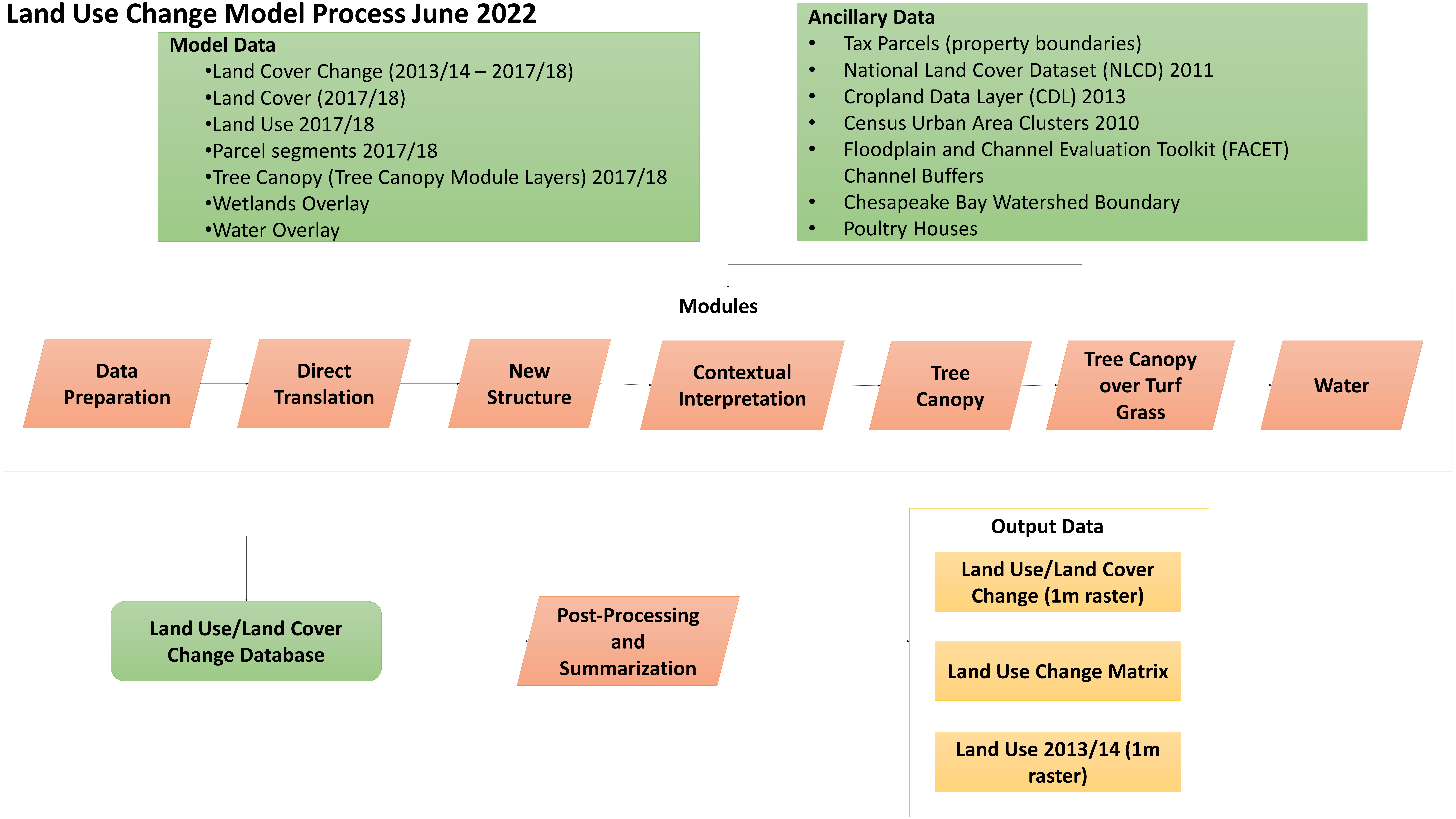
Land Use Change

- Need unique LU change model
    - Differences 2 static LU maps to create change causes artifacts that are not change
    - Using spectral LC change adds context to what the change is
- Model diagram
- LC vs LU change (subdivision images)
- Change matrix (18x18 for CBW and some interpretations)

Hydrography

- Derived from geomorphons
- Valleys within the valleys
    - Take from existing slides
- Tease 2024 nexus of LU, Lu change, and hydrography (streams and buffers)
    - Second example of farm ditches on LU?

Land Use Change Model Process June 2022



Model Data

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- Water Overlay

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- Census Urban Area Clusters 2010
- Floodplain and Channel Evaluation Toolkit (FACET) Channel Buffers
- Chesapeake Bay Watershed Boundary
- Poultry Houses

Modules

Data Preparation

Direct Translation

New Structure

Contextual Interpretation

Tree Canopy

Tree Canopy over Turf Grass

Water

Land Use/Land Cover Change Database

Post-Processing and Summarization

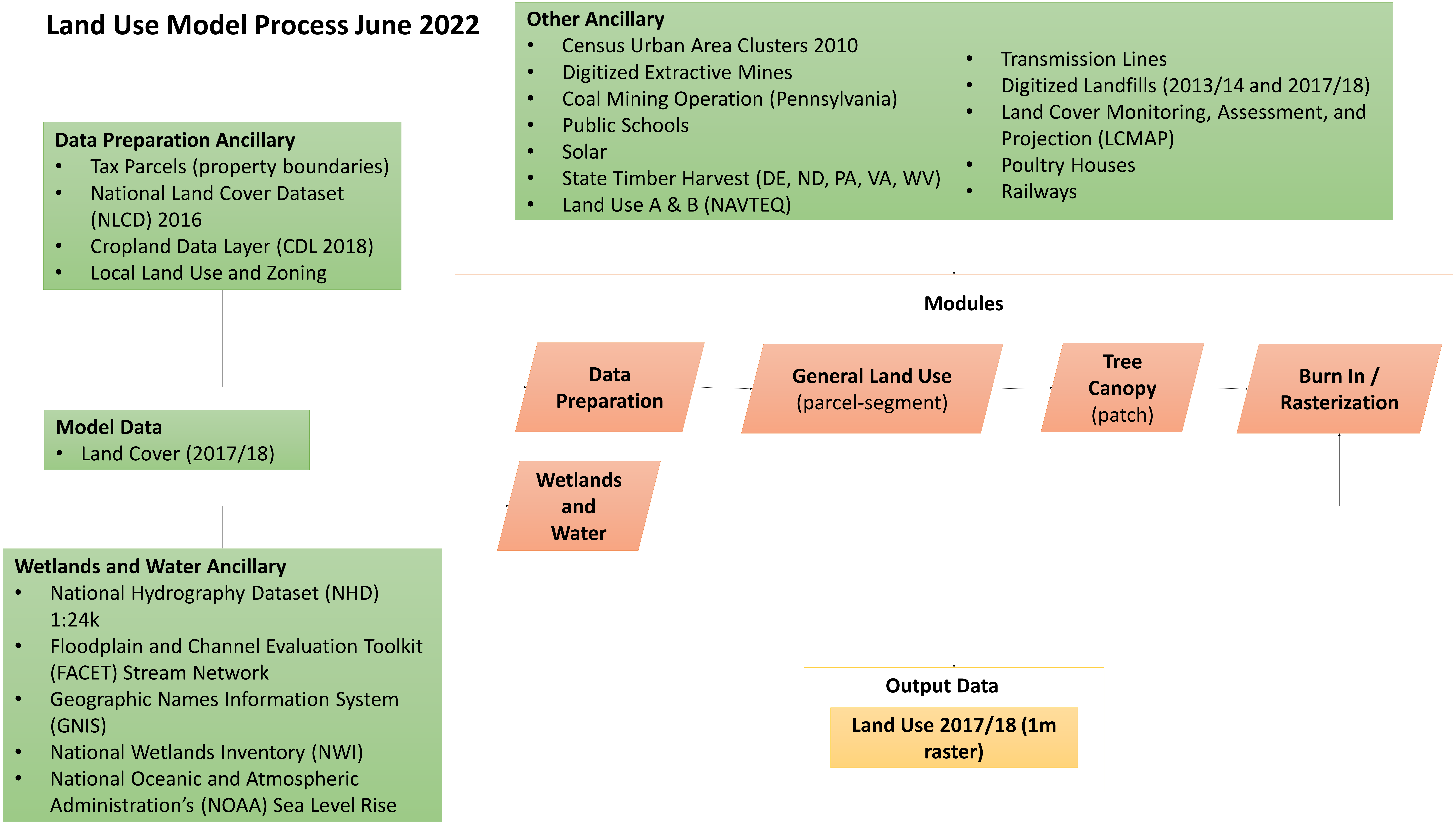
Output Data

Land Use/Land Cover Change (1m raster)

Land Use Change Matrix

Land Use 2013/14 (1m raster)

Land Use Model Process June 2022



Other Ancillary

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Data Preparation Ancillary

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- Cropland Data Layer (CDL 2018)
- Local Land Use and Zoning

Model Data

- Land Cover (2017/18)

Modules

Data Preparation

General Land Use (parcel-segment)

Tree Canopy (patch)

Burn In / Rasterization

Wetlands and Water

Wetlands and Water Ancillary

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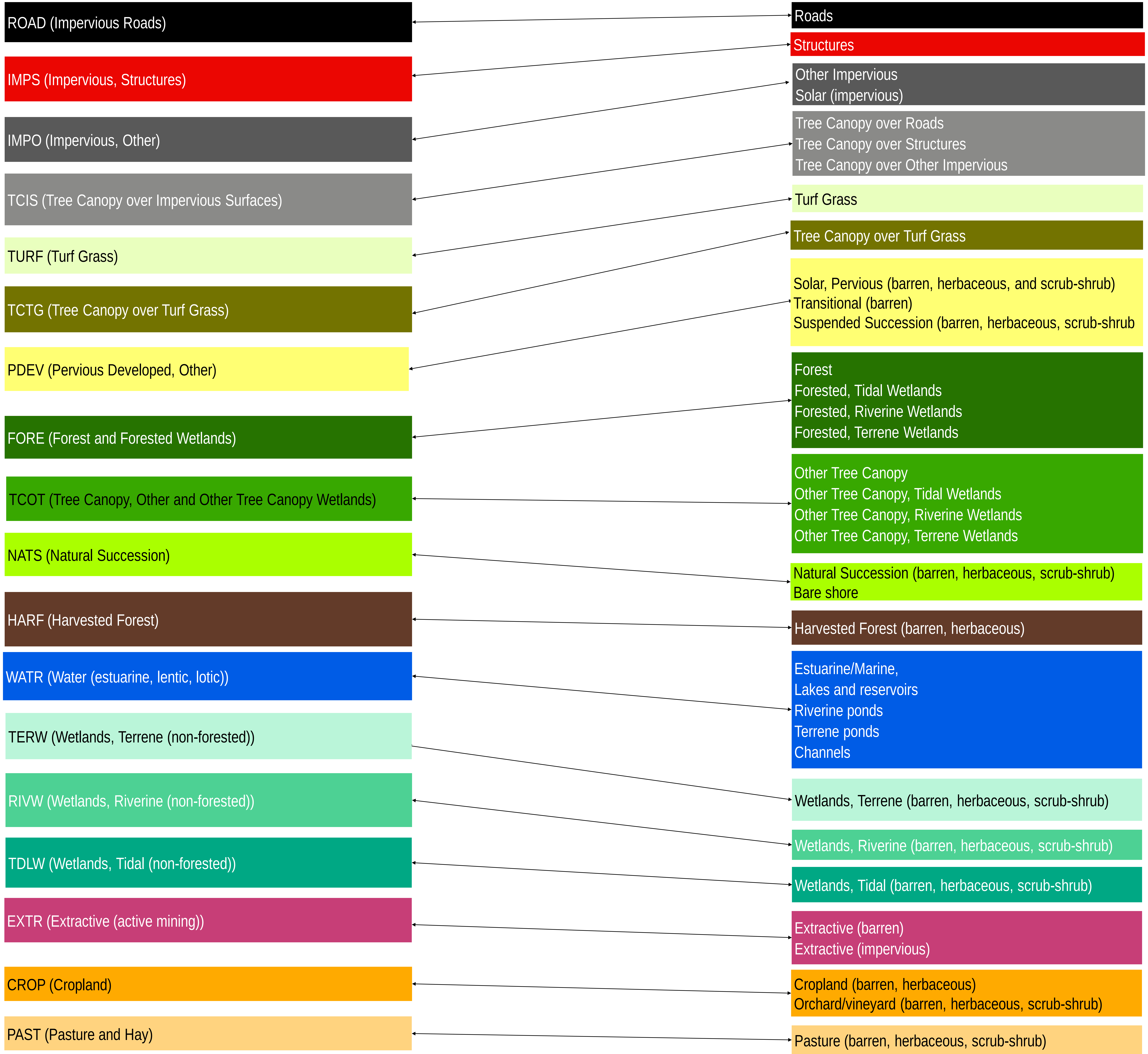
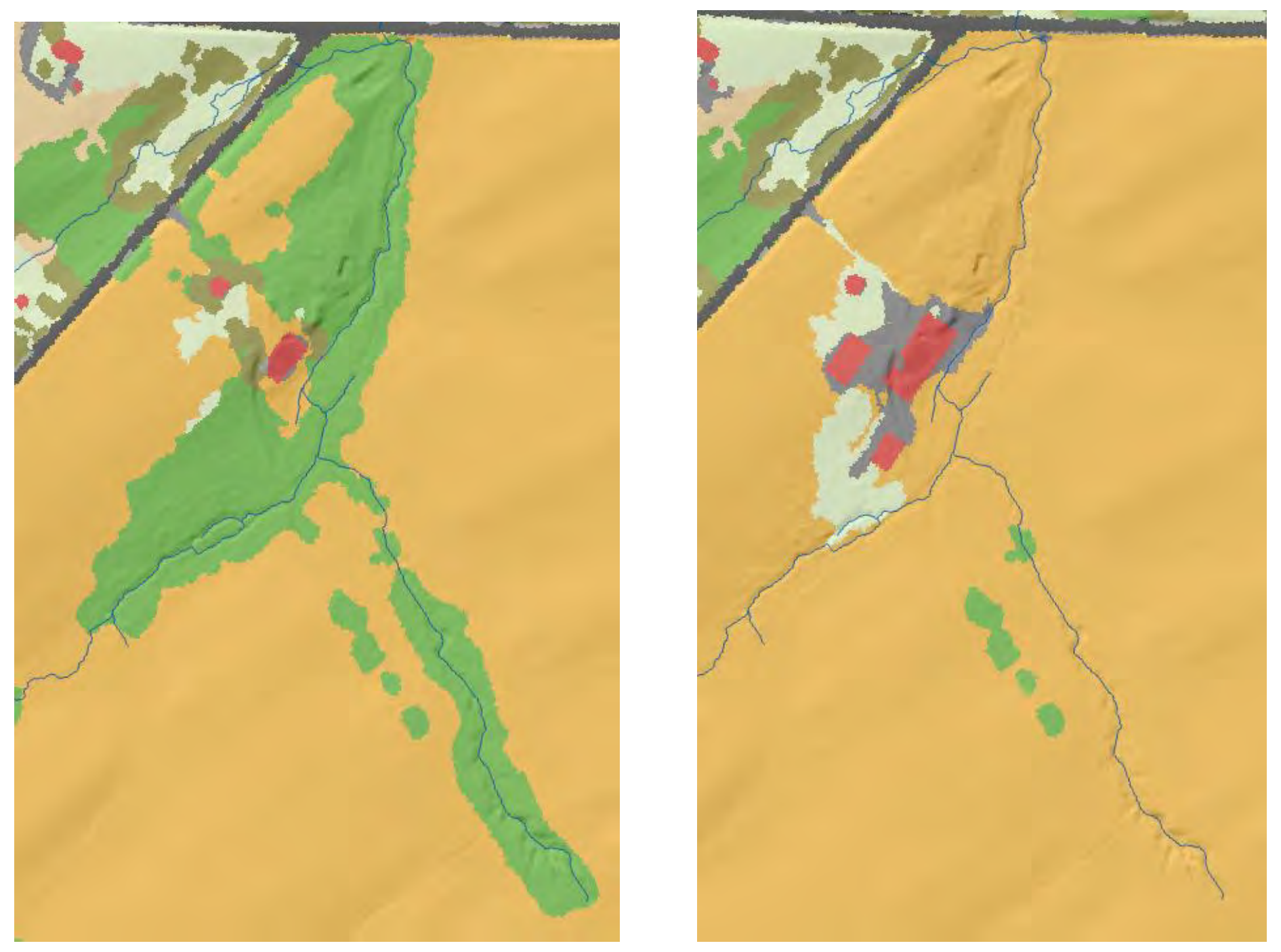
- Floodplain and Channel Evaluation Toolkit (FACET) Stream Network
- Geographic Names Information System (GNIS)
- National Wetlands Inventory (NWI)
- National Oceanic and Atmospheric Administration's (NOAA) Sea Level Rise

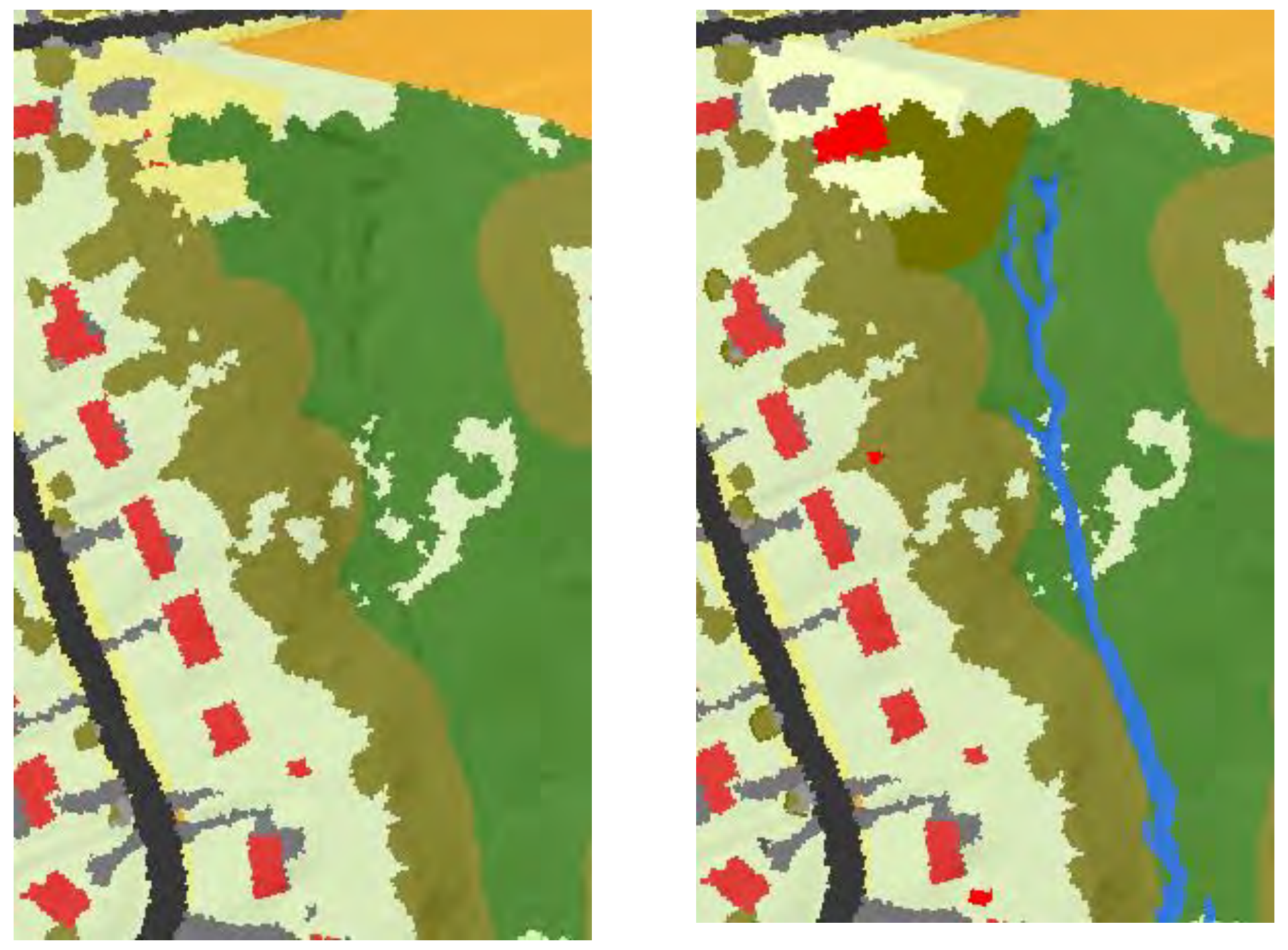
Output Data

Land Use 2017/18 (1m raster)



General Land Uses	Detailed Land Uses
ROAD (Impervious Roads)	Roads
IMPS (Impervious, Structures)	Structures
IMPO (Impervious, Other)	Other Impervious Solar (impervious)
TCIS (Tree Canopy over Impervious Surfaces)	Tree Canopy over Roads Tree Canopy over Structures Tree Canopy over Other Impervious
TURF (Turf Grass)	Turf Grass
TCTG (Tree Canopy over Turf Grass)	Tree Canopy over Turf Grass
PDEV (Pervious Developed, Other)	Solar, Pervious (barren, herbaceous, and scrub-shrub) Transitional (barren) Suspended Succession (barren, herbaceous, scrub-shrub
FORE (Forest and Forested Wetlands)	Forest Forested, Tidal Wetlands Forested, Riverine Wetlands Forested, Terrene Wetlands
TCOT (Tree Canopy, Other and Other Tree Canopy Wetlands)	Other Tree Canopy Other Tree Canopy, Tidal Wetlands Other Tree Canopy, Riverine Wetlands Other Tree Canopy, Terrene Wetlands
NATS (Natural Succession)	Natural Succession (barren, herbaceous, scrub-shrub) Bare shore
HARF (Harvested Forest)	Harvested Forest (barren, herbaceous)
WATR (Water (estuarine, lentic, lotic))	Estuarine/Marine, Lakes and reservoirs Riverine ponds Terrene ponds Channels
TERW (Wetlands, Terrene (non-forested))	Wetlands, Terrene (barren, herbaceous, scrub-shrub)
RIVW (Wetlands, Riverine (non-forested))	Wetlands, Riverine (barren, herbaceous, scrub-shrub)
TDLW (Wetlands, Tidal (non-forested))	Wetlands, Tidal (barren, herbaceous, scrub-shrub)
EXTR (Extractive (active mining))	Extractive (barren) Extractive (impervious)
CROP (Cropland)	Cropland (barren, herbaceous) Orchard/vineyard (barren, herbaceous, scrub-shrub)
PAST (Pasture and Hay)	Pasture (barren, herbaceous, scrub-shrub)





Community Engagement through Three-dimensional Mapping: Part 1 – Introduction

John C. Wolf

U.S. Geological Survey, Lower Mississippi-Gulf Water Science Center, Chesapeake Bay Program Office, Annapolis, Maryland

Abstract

Local land conservation has become technologically sophisticated. The availability of geographic information system (GIS) capabilities has enabled land trusts and watershed organizations to benefit from a wellspring of ever-expanding environmental information. Traditionally, online two-dimensional (2D) mapping applications are used to communicate landscape assessments, monitor status and trends, target conservation and restoration actions, and track implementation of projects. However, traditional 2D maps have limitations, particularly in terms of how map users make connections between geographic "space" and the phenomenon of "place" (or how local stakeholders experience the land and resources they value).

Interactive 3D visualization can better connect local stakeholders to place-based stewardship opportunities and challenges. Despite a lingering perception that 3D is beyond the capabilities of local organizations, technological advancements have brought 3D mapping to a much more general audience. Specifically, the increasing availability of Light Detection and Ranging (LiDAR), building footprint, and high-resolution land cover data enables the creation of realistic, interactive landscapes that stakeholders can explore through a variety of interfaces.

This poster is the first in a series aimed at demonstrating how local, interactive web scenes can be used to underscore conservation and restoration issues by visualizing structural elements of Chesapeake landscapes, providing a new approach to connecting stakeholders to "place".

Implications of 3D in Communication

Studies have shown that 3D can have multiple benefits:

- 3D visual displays are considered more intuitive and natural in appearance (Hamilton et al 2001) and are often easier to interpret (Lewis and Sheppard 2006),
- 3D visualization provides a sense of immersion in the environment, wherein the user can better appreciate the sense of scale and better judge impacts of development (Lai et al 2010),
- 3D GIS derived visualizations are particularly suitable for landscapes with many vertical structures (e.g., structures and vegetation) (Lai et al 2010),
- 3D graphics may be more visually appealing than 2D (Fisher et al 1997), and
- Users may perceive 3D landscapes with a higher degree of confidence and credibility (Lewis and Sheppard 2006).

Landscape visualization may be well suited for the following purposes:

- Communicating current environmental conditions,
- Communicating potential future or past conditions,
- Explaining ecosystem changes (natural or before/after interventions),
- Complementing local story lines for management decisions,
- Place-based storytelling -- integration of multiple topics for data-driven storytelling in a particular location.

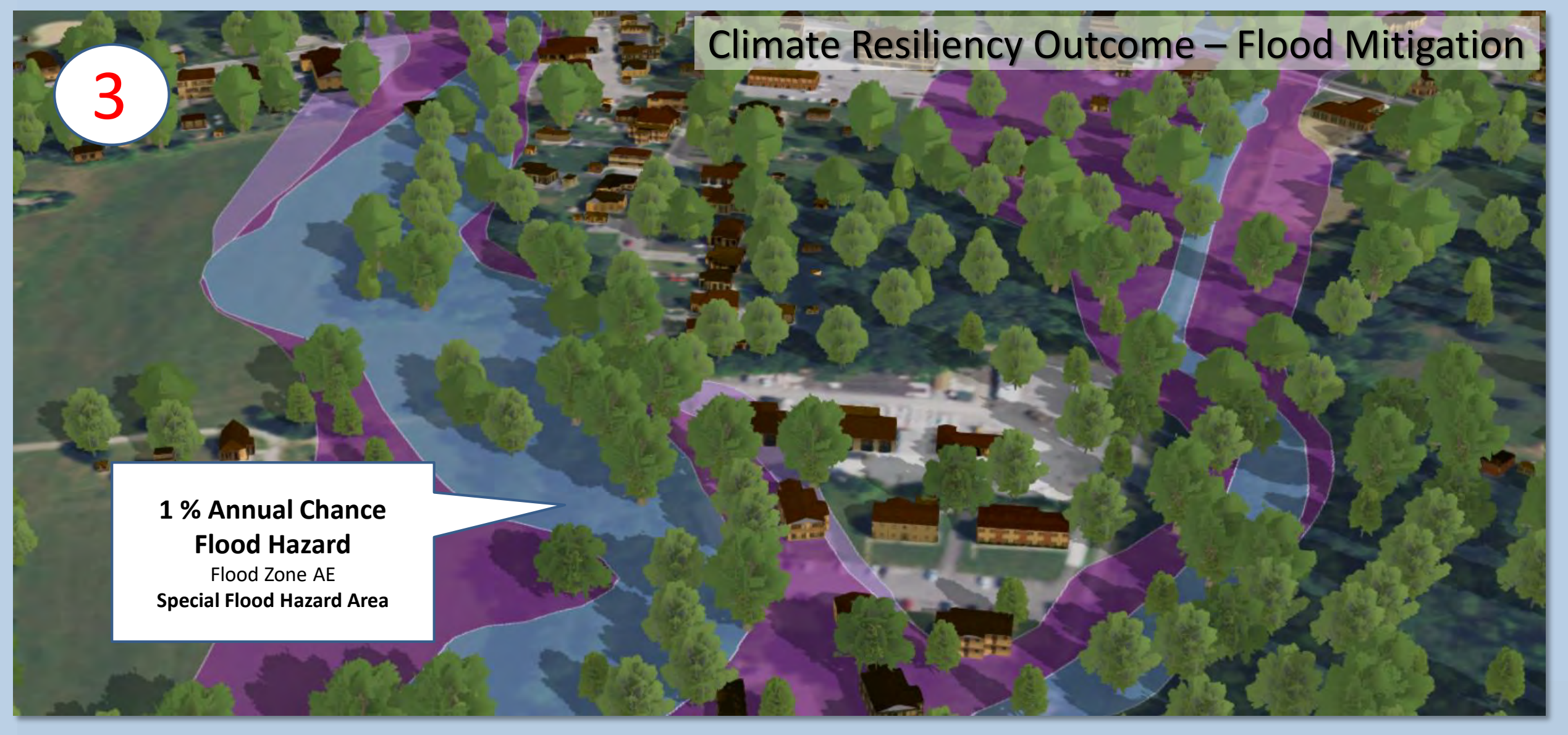


Figure 3. 3D landscape visualization of floodplain in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source of data: Frederick County, Maryland LiDAR and building footprint data.

Data-driven Landscapes

Conceptual diagrams (Figure 1a) have been shown to be an effective tool for science communication. Specifically, they:

- Provide synthesis, visualization, and context to scientific topics,
- Are accessible, informative, and visually interesting, and
- Facilitate communication among scientists, resource managers, and non-scientists (Thomas et al 2004).

However, conceptual diagrams are limited in their ability to convey place-based conditions without substantial investment of time in custom graphic design. They are best suited for applications where messaging is generic across an ecosystem and static images are the preferred form of communication.

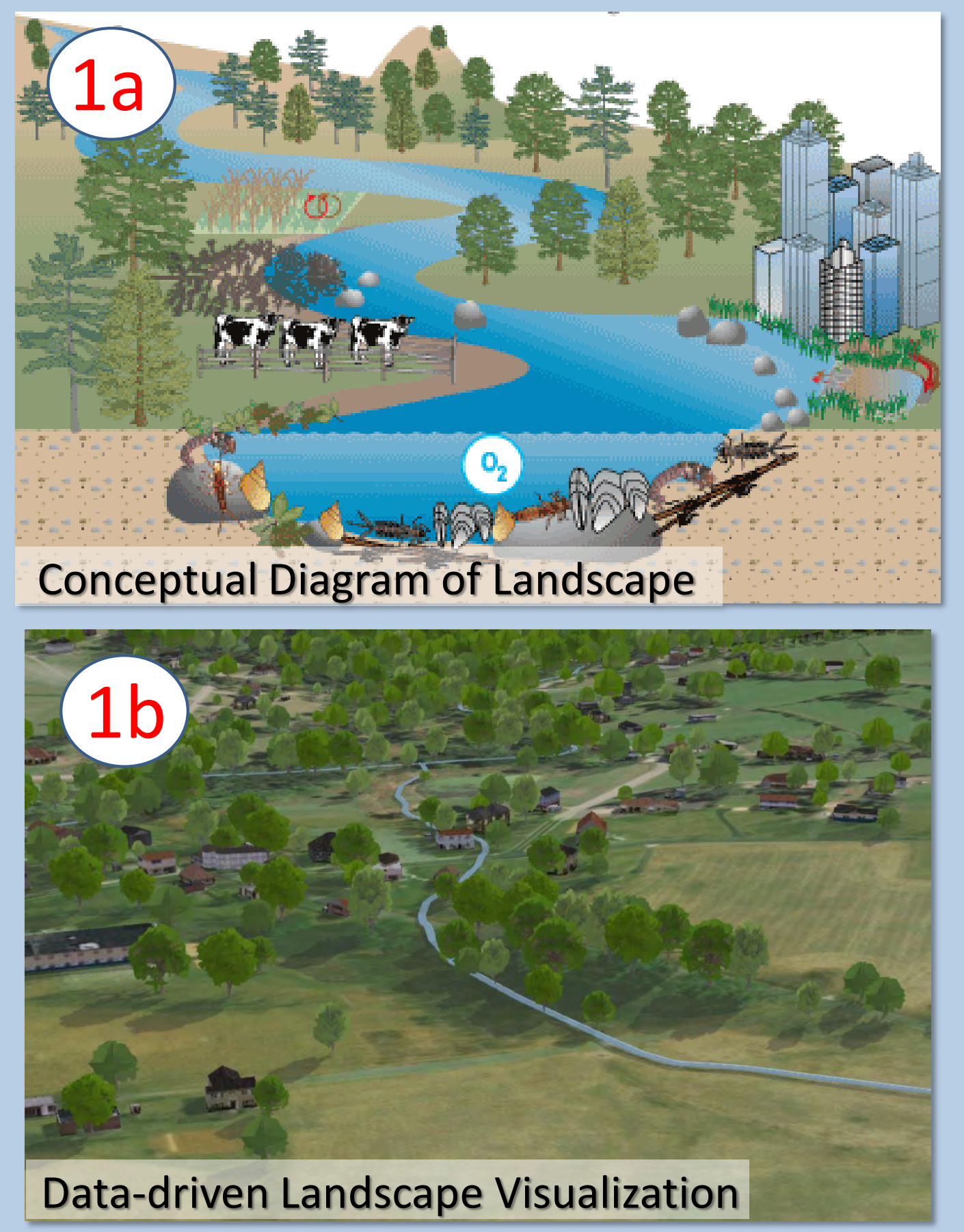


Figure 1. Comparison of conceptual diagram of a landscape/ecosystem (1a) and data-driven landscape (1b). Source: 1a – Lane et al 2007; 1b – derived from Frederick County, Maryland LiDAR and Building Footprints.

Conversely, data-driven landscape visualizations (Figure 2) derived from elevation data and building footprints can be used to communicate place-based ecosystem characteristics without significant manual intervention. Essentially, once the data is assembled and formatted and symbolization rules are defined, large areas of landscapes can be depicted in 3D representing both existing and potential conditions.

Data-driven landscape visualizations:

- Are rendered based on procedural rules,
- Require LiDAR and building footprint data,
- Can be generated at various levels of detail.

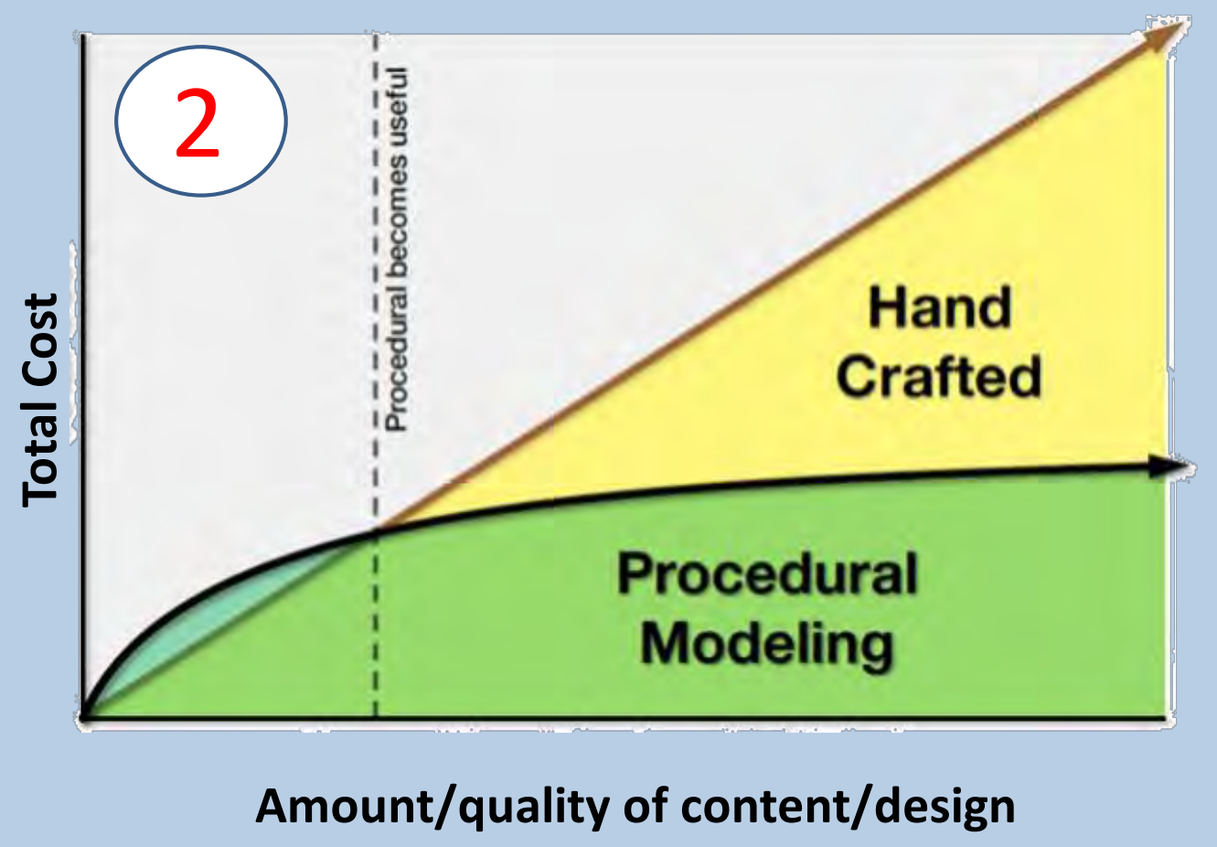


Figure 2. Cost relative to amount of effort in generating manual vs procedural landscapes. Source: Esri 2007.

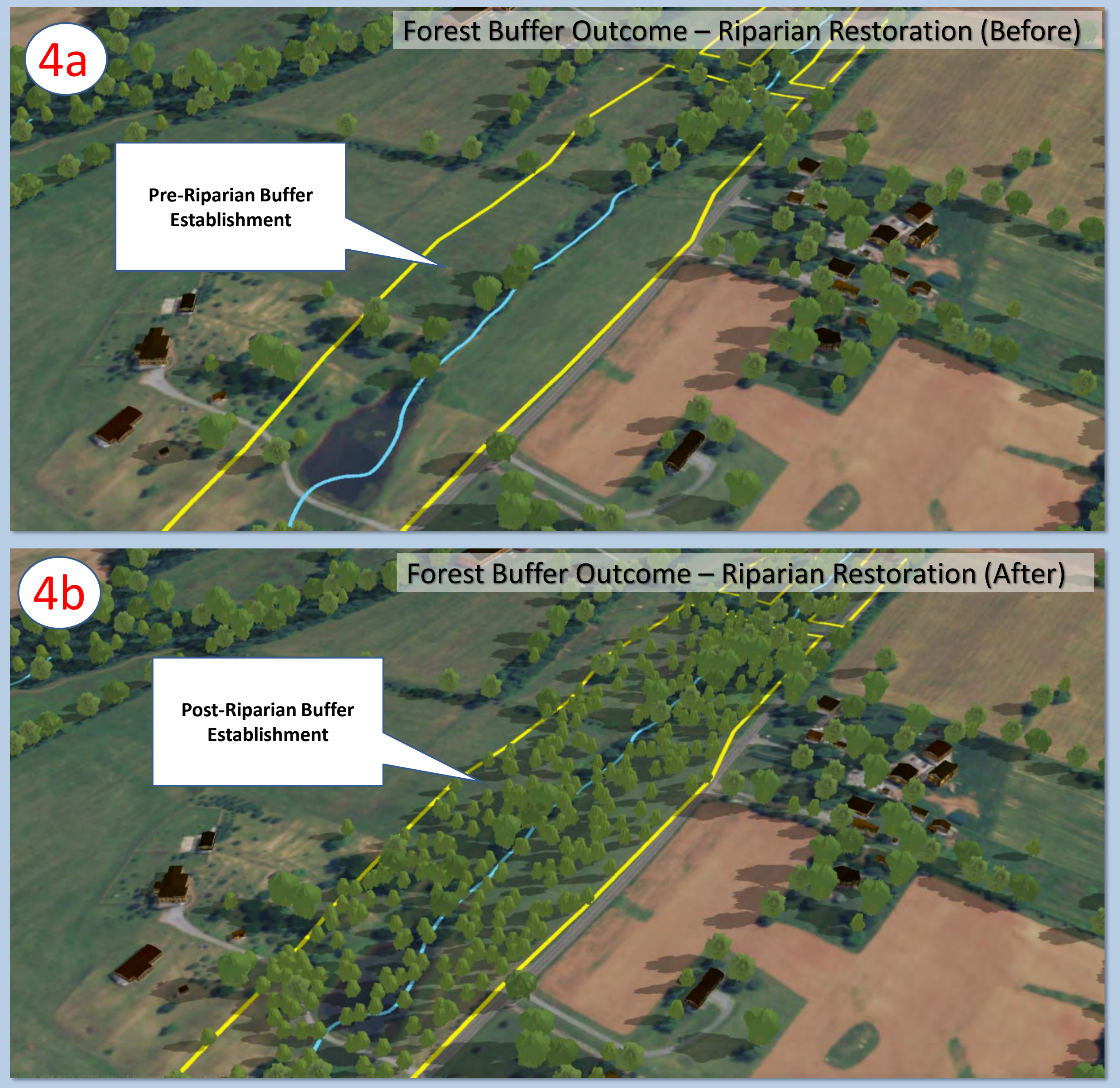
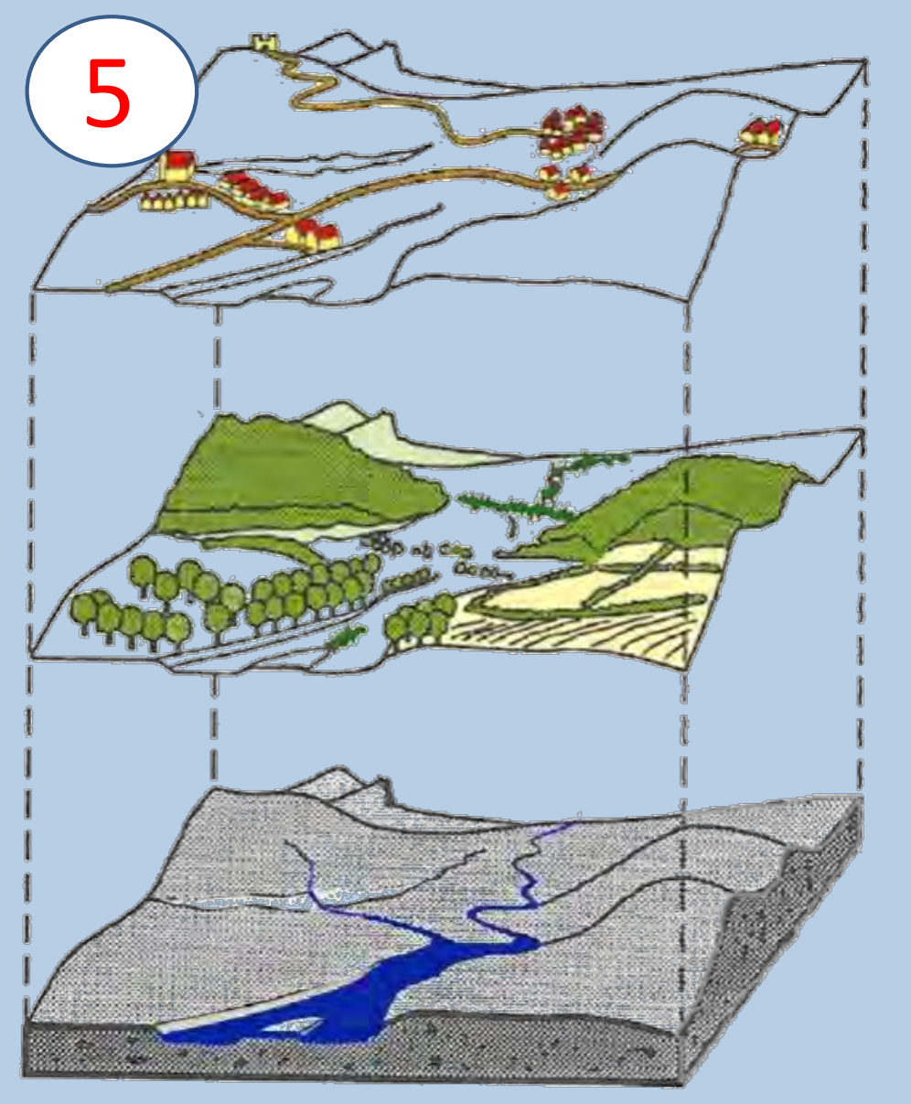


Figure 4. 3D landscape visualization of potential forest buffer restoration project in Hunting Creek Watershed in Frederick County, Maryland. Figure 4a shows before the restoration project occurred and 4b shows the restored riparian buffer. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source of data: Frederick County Maryland LiDAR and building footprint data.

Structural Elements of a 3D Base Map

The vertical dimension of landscapes is represented visually by distinguishing among terrain, vegetation, and cultural features (Figure 5). Each of these elements is derived independently from LiDAR source data, with building footprints used to separate buildings from vegetation.



Cultural Elements:
- Settlements
- Infrastructure
- Other built objects

Vegetation:
- Natural vegetation
- Agricultural land
- Greenways and landscape corridors
- Forests

Bio-physical Main Structures:
- Relief (topography, morphology)
- Hydrology

Figure 5. Landscape elements with vertical structure. Source: Walz et al 2016.

For More Information

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Next Steps

- ☐ Identify case study locations,
- ☐ Build visualizations,
- ☐ Design testing scenarios/quasi-experiments,
- ☐ Conduct user testing,
- ☐ Summarize results,
- ☐ Build story maps to communicate results, and
- ☐ Export scenes to virtual reality applications.

Potential Chesapeake Bay Watershed Application Areas

The Chesapeake Bay Watershed Agreement (CBWA) contains 10 Goals and 31 Outcomes that establish desired future conditions for a restored ecosystem. Many of these Goals and Outcomes involve manipulating the structural configuration of the landscape.

The Chesapeake Bay Program (CBP) Partnership has many stakeholders who, collectively, represent a diverse set of interests and technical knowledge. Given these diverse audiences, communicating science can be a challenge.

Examples of environmental issues that could be represented through landscape visualization include:

- Floodplain management (Climate Resiliency Outcome) (Figure 3),
- Riparian forest buffer establishment (Forest Buffer Outcome) (Figure 4a and 4b),
- Scenic landscape protection (Land Conservation Goal) (Figure 7),
- Wetlands protection and restoration (Wetlands Outcome) (Figure 8),
- Land change and development (Land Use Methods Outcome),
- Urban forests (Tree Canopy Outcome),
- Habitat connectivity (Vital Habitats and Stewardship Goal Teams),
- Bay grasses (Submerged Aquatic Vegetation Outcome),
- Fish passage (Fish Passage Outcome),
- Farm and forest land protection (Protected Lands Outcome),
- Stream health (Stream Health Outcome), and
- Sea level rise (Climate Resiliency Outcome).

Place vs. Space in Stakeholder Engagement

A fundamental premise of this research is that 3D landscape visualization is perceived differently by different audiences. In terms of human geography, "space" is often associated with the physical or natural elements of a landscape, whereas "place" incorporates social, cultural, historical, and personal factors (Dourish 2006). Space is concerned with the environment in general and policies that transcend specific localities. Conversely, place is concerned with the neighborhood, town, or community and is less focused on translating local conditions and issues to the broader geographic perspective (Figure 6).

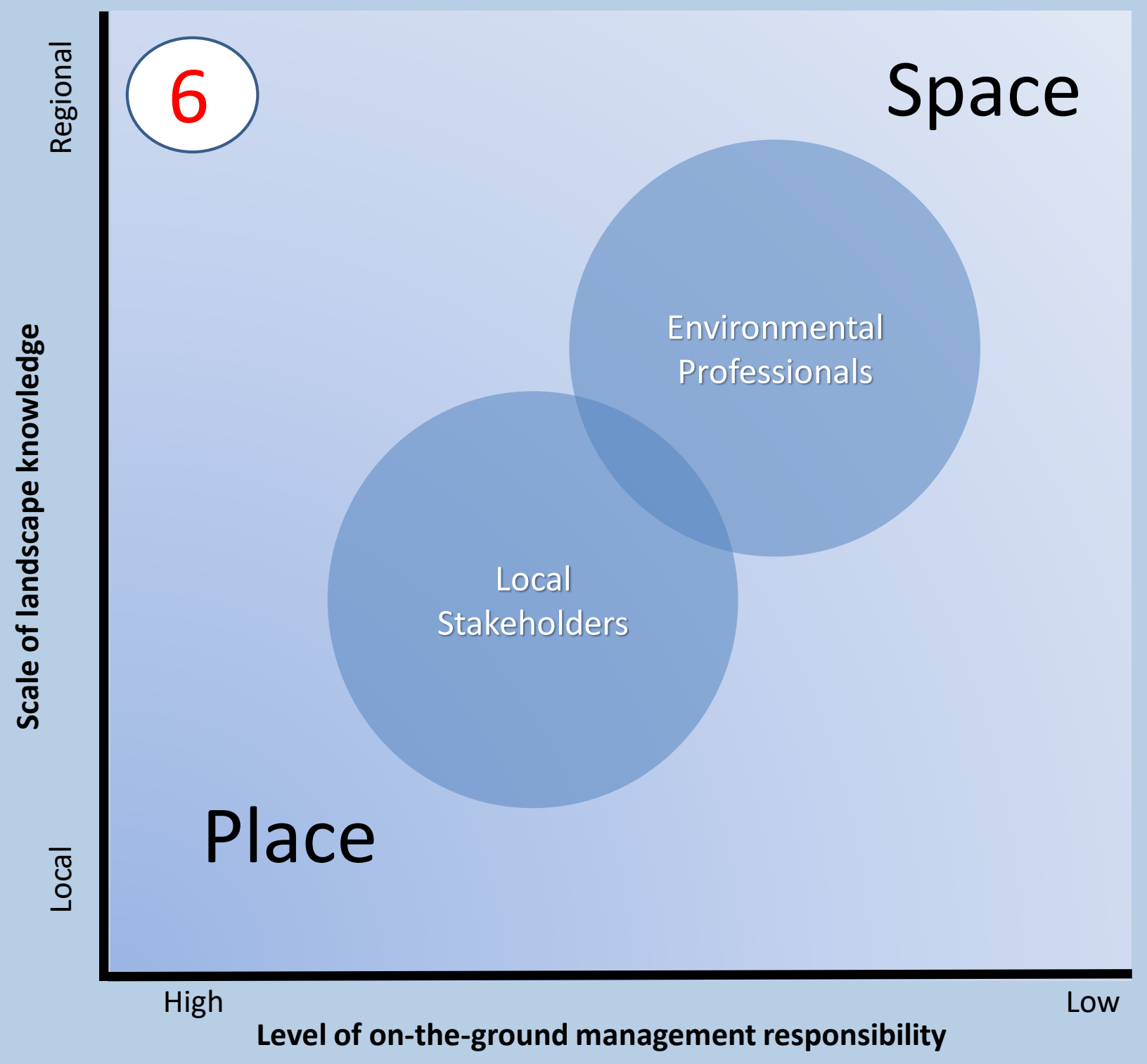

Figure 6. Potential perspectives of environmental professionals vs. local stakeholders regarding 3D landscapes and their use in communicating environmental issues. Modified from Price et al 2012.

Interactive Web Scenes

Interactive web scenes of the landscapes included in this poster are available at https://gis.chesapeakebay.net/viz/3dlandscape

Research Context and Questions

This research focuses on the use of 3D landscape visualization to communicate conservation and ecological restoration issues within the Chesapeake Bay watershed in the mid-Atlantic United States.

Specific research questions include the following:

- Is there a role for 3D mapping/landscape visualization to support science communication objectives?
- Under what circumstances and for what CBWA topics is it useful?
- Do different stakeholder groups (i.e., – scientists/environmental managers versus local stakeholders) perceive or value 3D mapping/landscape visualization differently?
- Are static images, animations, or interactive web scenes preferred?

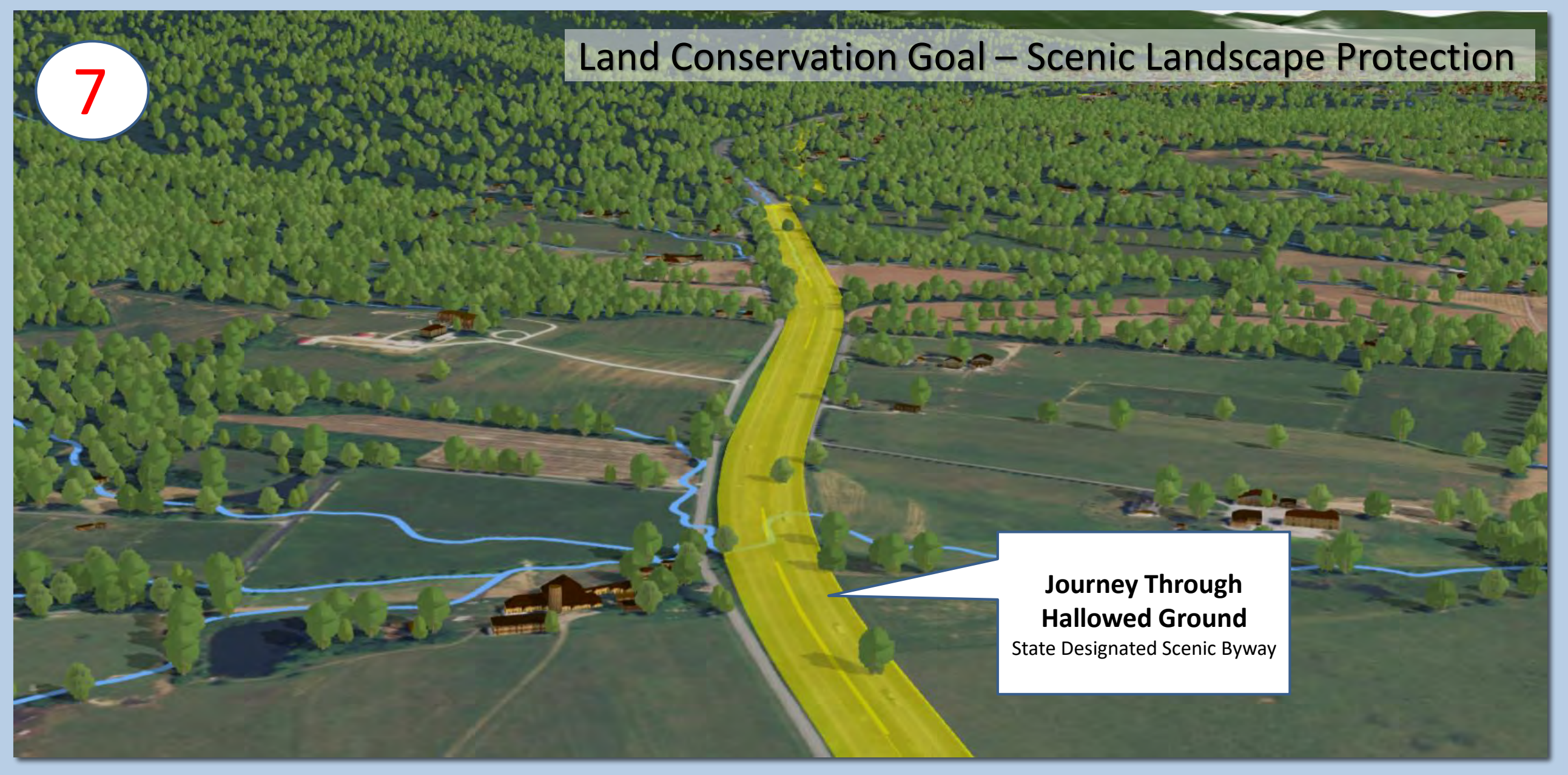

Figure 7. 3D landscape visualization of scenic byway in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source: Byway data – Maryland State Highway Administration.

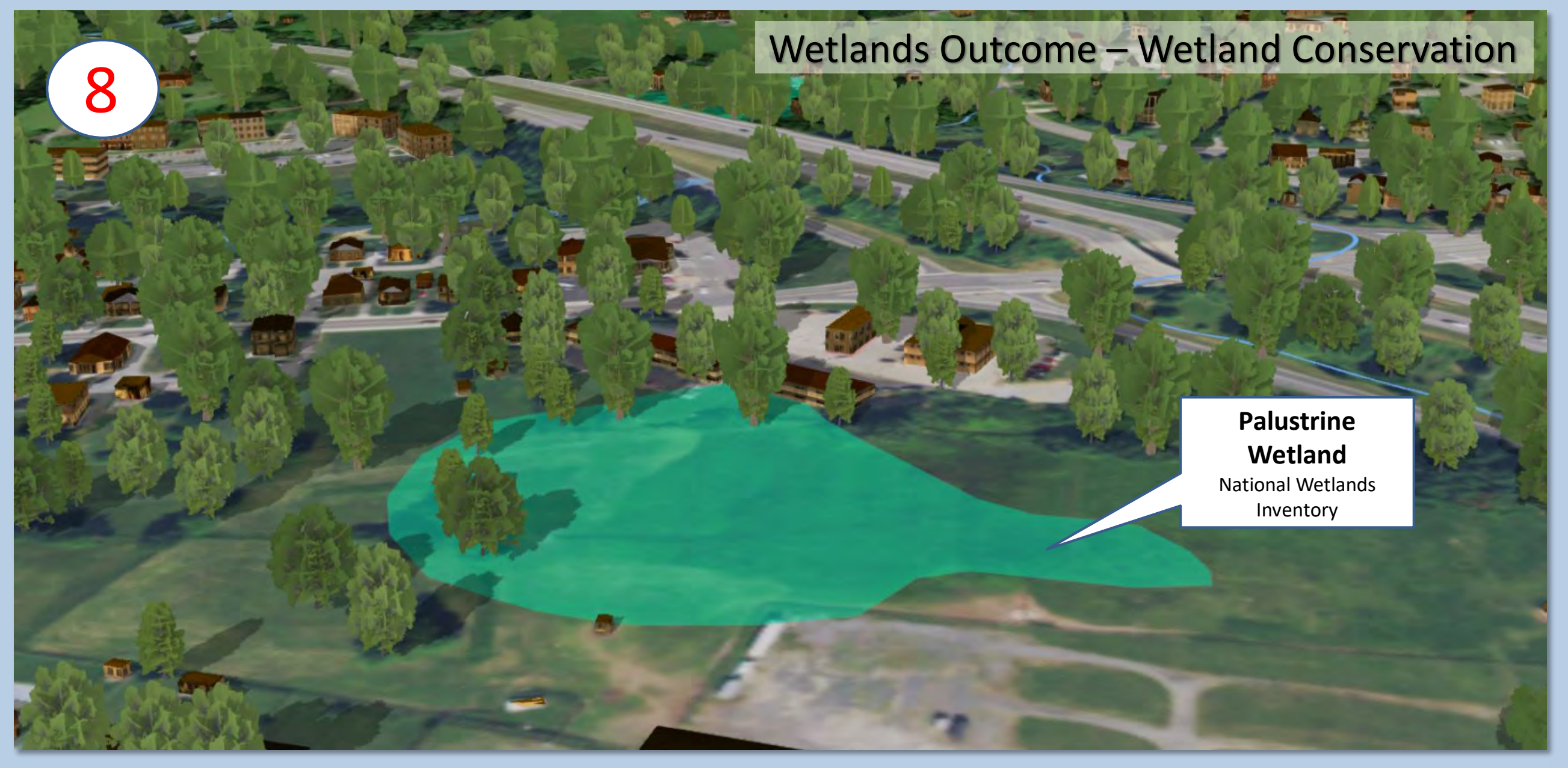

Figure 8. 3D landscape visualization of wetland in Hunting Creek Watershed in Frederick County, Maryland. Web scene derived using ArcGIS Pro and the ESRI Local Government 3D Base Map Solution. Source: ESRI USA Wetlands - wetlands of the United States from the National Wetlands Inventory produced by the US Fish and Wildlife Service.

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U.S. Department of the Interior
U.S. Geological Survey

North American Cartographic Information Society Annual Conference
October 2019

Chesapeake Bay Program
Science. Restoration. Partnership.

Restoring Wetlands of the Chesapeake Bay Watershed

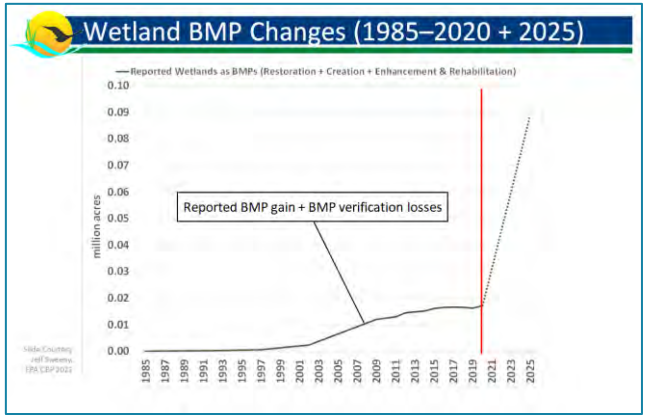
Katlyn Fuentes[1], Dede Lawal[1], and Chris Guy[2]
[1]Chesapeake Research Consortium, [2]U.S. Fish & Wildlife Service

Wetlands Outcome

- 85,000 acres of wetlands created or restored
- 150,000 acres enhanced

OUTLOOK **OFF COURSE**

RECENT PROGRESS **INCREASE**



Wetland's Outcome Attainment Strategy

Jul. 15, 2021 → **Aug. 2-3, 2022** → **Nov. 23, 2022** → **Dec. 8, 2022** → **Jan. 17, 2023**

Jul. 15, 2021: Outcome Attainability Team briefs the MB on status of 31 outcomes.
- MB/PSC directs the CBP to identify why wetlands are so far off course and what can be done about it, and develop a plan to achieve the outcome by 2025.

Aug. 2-3, 2022: *Restoring Wetlands of the Chesapeake Bay Watershed Workshop* identifies barriers, potential solutions and recommendations on moving forward.

Nov. 23, 2022: CBP submits draft *Restoring the Wetlands of the Chesapeake Watershed Workshop Action Plan* for MB consideration.

Dec. 8, 2022: CBP and Jurisdictions present wetland outcome attainment strategies for MB discussion.

Jan. 17, 2023: Wetlands Action Plan Finalized

Wetlands Workshop Process:

- PURPOSE: "Bring together key people to identify actions to overcome the barriers of implementing nontidal and tidal wetland restoration and accelerate progress towards the Wetlands Outcome identified in the 2014 Chesapeake Bay Watershed Agreement."
- OUTCOMES:
  1. Understanding of Barriers
  2. Identification of Approaches
  3. Development of an Action Plan
- STATS:
  - ❖ 167 attendees over two days
  - ❖ 400+ participants throughout the workshop planning & execution process
  - ❖ Representatives from each Bay State in attendance
  - ❖ 14 jurisdictional-specific office hours in October and November 2022

Workshop Recommendations

Cohesive Strategy	Cohesive strategy for tidal and nontidal wetlands across the watershed for site selection and priorities that take into consideration 10 goals and 31 outcomes associated with the Chesapeake Bay 2014 Agreement.
Long-term Capacity	Dedicated increased long-term capacity is needed to accelerate efforts –because of the time and complexity to complete wetland restoration projects, grant funded capacity does not retain and grow expertise.
Outreach and Design	Outreach and design are priority areas to grow capacity to increase the pipeline of projects and advance them to implementation.
Increased Funding	New and increased funding should be directed to the states to build wetland capacity. This is critical to be able to access and leverage increased federal funds that will be available.
Reporting of Progress	MB representatives meet formally with all the agencies within their jurisdictions report out progress of the wetland outcome attainment annually. Bay Program reports to PSC annually.

Action Plan: Partnership Action Plans

- JURISDICTIONS:
  - District of Columbia,
  - Delaware
  - Maryland
  - New York
  - Pennsylvania
  - Virginia
- FEDERAL : NOAA, NRCS, USACE, USEPA, USFWS
- NGOs: The Nature Conservancy


American Black Duck
(*Anas rubripes*)

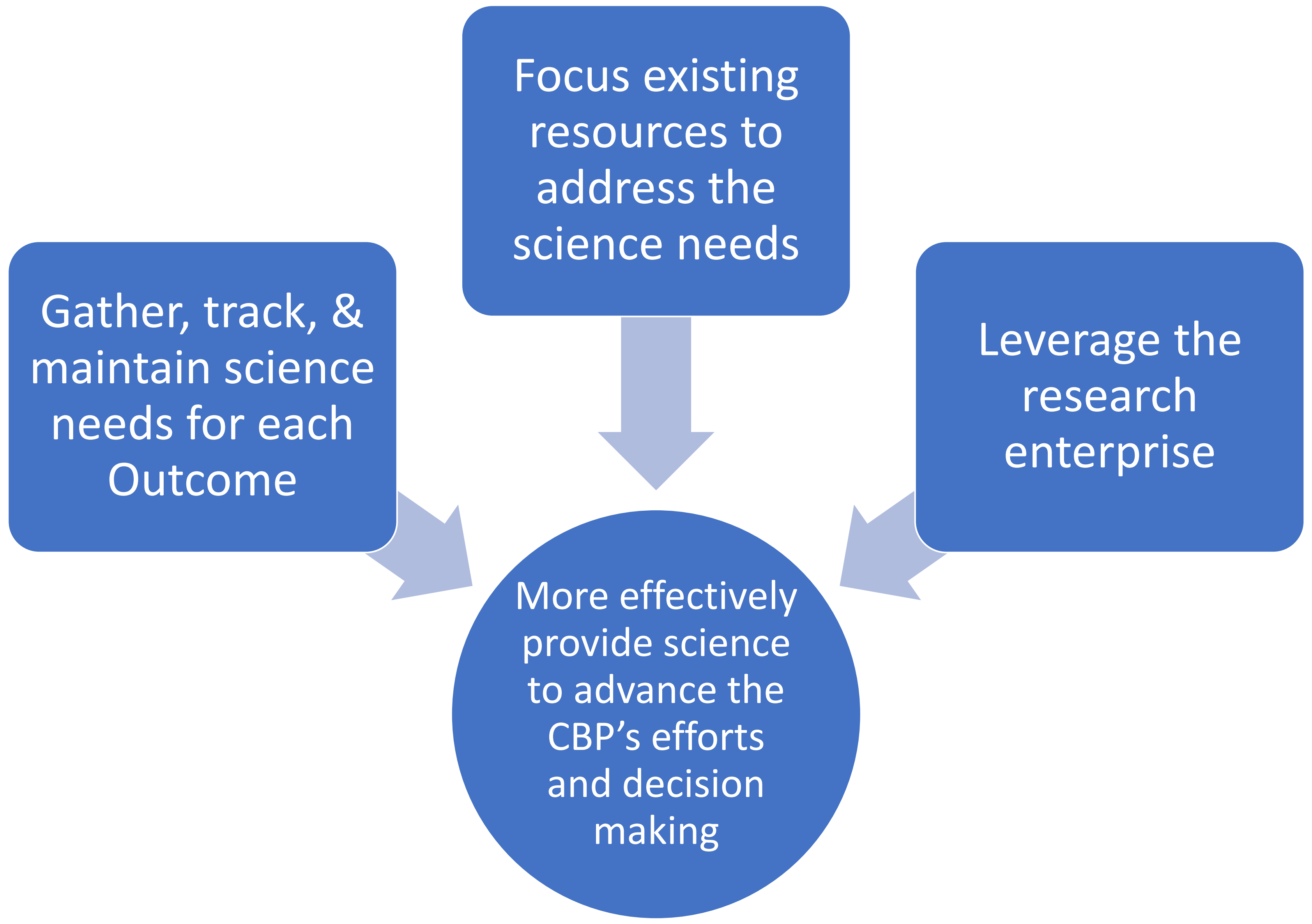
Scan to view the following resources:

Habitat GIT | Wetland Workgroup | Workshop Materials | Wetlands Action Plan

Strategic Science and Research Framework (SSRF): Leveraging Science to Progress Chesapeake Bay Restoration

Alexander Gunnerson (CRC), August Goldfischer (CRC), Breck Sullivan (USGS)

Purpose - The SSRF Provides a Strategic Approach to:



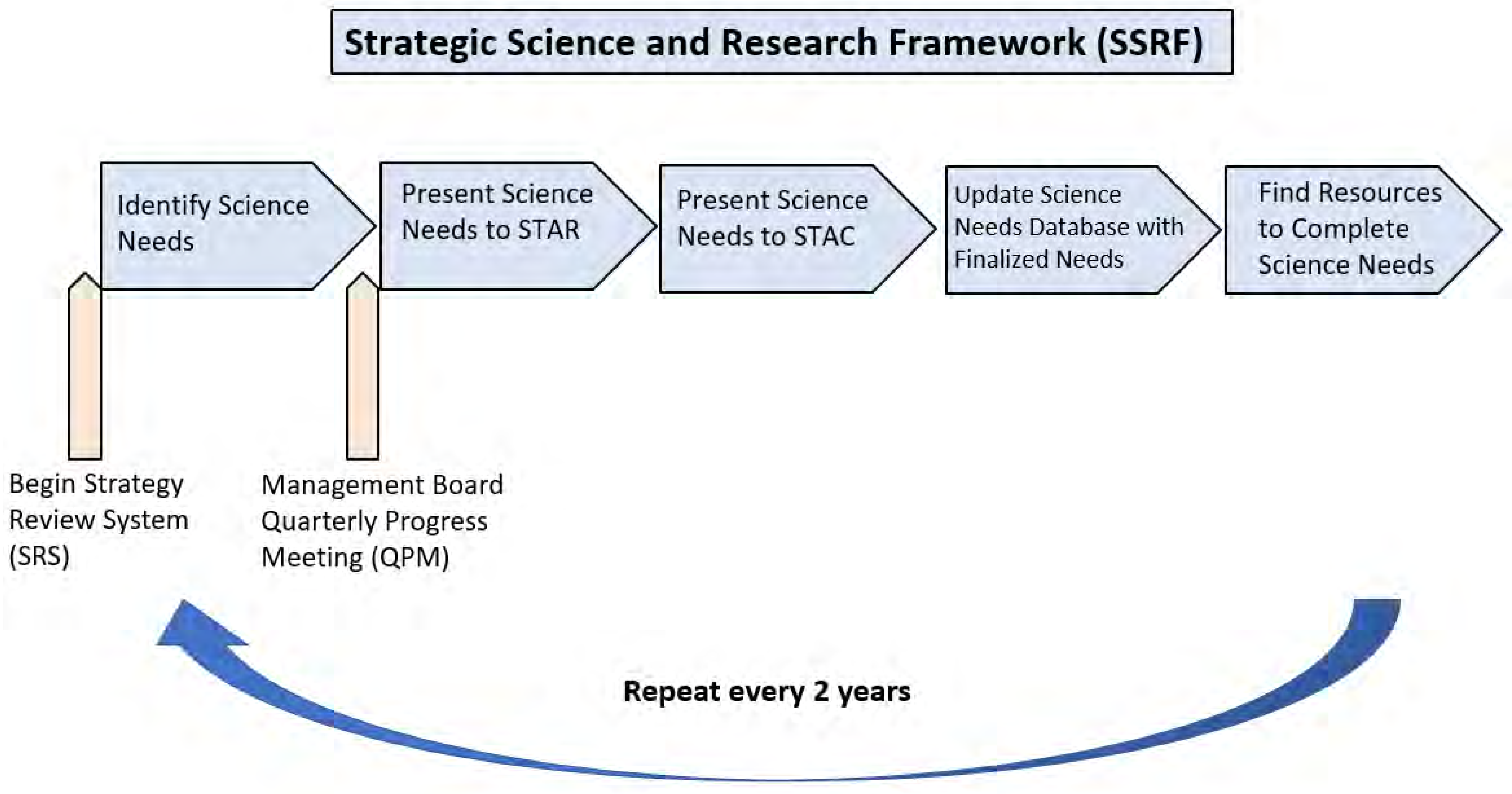
Focus existing resources to address the science needs

Gather, track, & maintain science needs for each Outcome

Leverage the research enterprise

More effectively provide science to advance the CBP's efforts and decision making

STAR Coordinates the SSRF to Support CBP Science



Strategic Science and Research Framework (SSRF)

Identify Science Needs

Present Science Needs to STAR

Present Science Needs to STAC

Update Science Needs Database with Finalized Needs

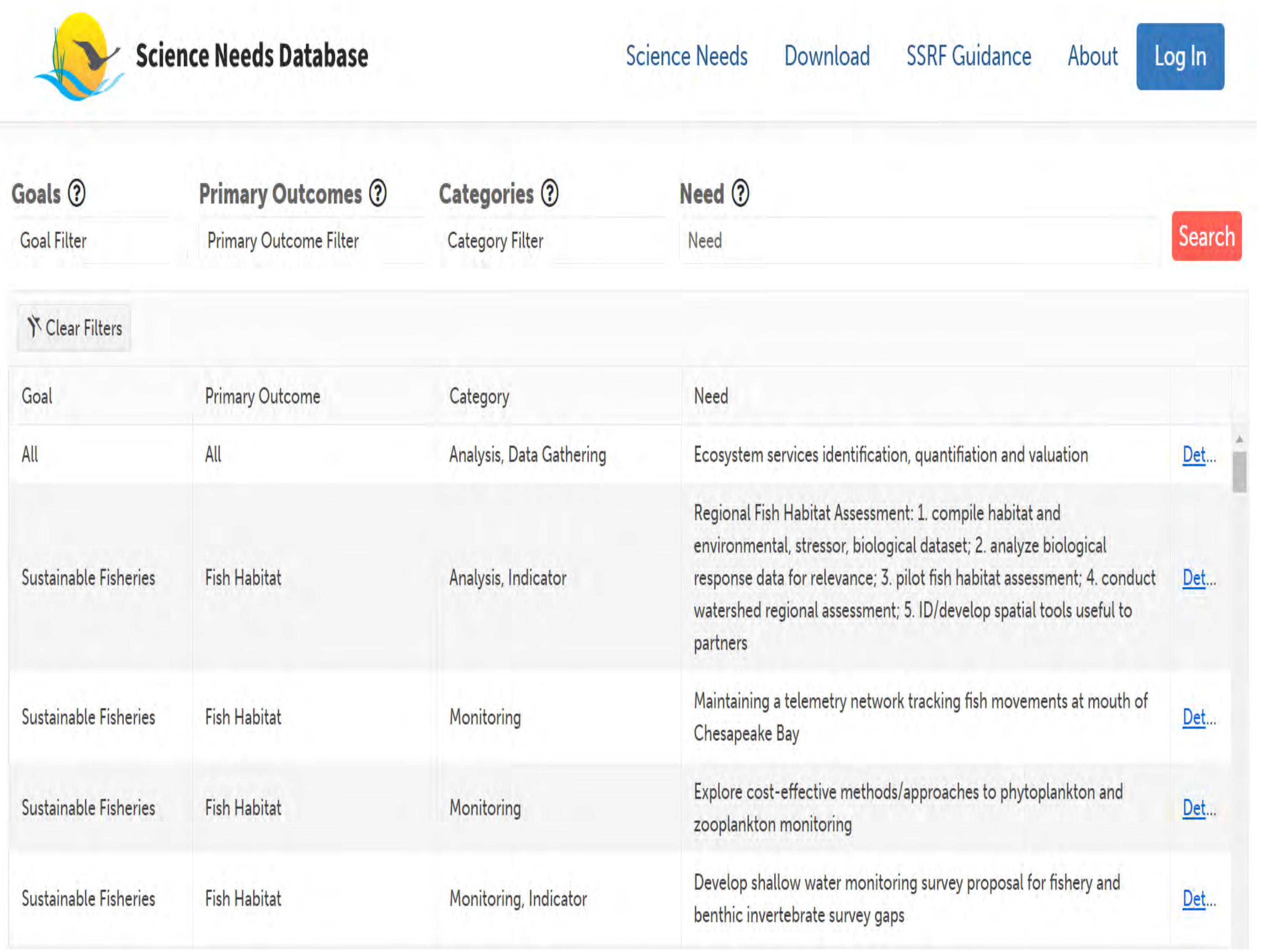
Find Resources to Complete Science Needs

Begin Strategy Review System (SRS)

Management Board Quarterly Progress Meeting (QPM)

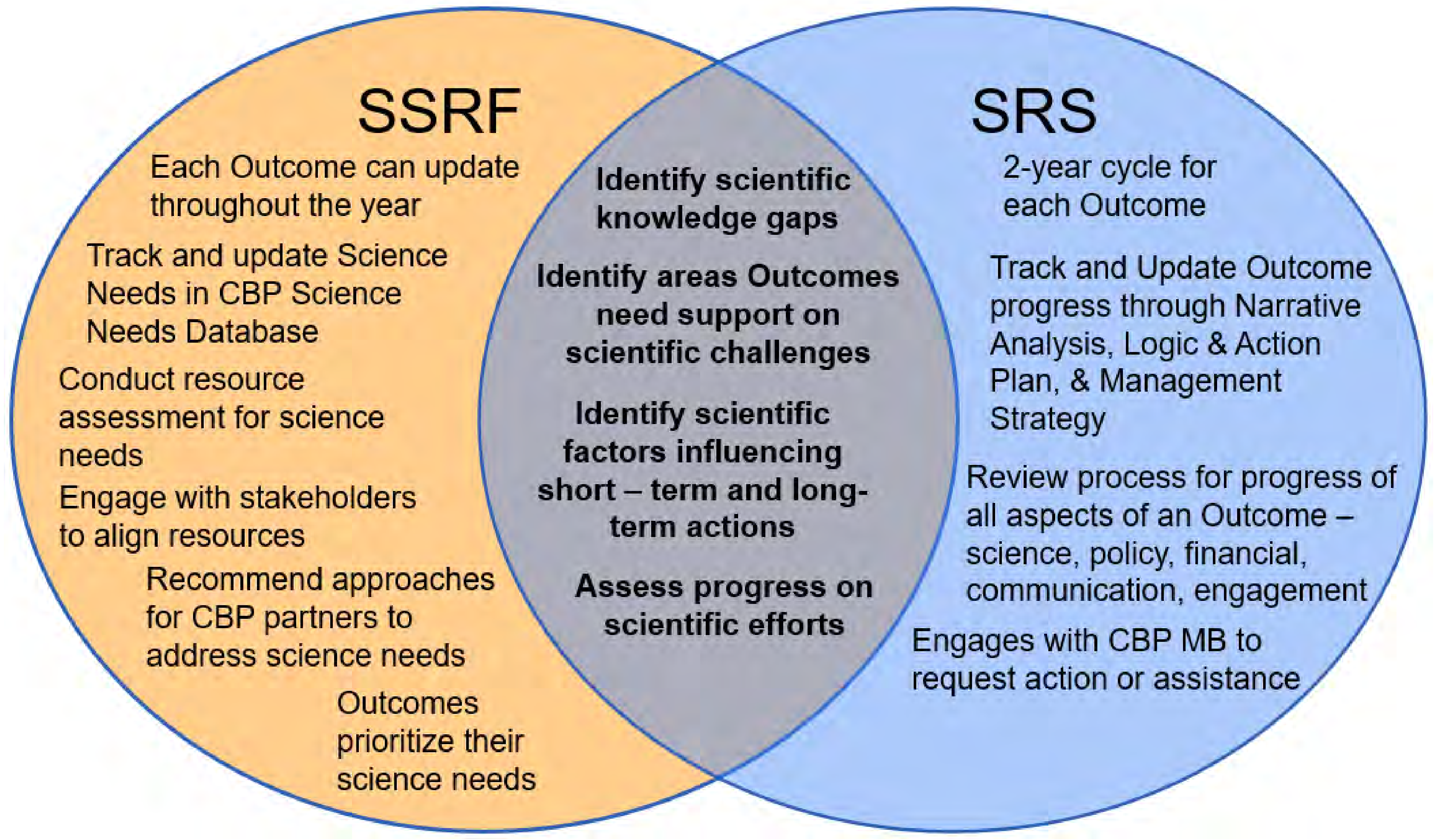
Repeat every 2 years

The Science Needs Database: One Stop Shop for Science Needs



Goal	Primary Outcome	Category	Need	
All	All	Analysis, Data Gathering	Ecosystem services identification, quantifiation and valuation	Det...
Sustainable Fisheries	Fish Habitat	Analysis, Indicator	Regional Fish Habitat Assessment: 1. compile habitat and environmental, stressor, biological dataset; 2. analyze biological response data for relevance; 3. pilot fish habitat assessment; 4. conduct watershed regional assessment; 5. ID/develop spatial tools useful to partners	Det...
Sustainable Fisheries	Fish Habitat	Monitoring	Maintaining a telemetry network tracking fish movements at mouth of Chesapeake Bay	Det...
Sustainable Fisheries	Fish Habitat	Monitoring	Explore cost-effective methods/approaches to phytoplankton and zooplankton monitoring	Det...
Sustainable Fisheries	Fish Habitat	Monitoring, Indicator	Develop shallow water monitoring survey proposal for fishery and benthic invertebrate survey gaps	Det...

The SSRF Complements Adaptive Management



SSRF

Each Outcome can update throughout the year

Track and update Science Needs in CBP Science Needs Database

Conduct resource assessment for science needs

Engage with stakeholders to align resources

Recommend approaches for CBP partners to address science needs

Outcomes prioritize their science needs

Identify scientific knowledge gaps

Identify areas Outcomes need support on scientific challenges

Identify scientific factors influencing short – term and long-term actions

Assess progress on scientific efforts

SRS

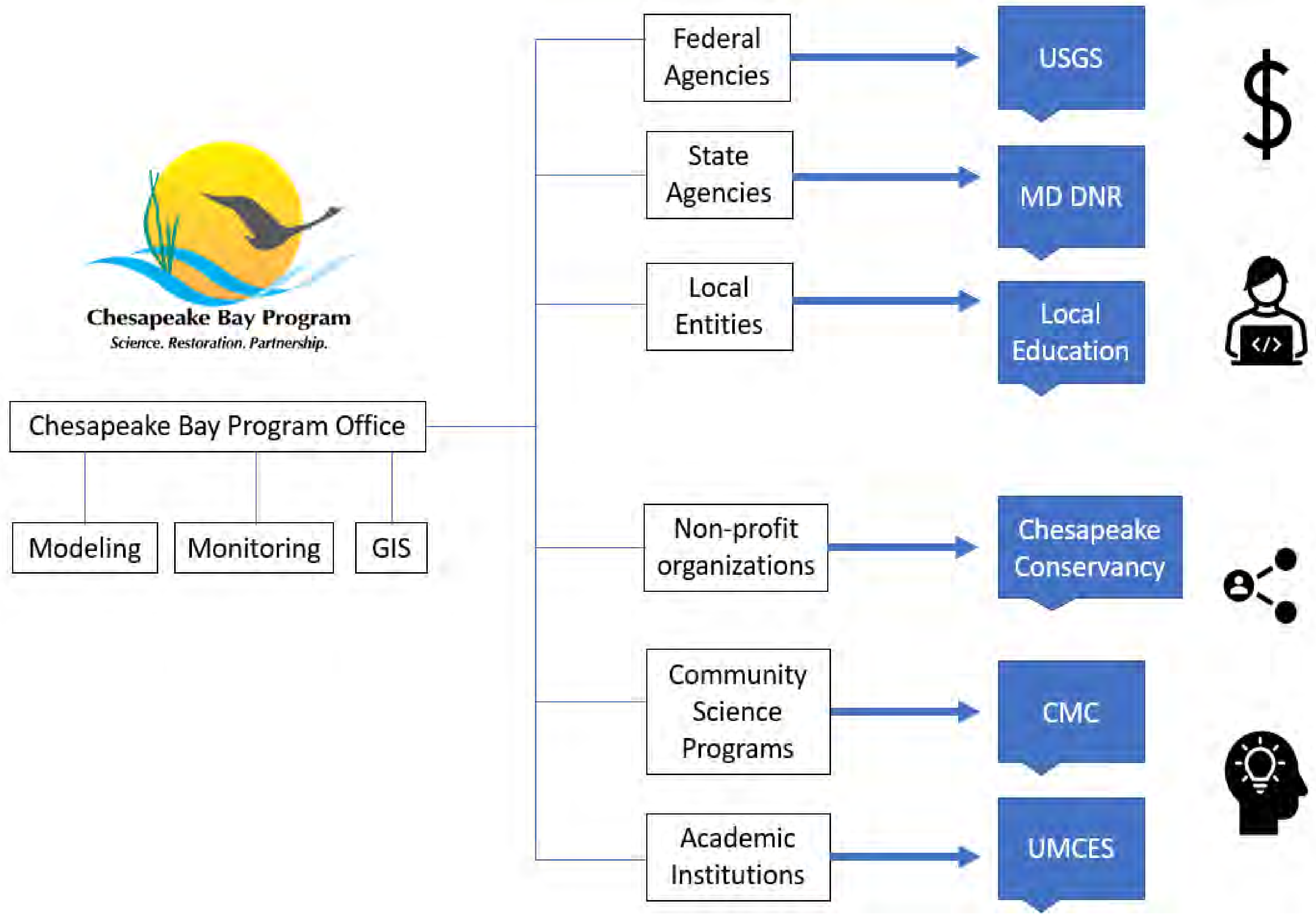
2-year cycle for each Outcome

Track and Update Outcome progress through Narrative Analysis, Logic & Action Plan, & Management Strategy

Review process for progress of all aspects of an Outcome – science, policy, financial, communication, engagement

Engages with CBP MB to request action or assistance

A Partnership Approach to Addressing Science Needs



Chesapeake Bay Program Office

Modeling

Monitoring

GIS

Federal Agencies → USGS

State Agencies → MD DNR

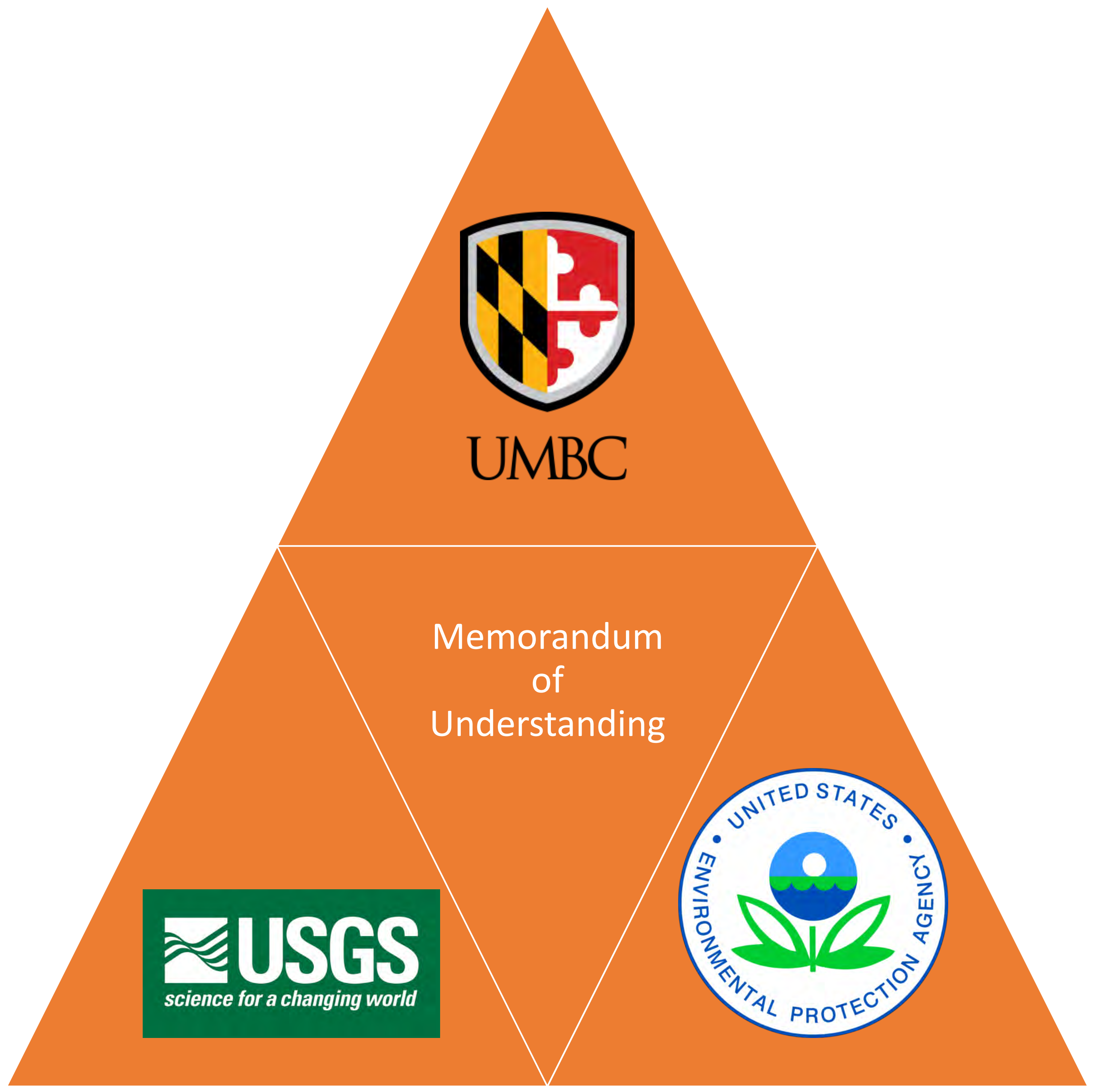
Local Entities → Local Education

Non-profit organizations → Chesapeake Conservancy

Community Science Programs → CMC

Academic Institutions → UMCES

Example of Partner Engagement



Memorandum of Understanding

Enhancing the Chesapeake Bay Program Monitoring Networks:
CBP enters a new phase of monitoring thanks to partnership investment

August Goldfischer (CRC); Breck Sullivan, Peter Tango, and Scott Phillips (USGS); Denice Wardrop (Penn State); Lee McDonnell, Kaylyn Gootman (EPA)

Timeline of Monitoring Review Process
①

March 2021 Principals' Staff Committee requested a study and recommendations on how to improve CBP monitoring networks.

2021-2022 STAR- and STAC-led team conducted a review with input from all GITs and outcome leads, summarizing findings in a report.

2022 Communicated findings and developed sampling designs to address data collection needs.

2022 The team worked with scientists and managers to develop cost estimates based on proposed sampling designs.

2022-2023 CBP partners collaborate to maintain existing monitoring networks, with help from Infrastructure, Investment and Jobs Act (IIJA).

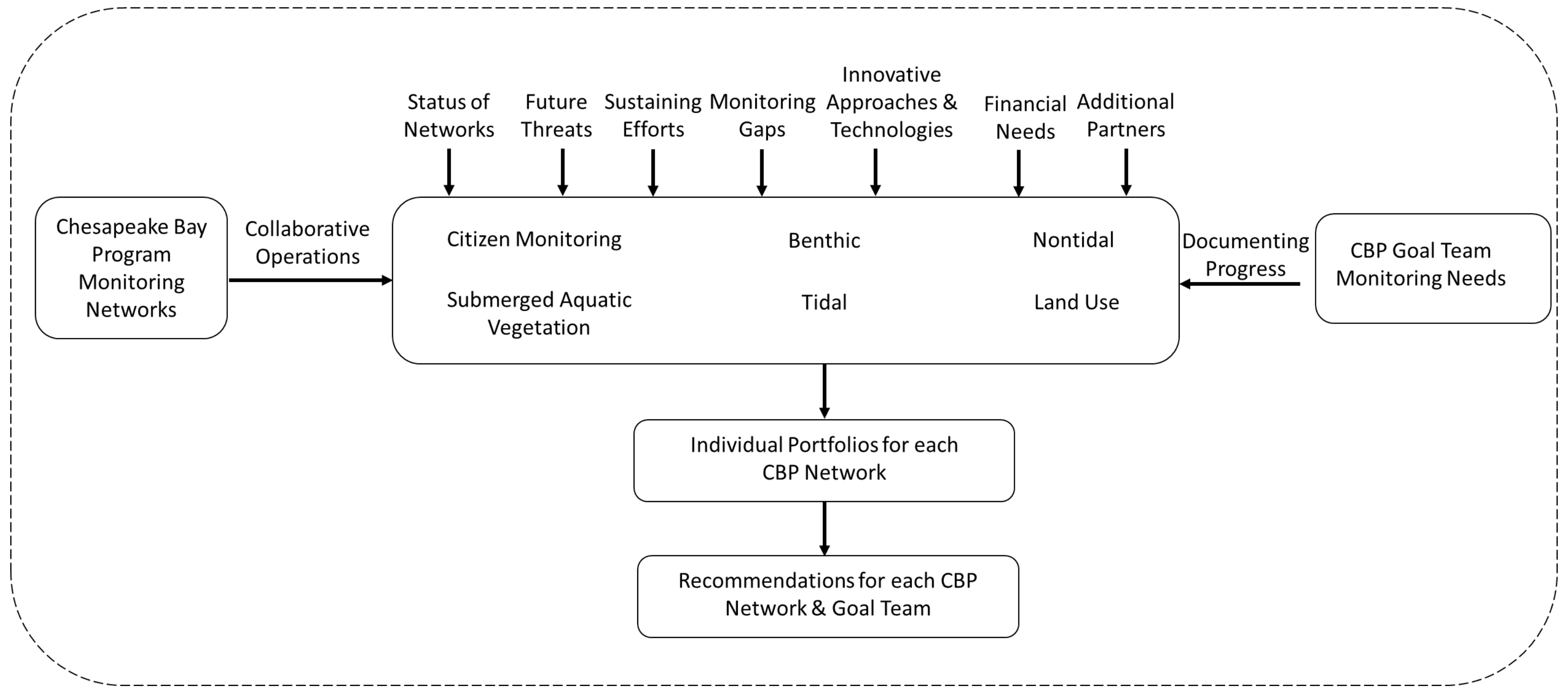
2023-onward CBP partners enhance existing networks, establish new monitoring, and sustain monitoring long-term.

Key Findings
②

! Monitoring is critical to assess progress towards meeting goals and outcomes of the 2014 Watershed Agreement.

Monitoring is insufficient for many CBP Outcomes.

$ Opportunities for enhancing the networks exist but funding is a challenge.



Monitoring Networks Overview
③

Monitoring Networks
- Nontidal
- Tidal
- Submerged Aquatic Vegetation (SAV)
- Benthic
- Community Monitoring
- Land Use

Available Data
- Continuous Monitoring
- Long-term fixed stations
- Dataflow
- SAV Watchers Program
- Aerial SAV
- Macroinvertebrate
- High resolution ($1m^2$) land cover and land use

Data Uses
- Status & Trends
- Model Development, Calibration, & Verification
- BMP Effectiveness assessment
- Climate Impact Assessment
- Research/hypothesis testing
- Leveraging for Proposals
- Policy Making
- Management Decision Support
- Communication
- Outreach & Education
- Indicator Development & Reporting
- Forecasting
- Scientific Discovery

		Maintain	Enhance	Establish
Goal	**Outcome**			
Sustainable Fisheries	Forage Fish		x	x
	Fish Habitat		x	x
	Oysters	x	x	
	Blue Crab Abundance	x	x	
	Blue Crab Management	Outcome is complete		
Vital Habitats	Wetland		x	
	Black Duck		x	
	Stream Health		x	
	Brook Trout		x	
	Fish Passage	x		
	Forest Buffers	x	x	
	Tree Canopy	x	x	
	Submerged Aquatic Vegetation		x	
Water Quality	WIP 2017	Outcome is complete		
	WIP 2025		x	
	WQSAM	x	x	x
Toxic Contaminants	Toxic Contaminants Research			x
	Toxic Contaminants Policy & Prevention			x
Healthy Watersheds	Healthy Watersheds	x		

		Maintain	Enhance	Establish
Goal	**Outcome**			
Climate Resiliency	Climate Monitoring and Assessment	x	x	x
	Climate Adaptation			x
Land Conservation	Protected Lands	x	x	x
	Land Use Methods and Metrics	x	x	
	Land Use Options Evaluation	x		
Stewardship	Citizen Stewardship	x		
	Local Leadership			x
	Diversity		x	x
Public Access	Public Access Site Development	x		
Environmental Literacy	Student	x		
	Sustainable	x		
	Environmental Literacy Planning	x		

Building Capacity
④

Federal Monitoring Partners ⟷ State and DC Monitoring Managers ⟷ Local Govt., Academic, NGOs Monitoring Managers

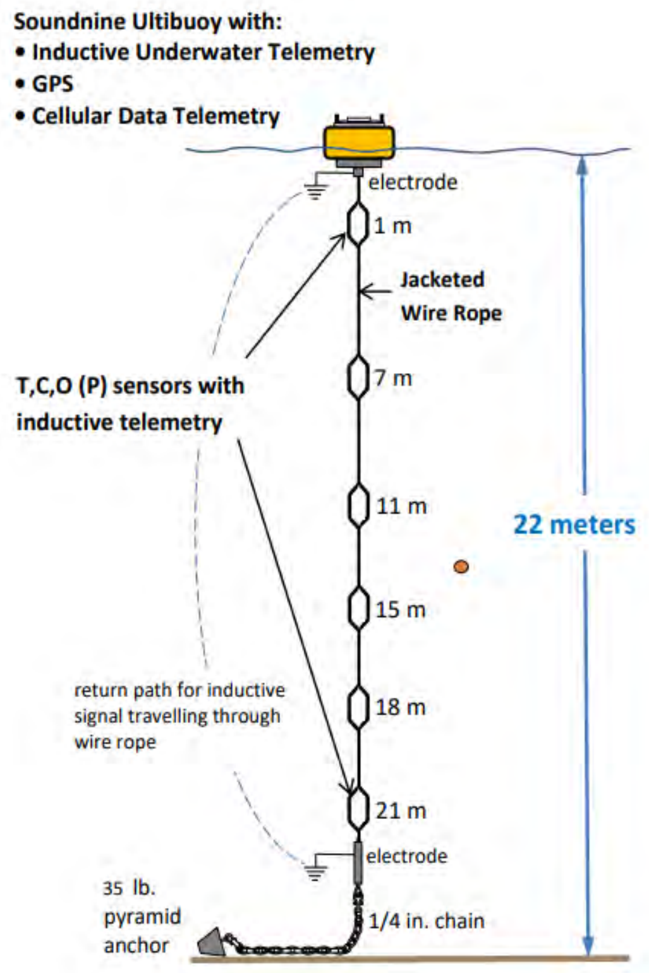
Monitoring Networks:
- CBP Core Networks
- Partner-led Networks
- Establishing New Networks

Process:
- Kick-off meeting 1/11/2023
- STAR Integrated Monitoring Team

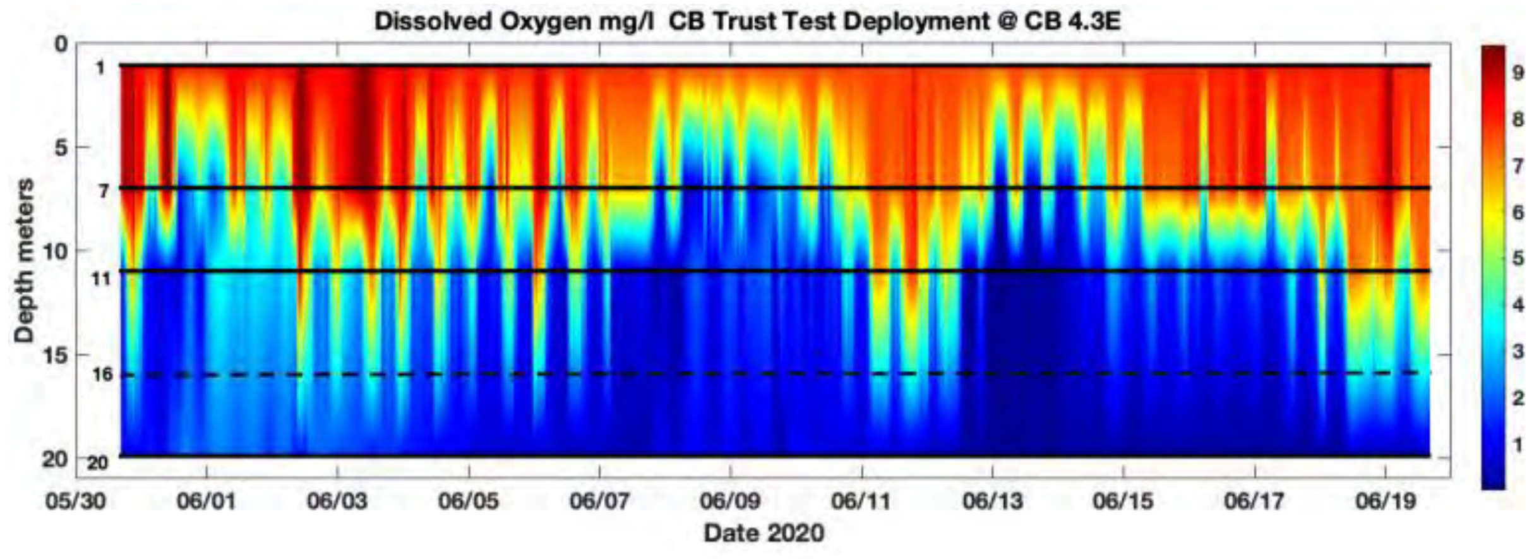
Partnership in Action 1: Hypoxia Monitoring Network
⑤

Image credit: Mike Bireley

Hypoxia Monitoring Pilot Project Team:
(L-R) Doug Wilson, C.J. Pellerin, Max Ruehrmund, Jay Lazar

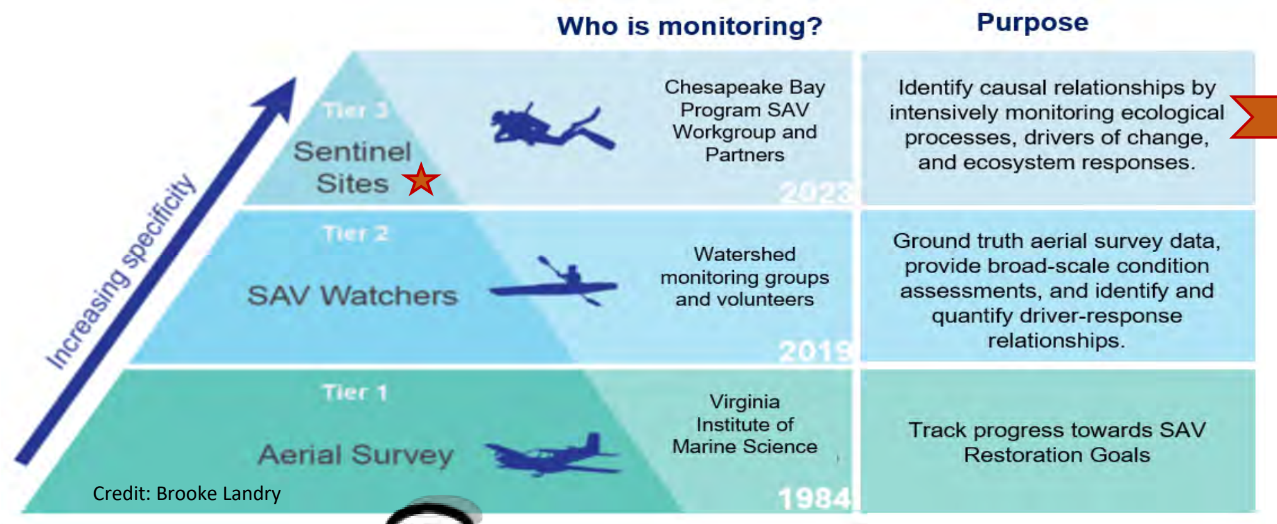


- *Schematic of Buoy with Sensors and Mooring System. Image credit: Doug Wilson, Caribbean Wind LLC.*
- *Top of Buoy. Image credit: NOAA Chesapeake Bay Office*



Example data set for approximately 1 month in 2020, 20-meter water column depth, deployed near the mouth of the Choptank River, MD. Image credit: NOAA Chesapeake Bay Office

Partnership in Action 2: SAV Sentinel Sites
⑥



Credit: Brooke Landry

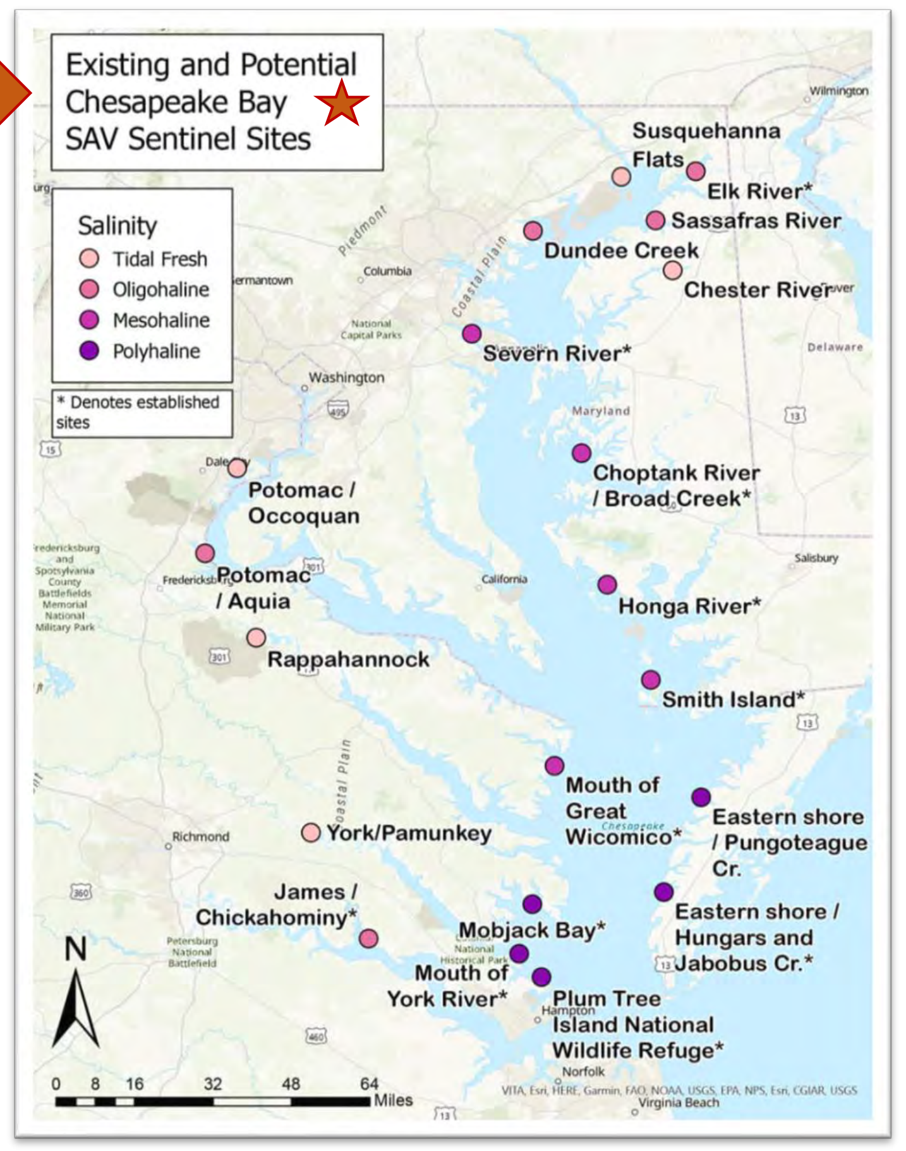


Image credit: Mike Bireley

Photo credit: Michael Norman

SAV Biologist Brooke Landry collects SAV plants.

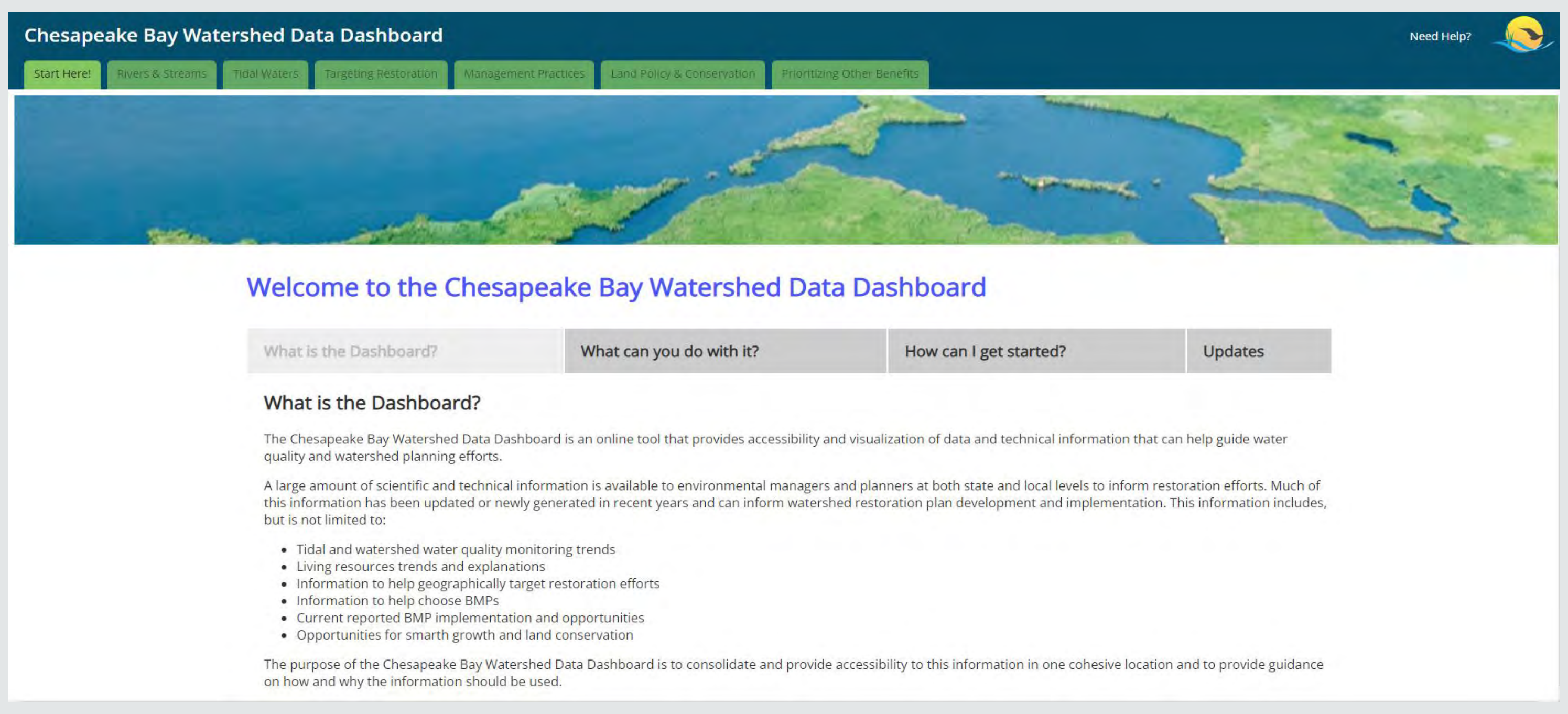
Photo credit: Maryland Department of Natural Resources

SAV Biologist Becky Golden collects SAV data.

More partnership

and collaboration to come!

Tools and Resources for planning in the Chesapeake



Chesapeake Bay Watershed Data Dashboard

Need Help?

Welcome to the Chesapeake Bay Watershed Data Dashboard

What is the Dashboard?

The Chesapeake Bay Watershed Data Dashboard is an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

A large amount of scientific and technical information is available to environmental managers and planners at both state and local levels to inform restoration efforts. Much of this information has been updated or newly generated in recent years and can inform watershed restoration plan development and implementation. This information includes, but is not limited to:

- Tidal and watershed water quality monitoring trends
- Living resources trends and explanations
- Information to help geographically target restoration efforts
- Information to help choose BMPs
- Current reported BMP implementation and opportunities
- Opportunities for smarth growth and land conservation

The purpose of the Chesapeake Bay Watershed Data Dashboard is to consolidate and provide accessibility to this information in one cohesive location and to provide guidance on how and why the information should be used.

Chesapeake Bay Watershed Data Dashboard

The Chesapeake Bay Watershed Data Dashboard is an online tool that provides accessibility and visualization of data and technical information that can help guide water quality and watershed planning efforts.

Chesapeake Bay

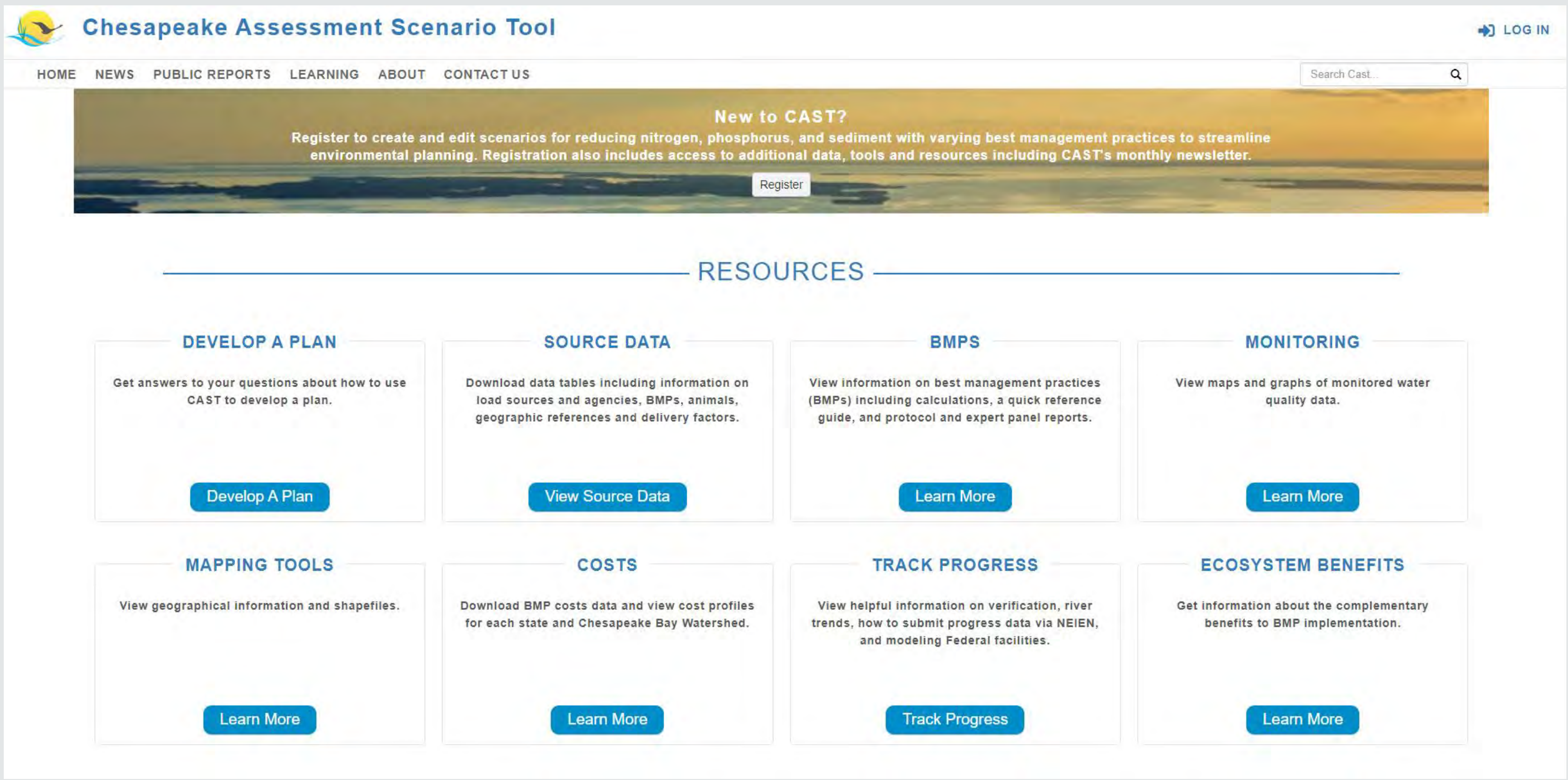
Environmental Justice and Equity Dashboard

The Chesapeake Executive Council's Diversity, Equity, Inclusion and Justice (DEIJ) Statement commits to including DEIJ in all areas of Chesapeake Bay restoration and conservation. To help workgroup leaders identify opportunities to implement DEIJ into their work, we have developed the Chesapeake Environmental Justice and Equity Dashboard, a web application that integrates data from multiple sources to convey demographic, socioeconomic, environmental, and programmatic topics connected to the Chesapeake Bay Watershed Agreement and Chesapeake specific DEIJ initiatives.

The dashboard is currently accessible in this draft or beta release as we collect information from users on content and usability. Please send comments or suggestions to diversitydashboard@chesapeakebay.net.

Chesapeake Bay Environmental Justice and Equity Dashboard

Provides access to a variety of spatial data layers pertinent to addressing environmental issues in areas with underrepresented populations, which include communities of color, low income, and linguistically isolated communities.



Chesapeake Assessment Scenario Tool

New to CAST?

Register to create and edit scenarios for reducing nitrogen, phosphorus, and sediment with varying best management practices to streamline environmental planning. Registration also includes access to additional data, tools and resources including CAST's monthly newsletter.

RESOURCES

DEVELOP A PLAN

Get answers to your questions about how to use CAST to develop a plan.

SOURCE DATA

Download data tables including information on load sources and agencies, BMPs, animals, geographic references and delivery factors.

BMPS

View information on best management practices (BMPs) including calculations, a quick reference guide, and protocol and expert panel reports.

MONITORING

View maps and graphs of monitored water quality data.

MAPPING TOOLS

View geographical information and shapefiles.

COSTS

Download BMP costs data and view cost profiles for each state and Chesapeake Bay Watershed.

TRACK PROGRESS

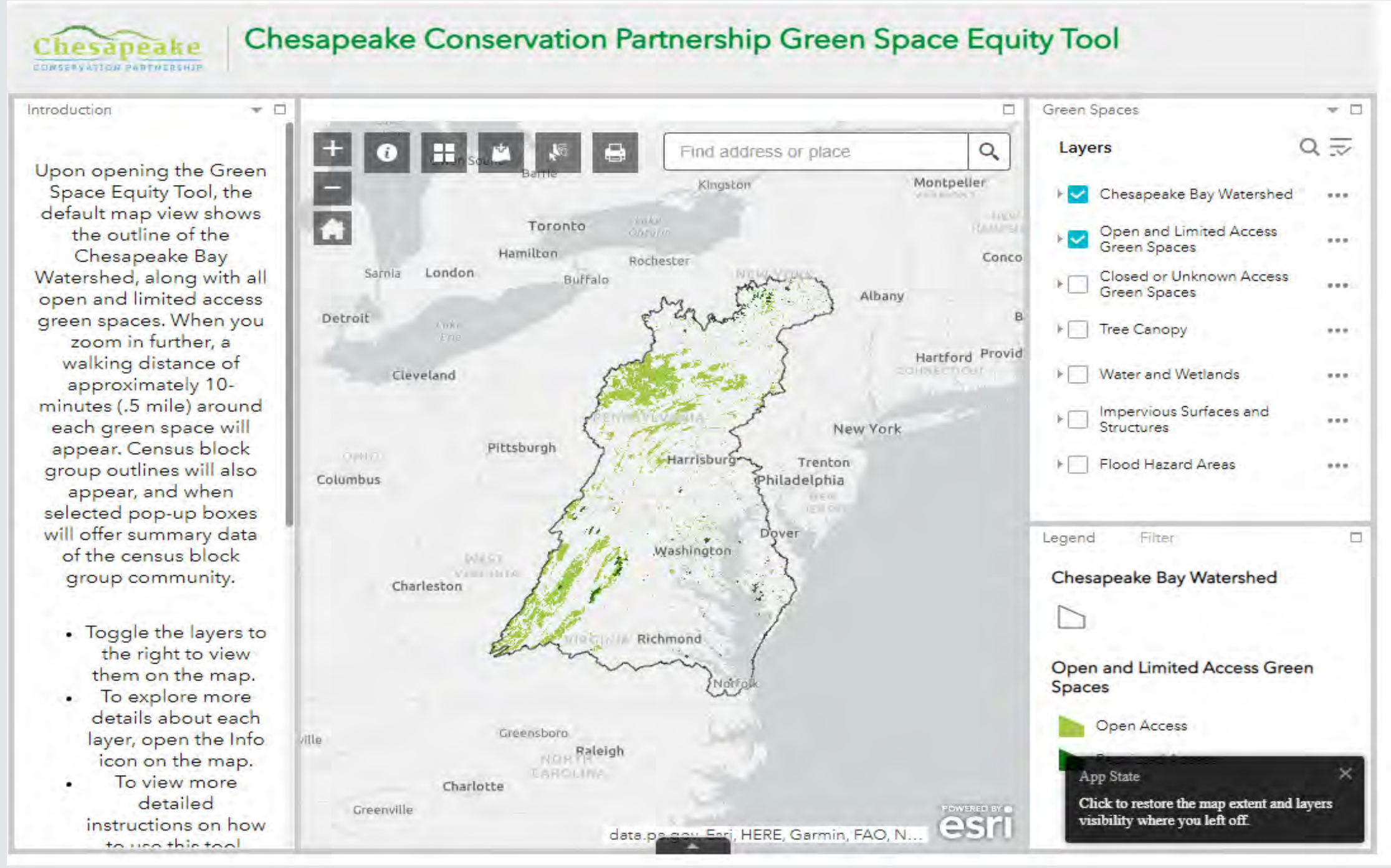
View helpful information on verification, river trends, how to submit progress data via NEIEN, and modeling Federal facilities.

ECOSYSTEM BENEFITS

Get information about the complementary benefits to BMP implementation.

Chesapeake Assessment Scenario Tool (CAST)

Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.



Chesapeake Conservation Partnership Green Space Equity Tool

Upon opening the Green Space Equity Tool, the default map view shows the outline of the Chesapeake Bay Watershed, along with all open and limited access green spaces. When you zoom in further, a walking distance of approximately 10-minutes (.5 mile) around each green space will appear. Census block group outlines will also appear, and when selected pop-up boxes will offer summary data of the census block group community.

- Toggle the layers to the right to view them on the map.
- To explore more details about each layer, open the Info icon on the map.
- To view more detailed instructions on how to use this tool

Layers

- ☑ Chesapeake Bay Watershed
- ☑ Open and Limited Access Green Spaces
- ☐ Closed or Unknown Access Green Spaces
- ☐ Tree Canopy
- ☐ Water and Wetlands
- ☐ Impervious Surfaces and Structures
- ☐ Flood Hazard Areas

Chesapeake Bay Watershed

Open and Limited Access Green Spaces

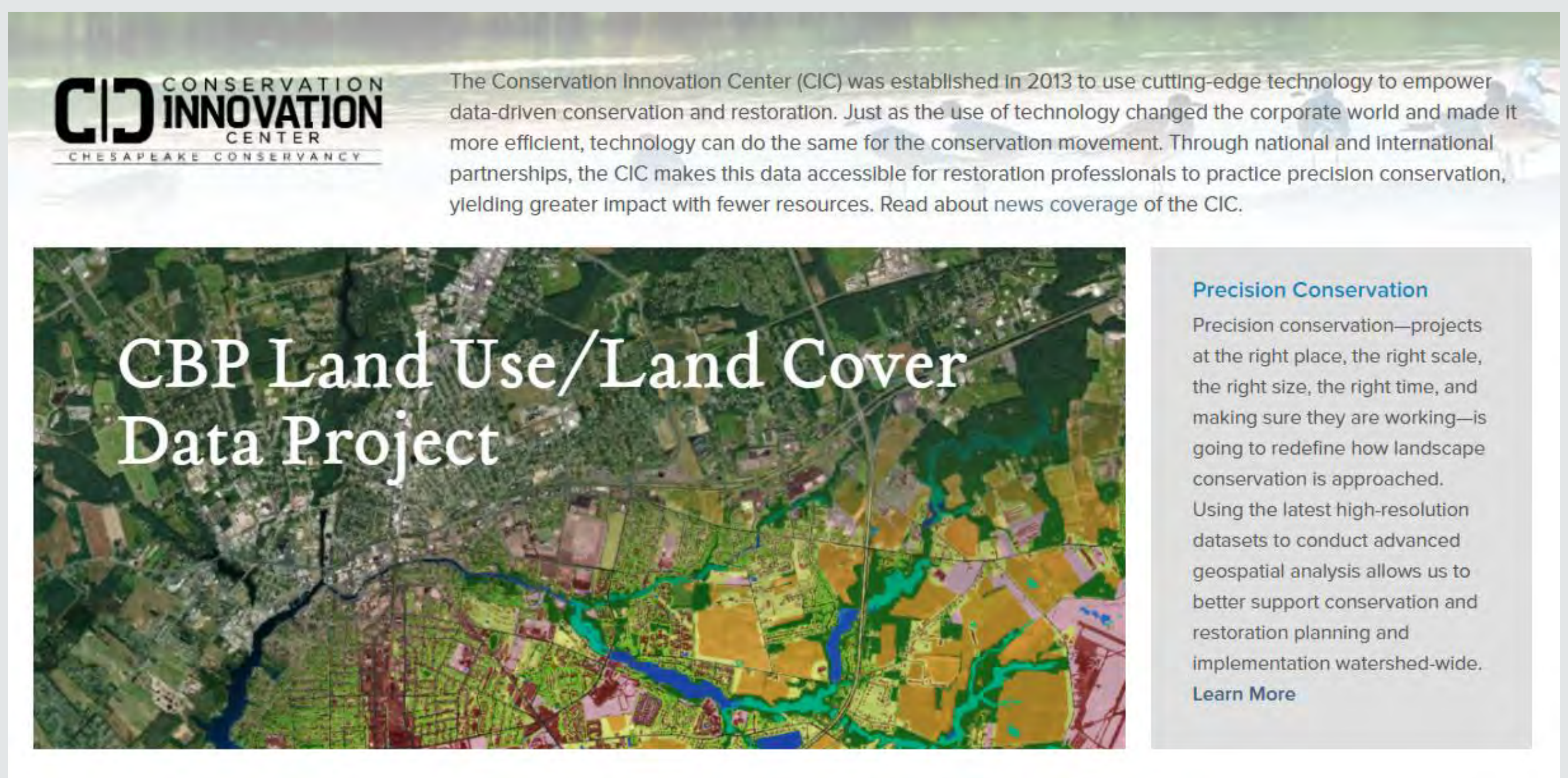
Open Access

App State

Click to restore the map extent and layers visibility where you left off.

Chesapeake Conservation Partnership Green Space Equity Mapping Tool

Assists in identifying and prioritizing conservation opportunities in low-income communities and communities of color throughout the watershed with limited or no access to open space.



The Conservation Innovation Center (CIC) was established in 2013 to use cutting-edge technology to empower data-driven conservation and restoration. Just as the use of technology changed the corporate world and made it more efficient, technology can do the same for the conservation movement. Through national and international partnerships, the CIC makes this data accessible for restoration professionals to practice precision conservation, yielding greater impact with fewer resources. Read about news coverage of the CIC.

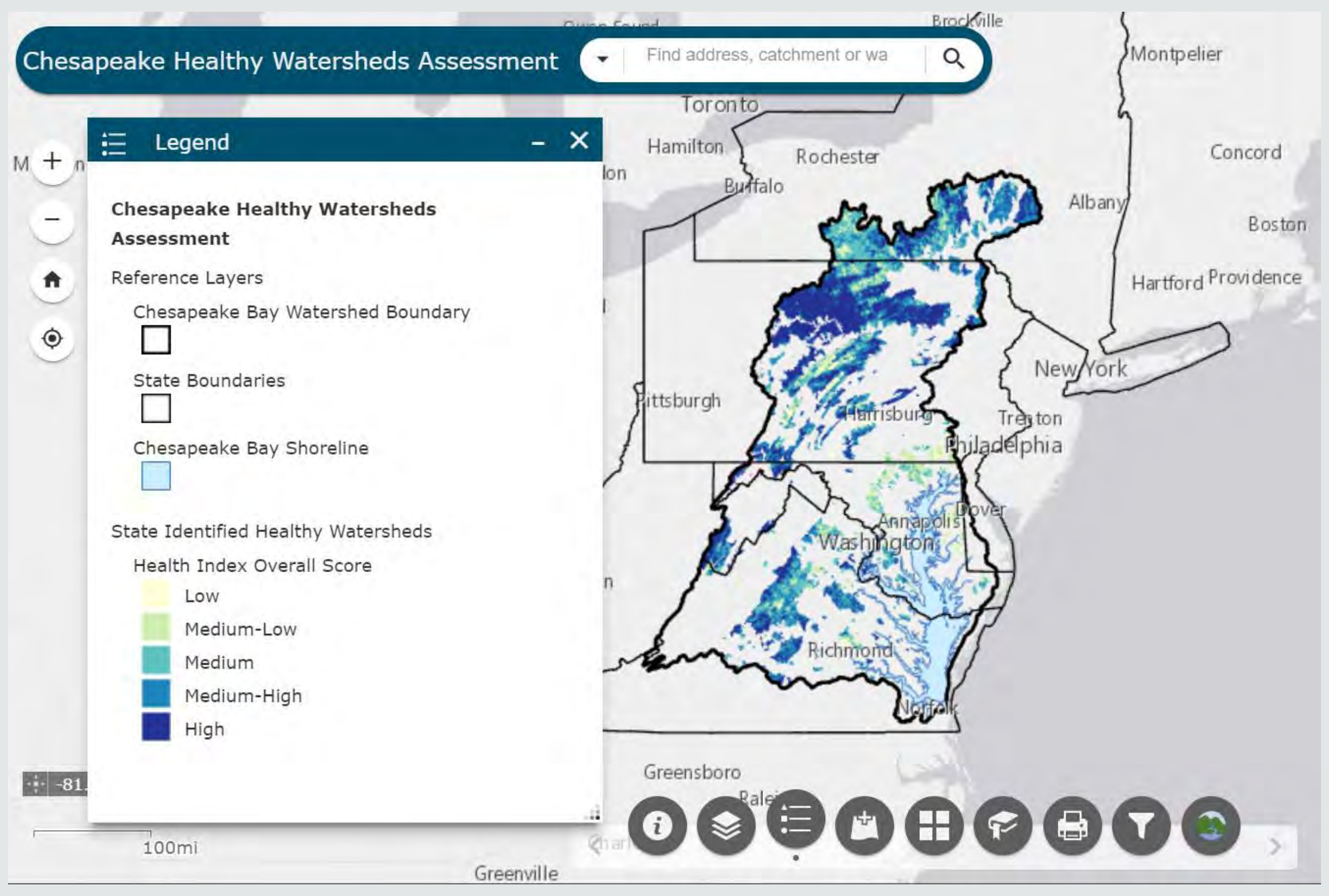
Precision Conservation

Precision conservation—projects at the right place, the right scale, the right size, the right time, and making sure they are working—is going to redefine how landscape conservation is approached. Using the latest high-resolution datasets to conduct advanced geospatial analysis allows us to better support conservation and restoration planning and implementation watershed-wide.

Learn More

Chesapeake Bay High Resolution Land Use Land Cover Data

1-meter resolution land cover and land use/land cover datasets of the Chesapeake Bay watershed regional area (206 counties, over 250,000 km2). These data are foundational, authoritative, and transformative looks at the landscape and its management throughout the region.



Chesapeake Healthy Watersheds Assessment

Legend

Chesapeake Healthy Watersheds Assessment

Reference Layers

Chesapeake Bay Watershed Boundary ☐

State Boundaries ☐

Chesapeake Bay Shoreline ☐

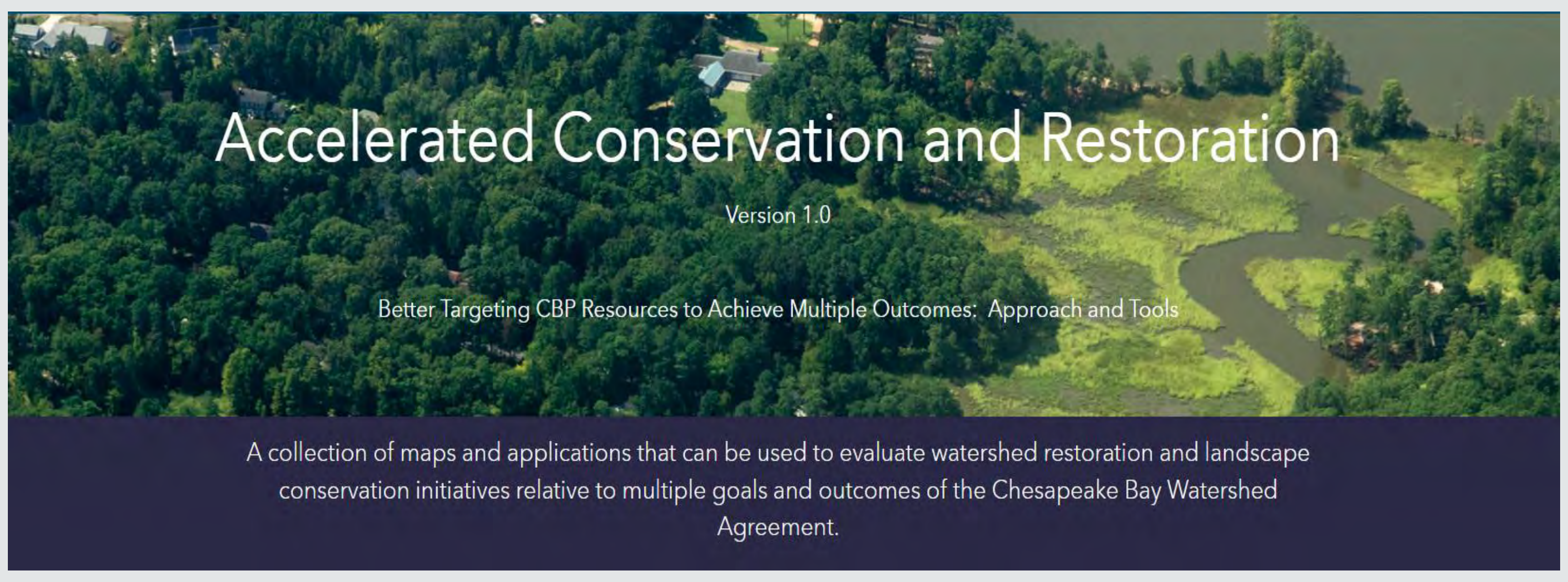
State Identified Healthy Watersheds

Health Index Overall Score

- Low
- Medium-Low
- Medium
- Medium-High
- High

Chesapeake Healthy Watersheds Assessment

Assessing the Healthy and Vulnerability of Healthy Watersheds within the Chesapeake Bay Watershed Catchment data at NHD Plus Version 2 scale



Accelerated Conservation and Restoration

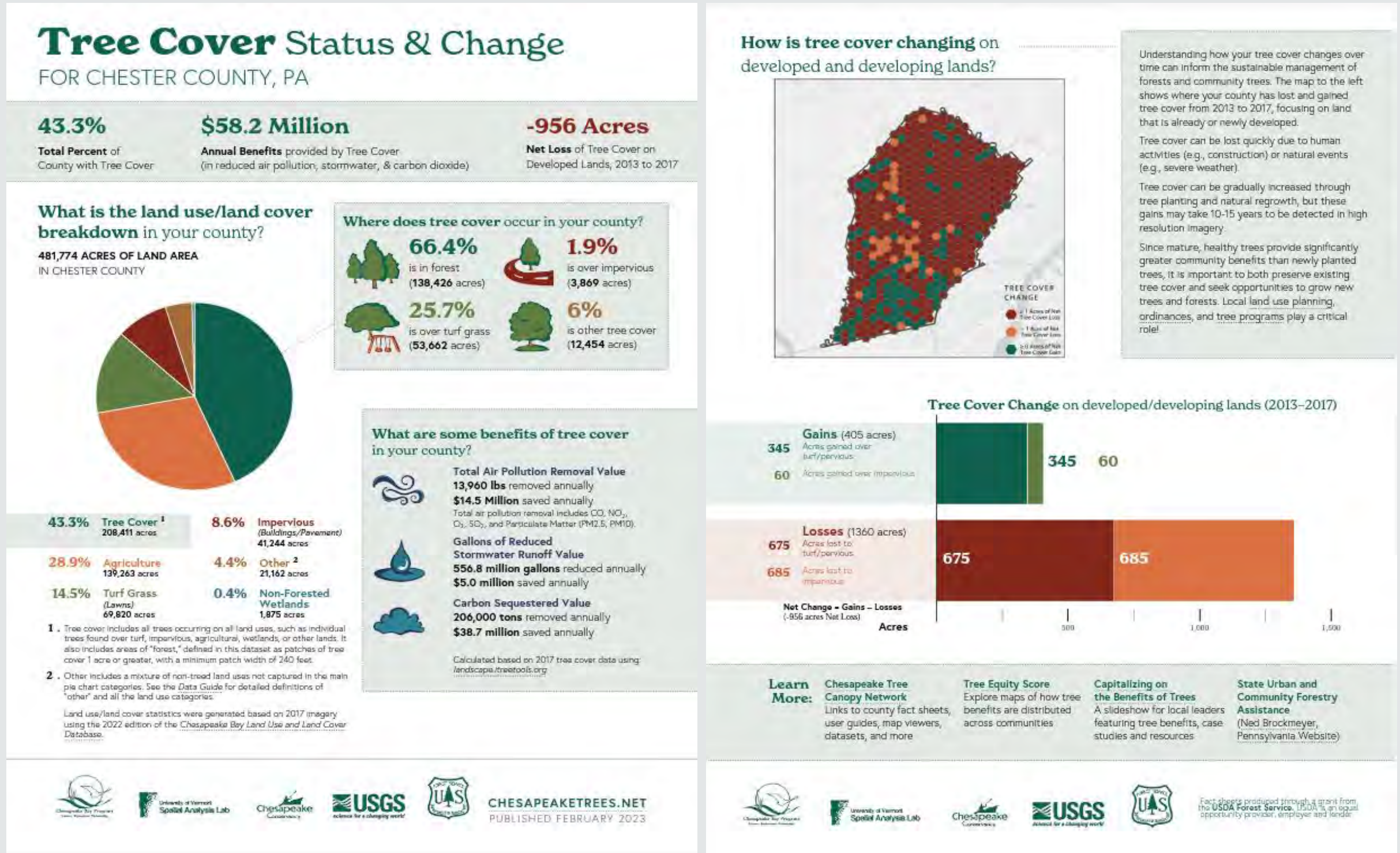
Version 1.0

Better Targeting CBP Resources to Achieve Multiple Outcomes: Approach and Tools

A collection of maps and applications that can be used to evaluate watershed restoration and landscape conservation initiatives relative to multiple goals and outcomes of the Chesapeake Bay Watershed Agreement.

Accelerated Conservation and Restoration Targeting Portal

A collection of maps and applications that can be used to evaluate watershed restoration and landscape conservation initiatives relative to multiple goals and outcomes of the Chesapeake Bay Watershed Agreement.



Tree Cover Status & Change

FOR CHESTER COUNTY, PA

43.3%	$58.2 Million	-956 Acres
Total Percent of County with Tree Cover	**Annual Benefits** provided by Tree Cover (in reduced air pollution, stormwater, & carbon dioxide)	**Net Loss** of Tree Cover on Developed Lands, 2013 to 2017

What is the land use/land cover breakdown in your county?

481,774 ACRES OF LAND AREA IN CHESTER COUNTY

43.3%	Tree Cover [1] 208,411 acres	8.6%	Impervious (Buildings/Pavement) 41,244 acres
28.9%	Agriculture 139,263 acres	4.4%	Other [2] 21,162 acres
14.5%	Turf Grass (Lawns) 69,820 acres	0.4%	Non-Forested Wetlands 1,875 acres

Where does tree cover occur in your county?

66.4% is in forest (138,426 acres)	1.9% is over impervious (3,869 acres)
25.7% is over turf grass (53,662 acres)	6% is other tree cover (12,454 acres)

What are some benefits of tree cover in your county?

Total Air Pollution Removal Value
13,960 lbs removed annually
$14.5 Million saved annually
Total air pollution removal includes CO, NO_2, O_3, SO_2, and Particulate Matter (PM2.5, PM10).

Gallons of Reduced Stormwater Runoff Value
556.8 million gallons reduced annually
$5.0 million saved annually

Carbon Sequestered Value
206,000 tons removed annually
$38.7 million saved annually

Calculated based on 2017 tree cover data using: landscape.itreetools.org

[1] Tree cover includes all trees occurring on all land uses, such as individual trees found over turf, impervious, agricultural, wetlands, or other lands. It also includes areas of "forest," defined in this dataset as patches of tree cover 1 acre or greater, with a minimum patch width of 240 feet.

[2] Other includes a mixture of non-treed land uses not captured in the main pie chart categories. See the Data Guide for detailed definitions of "other" and all the land use categories.

Land use/land cover statistics were generated based on 2017 imagery using the 2022 edition of the Chesapeake Bay Land Use and Land Cover Database.

CHESAPEAKETREES.NET
PUBLISHED FEBRUARY 2023

How is tree cover changing on developed and developing lands?

Understanding how your tree cover changes over time can inform the sustainable management of forests and community trees. The map to the left shows where your county has lost and gained tree cover from 2013 to 2017, focusing on land that is already or newly developed.

Tree cover can be lost quickly due to human activities (e.g., construction) or natural events (e.g., severe weather).

Tree cover can be gradually increased through tree planting and natural regrowth, but these gains may take 10-15 years to be detected in high resolution imagery.

Since mature, healthy trees provide significantly greater community benefits than newly planted trees, it is important to both preserve existing tree cover and seek opportunities to grow new trees and forests. Local land use planning, ordinances, and tree programs play a critical role!

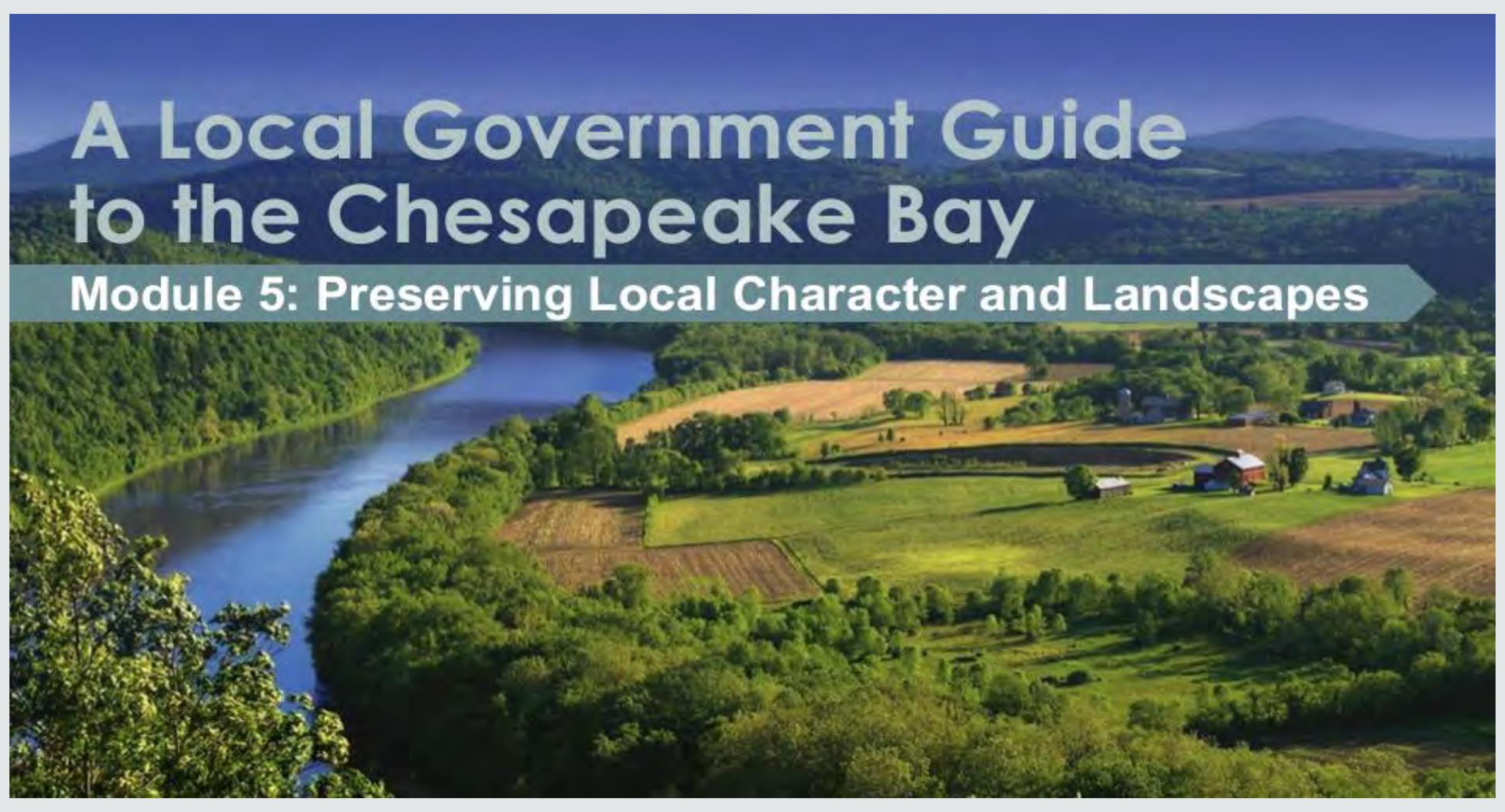
Tree Cover Change on developed/developing lands (2013–2017)

Learn More:			
Chesapeake Tree Canopy Network Links to county fact sheets, user guides, map viewers, datasets, and more	**Tree Equity Score** Explore maps of how tree benefits are distributed across communities	**Capitalizing on the Benefits of Trees** A slideshow for local leaders featuring tree benefits, case studies and resources	**State Urban and Community Forestry Assistance** (Ned Brockmeyer, Pennsylvania Website)

Fact sheets produced through a grant from the USDA Forest Service. USDA is an equal opportunity provider, employer and lender.

County Tree Cover Fact Sheet

County Tree Cover Fact Sheets are for all Chesapeake watershed counties sharing tree cover status, benefits (from i-Tree) and change information over the 2013/14 to 2017/18 time periods



A Local Government Guide to the Chesapeake Bay

Module 5: Preserving Local Character and Landscapes

A Local Government Guide to the Chesapeake Bay Module 5

highlights the economic, ecological, cultural, and recreational value of the conserved landscapes around the Chesapeake Bay watershed to the people and communities of the region

For links to all the listed tools please scan the QR code!

Chesapeake Bay Program

40 years of science, restoration and partnership

A LOCAL GOVERNMENT GUIDE TO THE CHESAPEAKE BAY

PROJECT OVERVIEW

- *A Local Government Guide to the Chesapeake Bay* is a series of educational modules created to support decision making by local officials

- Modules include a customizable presentation, one page handout, a PDF and a video
- Icons highlight how the information aligns with local government priorities
- Highly visual and succinct information

Check out the modules at this QR code:

LOCAL GOVERNMENT PRIORITIES

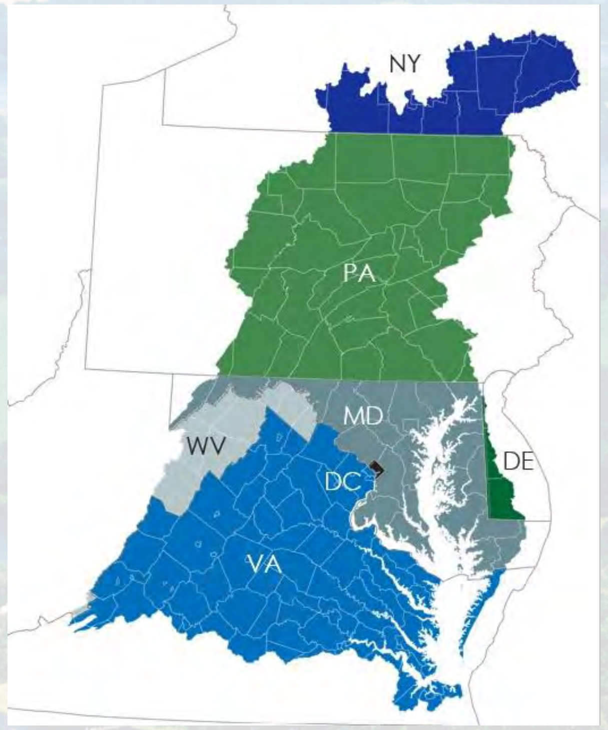
- Economic Development
- Public Safety and Health
- Infrastructure Maintenance & Finance
- Education

MODULES

How the Watershed Works

Foundations of Clean Water

Preserving Local Character and Landscapes



Preparing Your Community for Water Extremes

Capitalizing on the Benefits of Trees

Building the Workforce of Today and Tomorrow

Protecting Community Infrastructure Through Stormwater Resilience

Clean Water for the Economy

Understanding and Supporting Your Agricultural Allies

Keys to Building Community Buy-in for the Environment

Your Health and the Environment

PROJECT ENGAGEMENT

- 400+ people have accessed the modules
- 1,500+ local officials directly engaged
- Shared with 10,000+ local officials
- 4 states have tailored the modules

HOW TO USE THE MODULES

- Modules are easily customized and shared
- Example uses: one-pager as handout, ppt as the basis for a presentation, one slide as an infographic, pdf version as a handbook etc.
- NEW WEBSITE for modules→ Summer 2023
- "Train the trainer" → Fall 2023

40 years of monitoring and analysis in the Chesapeake Bay Program partnership : Insights on ecosystem change and new monitoring investments for improved decision support

Peter Tango USGS@CBPO Biennial SRS Meeting 2023, Charlottesville, VA

Credits: STAR and its workgroups, CBP Monitoring Team, CBP partnership contributions over many decades

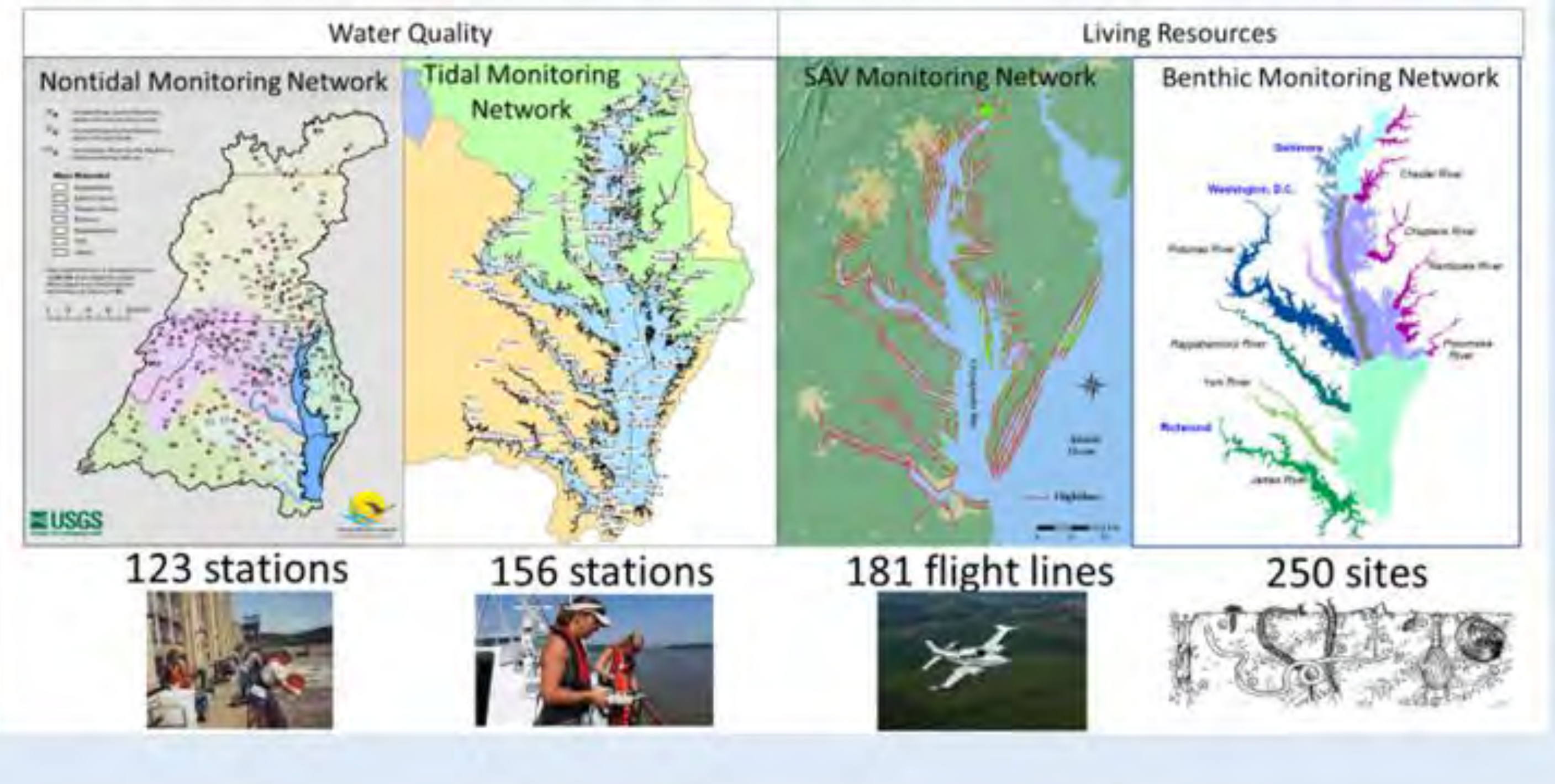
Chesapeake Bay Program

40 years of science, restoration and partnership

Abstract: The Chesapeake Bay Program Monitoring Programming had its first full year of operation in 1985. Water quality and living resource monitoring programs are valued for providing 1) decision-support on progress toward management goals and outcomes, 2) research insight, 3) development-calibration- verification of models, 4) education, 5) management targeting activities, 6) regulatory endpoint assessments, and 7) forecasting change over time. **Watershed monitoring results show improvements** across time though progress can vary by location and estimated results are generally greater than measured results as lag time for some effects are yet to be realized. The **Stream Health Benthic Index of Biotic Integrity analysis shows improvement** of watershed health in the last 20 years. **Various bay indicators demonstrate progress with Bay response**, however, the partnership expresses interest in accelerating the pace change. **Monitoring data have provided insight into climate change affects on the pace of progress. New monitoring approaches** are being incorporated into our assessment efforts. **Additional support is needed** for effectively monitoring of progress towards addressing all 2014 Chesapeake Watershed Agreement outcomes.

Core Monitoring Networks

CBP Partnership Monitoring Networks: Annual Monitoring



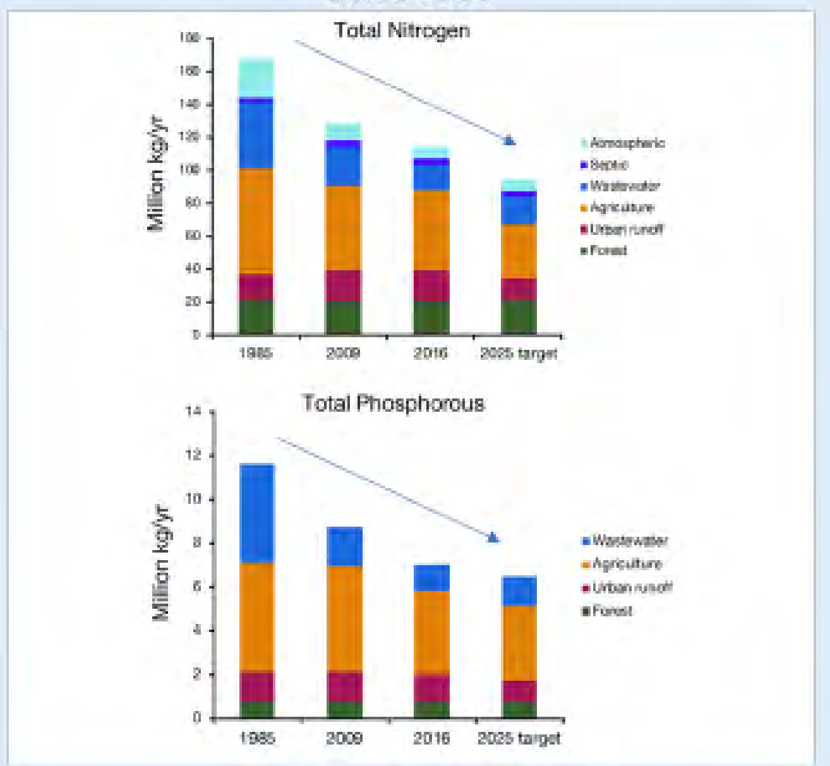
Community Science

Land Use Land Cover

1. Core Chesapeake Bay Program Monitoring Program Elements include nontidal and tidal water quality, submerged aquatic vegetation, tidal benthic macroinvertebrates, Community Science, and Land Use Land Cover change

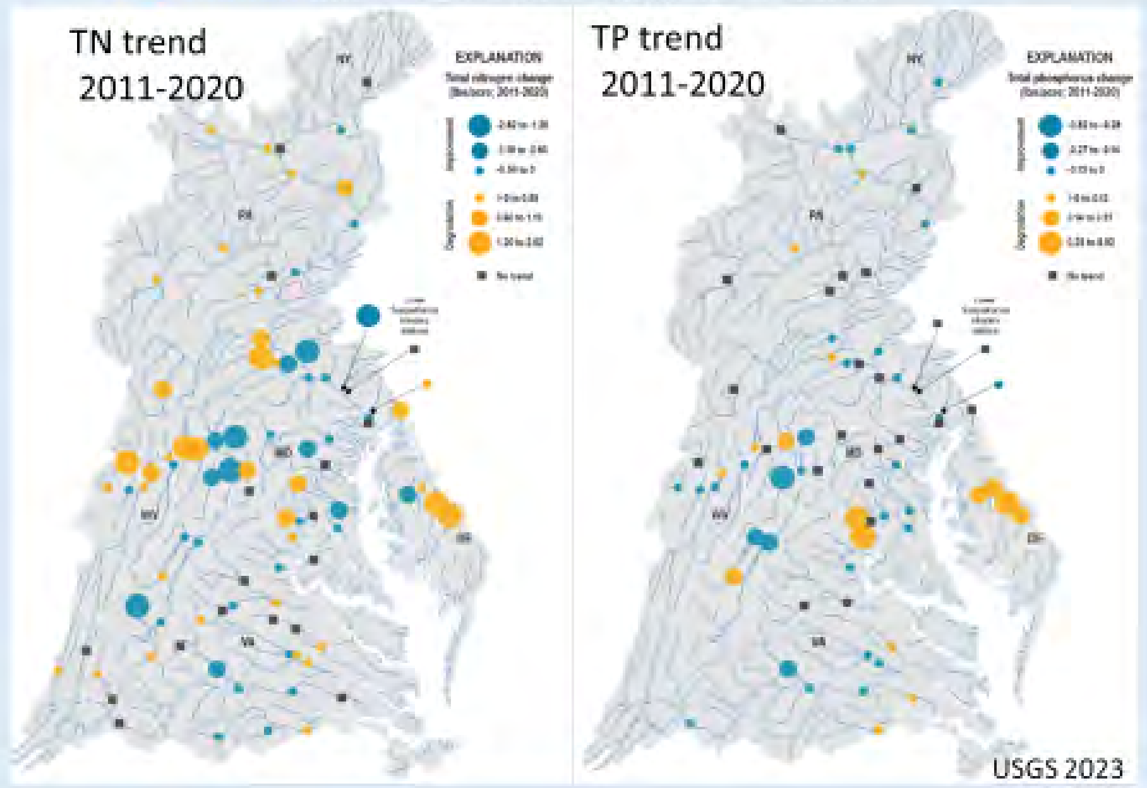
Watershed nutrient management shows cumulative progress but mixed local results

Estimated cumulative load reductions to the bay since 1985



D. Boesch 2019 Frontiers in Marine Science

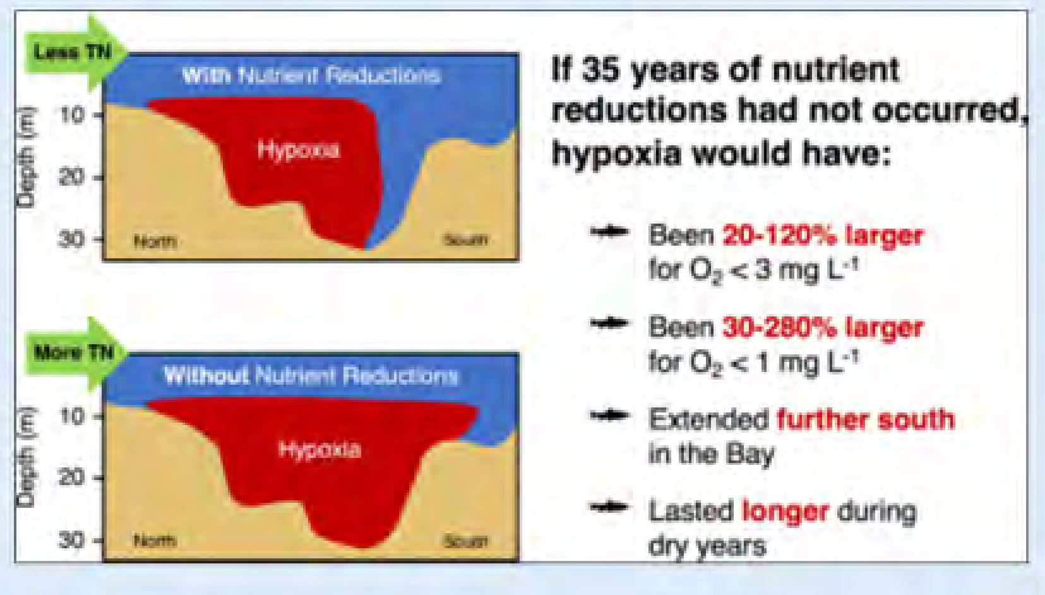
Spatially diverse patterns in trends for improvement and degradation offer targets for management action



USGS 2023

2. Watershed conditions improve though unevenly across the watershed

Are we seeing progress in the Bay response to management? Yes.



If 35 years of nutrient reductions had not occurred, hypoxia would have:

- Been **20-120% larger** for $O_2 < 3$ mg L^{-1}
- Been **30-280% larger** for $O_2 < 1$ mg L^{-1}
- Extended **further south** in the Bay
- Lasted **longer** during dry years

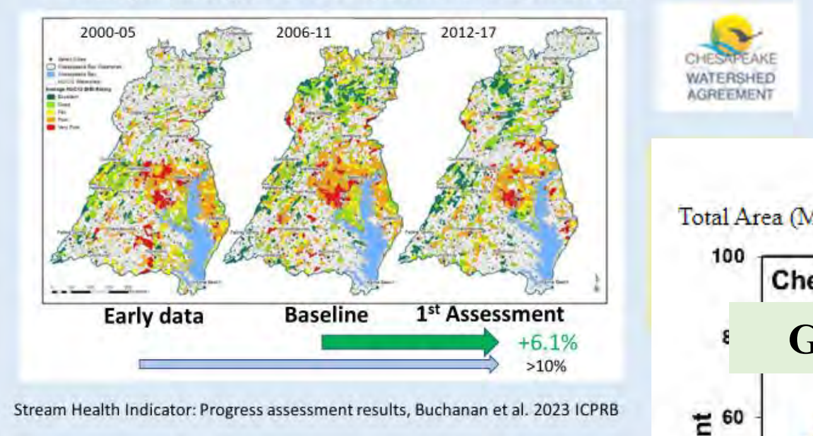
Frankel, L.T., M.A.M. Friedrichs, P. St-Laurent, A.J. Bever, R.N. Lipcius, G. Bhatt, G.W. Shenk, 2022. **Nitrogen reductions have** decreased hypoxia **in the Chesapeake Bay**: Evidence from empirical and numerical modeling, Science of the Total Environment, accepted for publication in December 2021

Science supporting improving water quality for the Bay

- Murphy, R. R., J. Keisman, J. Harcum, R.R. Karrh, M. Lane, E.S. Perry, and Q. Zhang. 2022. **Nutrient Improvements in Chesapeake Bay: Direct Effect of Load Reductions and Implications for Coastal Management.** Environ. Sci. Technol. 56:260-270.
- Fisher, T. R.; Fox, R. J.; Gustafson, A. B.; Koontz, E.; Lepori-Bui, M.; Lewis, J. 2021. **Localized Water Quality Improvement in the Choptank Estuary, a Tributary of Chesapeake Bay.** Estuar. Coast. 44, 1274-1293.
- Jones, C. 2020. **Recovery of a tidal freshwater embayment from eutrophication**: a multidecadal study. Estuaries and Coasts. 43:1318-1334.
- Lefcheck, J. S.; Orth, R. J.; Dennison, W. C.; Wilcox, D. J.; Murphy, R. R.; Keisman, J.; Gurbisz, C.; Hannam, M.; Landry, J. B.; Moore, K. A.; Patrick, C. J.; Testa, J.; Weller, D. E.; Batiuk, R. A. 2018. **Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region.** Proc. Natl. Acad. Sci. U.S.A. 115, 3658-3662.
- Zhang, Q.; Murphy, R. R.; Tian, R.; Forsyth, M. K.; Trentacoste, E. M.; Keisman, J.; Tango, P. J. 2018. **Chesapeake Bay's water quality condition has been recovering: Insights from a multimetric indicator assessment of thirty years of tidal monitoring data.** Sci. Total Environ. 637-638, 1617-1625.
- Ruhl, H. A.; Rybicki, N. B. 2010. **Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat.** Proc. Natl. Acad. Sci. U.S.A. 107, 16566.

Stream Health Outcome – Assessment impact

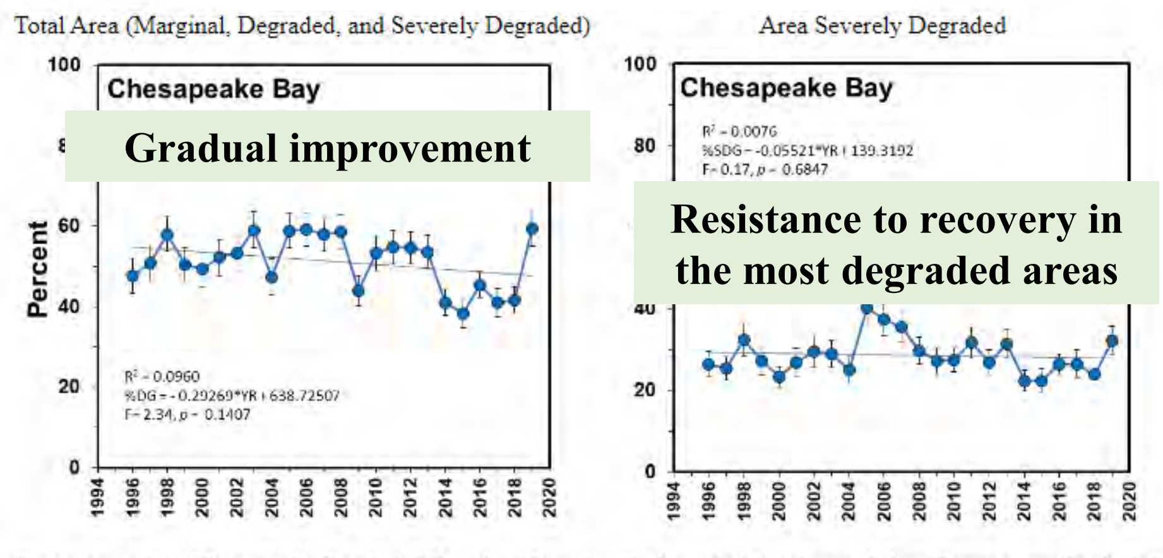
Management target of a 10% improvement for the watershed



Stream Health Indicator: Progress assessment results, Buchanan et al. 2023 ICPRB

Watershed macroinvertebrates: Chessie BIBI results improving 2000-2017

Tidal Bay IBI Baywide Results

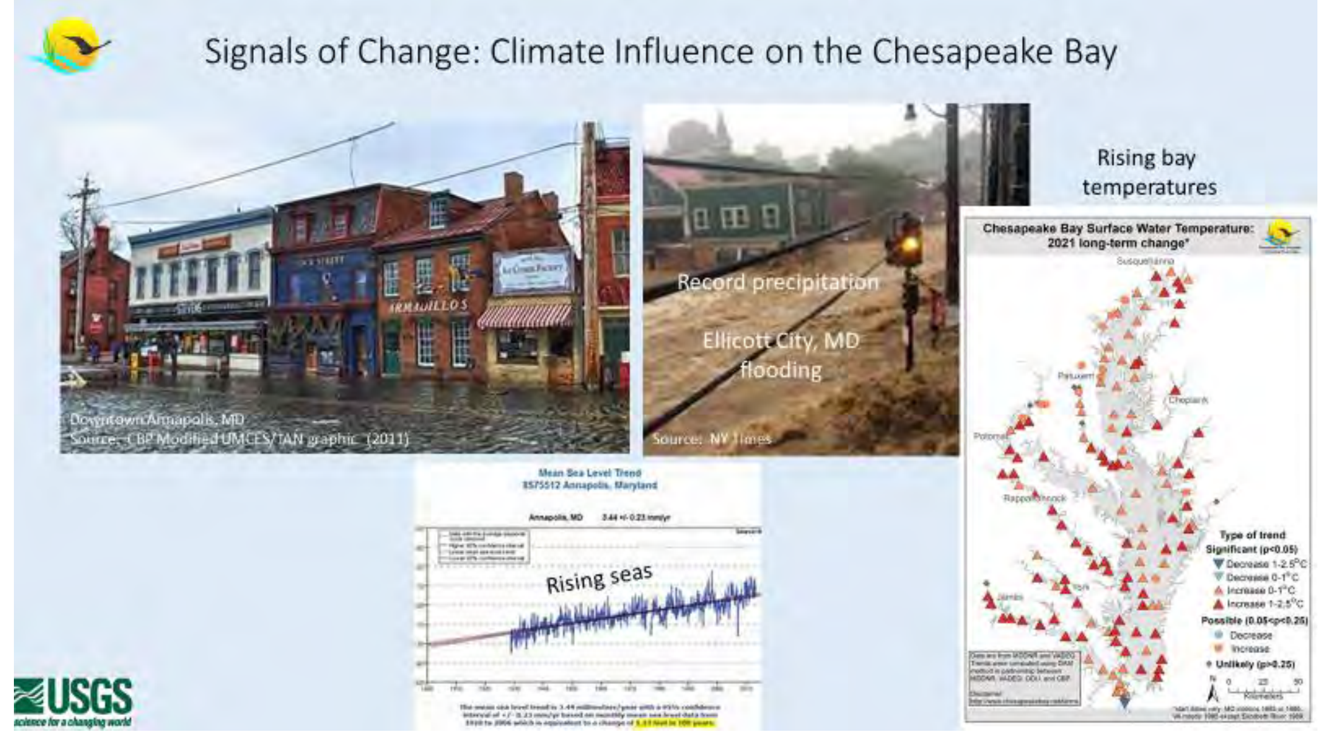


Proportion of the Chesapeake Bay (+/- 1 Standard Error) with degraded (total area failing Restoration Goals, left panel) and severely degraded (right panel) benthic community condition. Trends of temporal changes tested by ANOVA.

1994-2019

3. Bay and watershed indicators showing improvement, however, local to bay and watershed-wide measures vary in their pace of recovery

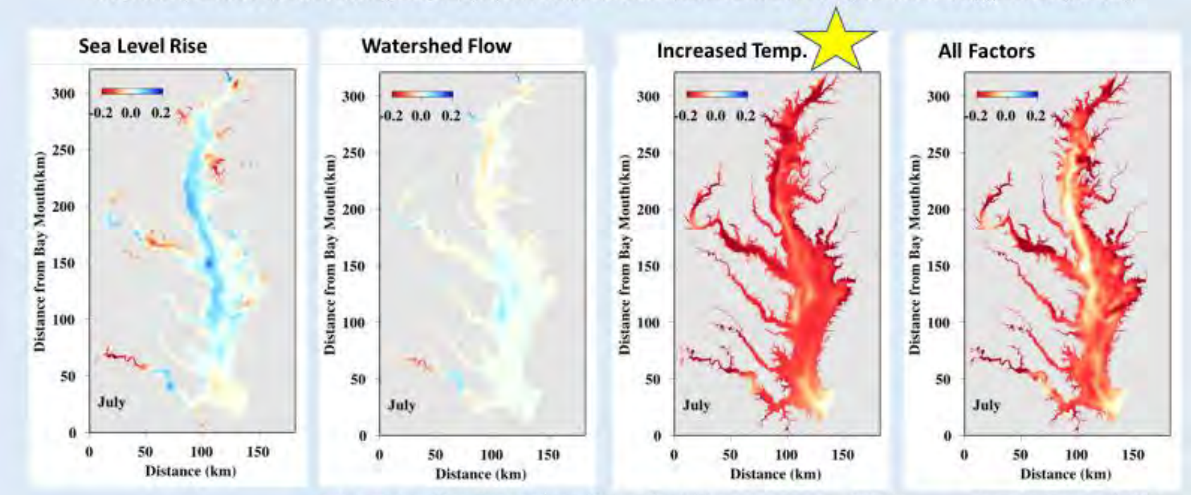
Signals of Change: Climate Influence on the Chesapeake Bay



Climate and Bottom Dissolved Oxygen Change: 1995 to 2025

Hinson et al. (2021) Negative effects on bay recovery:

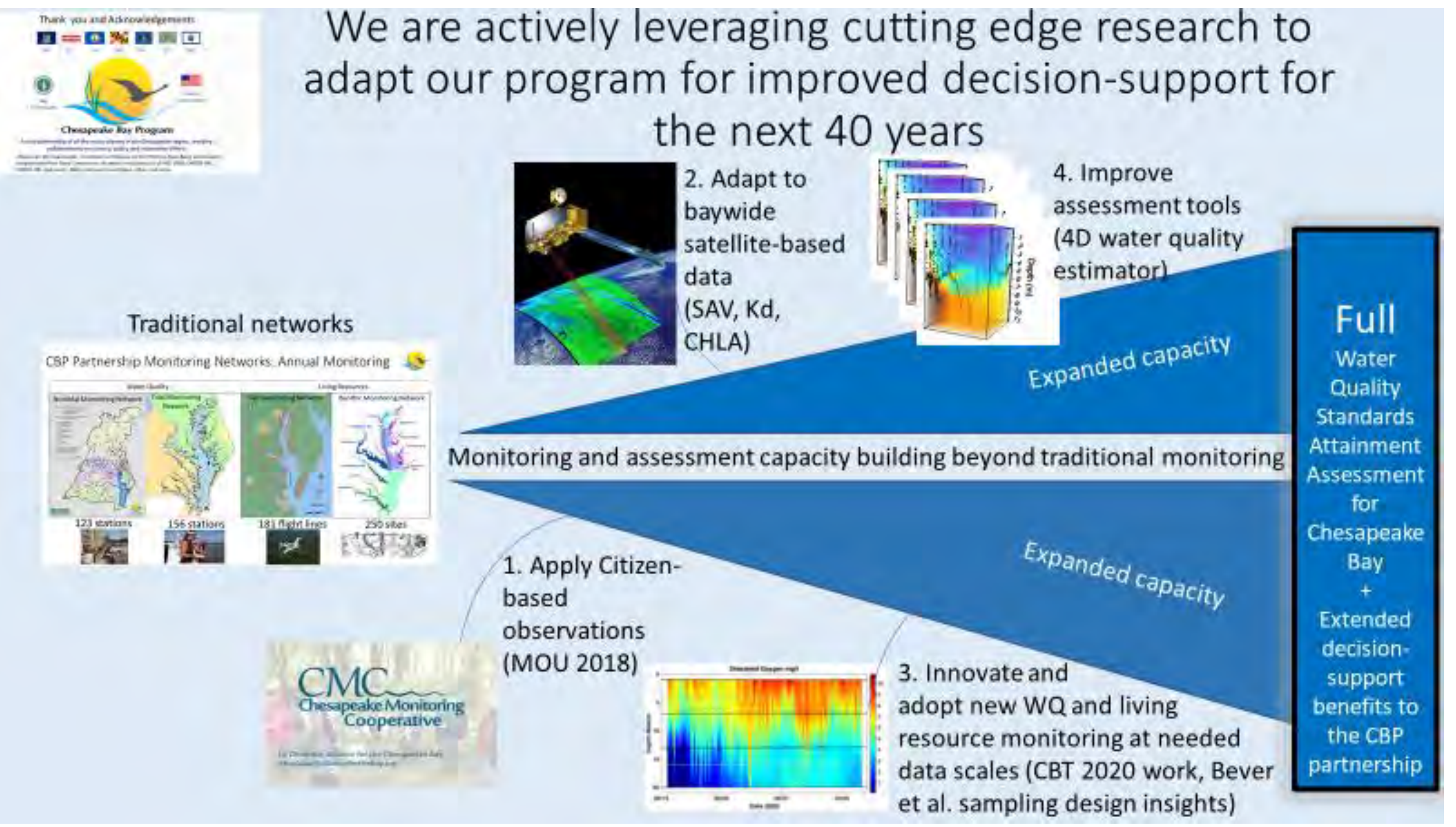
Increased water column temperatures are the predominant influence on dissolved oxygen conditions



Red = negative effect, Blue = positive effect on dissolved oxygen resources of the bay. Source: Hinson et al. 2021

4. Climate change effects are evident; temperature rise is widespread and important in negatively affecting the pace of ecosystem recovery

We are actively leveraging cutting edge research to adapt our program for improved decision-support for the next 40 years



Traditional networks

Monitoring and assessment capacity building beyond traditional monitoring

Expanded capacity

1. Apply Citizen-based observations (MOU 2018)

2. Adapt to baywide satellite-based data (SAV, Kd, CHLA)

3. Innovate and adopt new WQ and living resource monitoring at needed data scales (CBT 2020 work, Bever et al. sampling design insights)

4. Improve assessment tools (4D water quality estimator)

Full Water Quality Standards Attainment Assessment for Chesapeake Bay + Extended decision-support benefits to the CBP partnership

5. Investments continue to support maintaining core networks while leveraging an expanded set of tools for improved assessments and enhanced decision support

Current policy:
2014 Agreement

5 themes
10 goals
31 outcomes

- Abundant Life
  - Sustainable Fisheries
  - Vital Habitats
- Clean Water
  - Healthy Watersheds
  - Toxic Contaminants
  - Water Quality
- Climate Change
  - Climate Resiliency
- Conserved Lands
  - Land Conservation
- Engaged Communities
  - Environmental Literacy
  - Public Access
  - Stewardship

6. The recent Principal Staff Committee Monitoring Review highlighted additional support needed to improve monitoring to assess progress toward achieving all outcomes of the 2014 Chesapeake Watershed Agreement