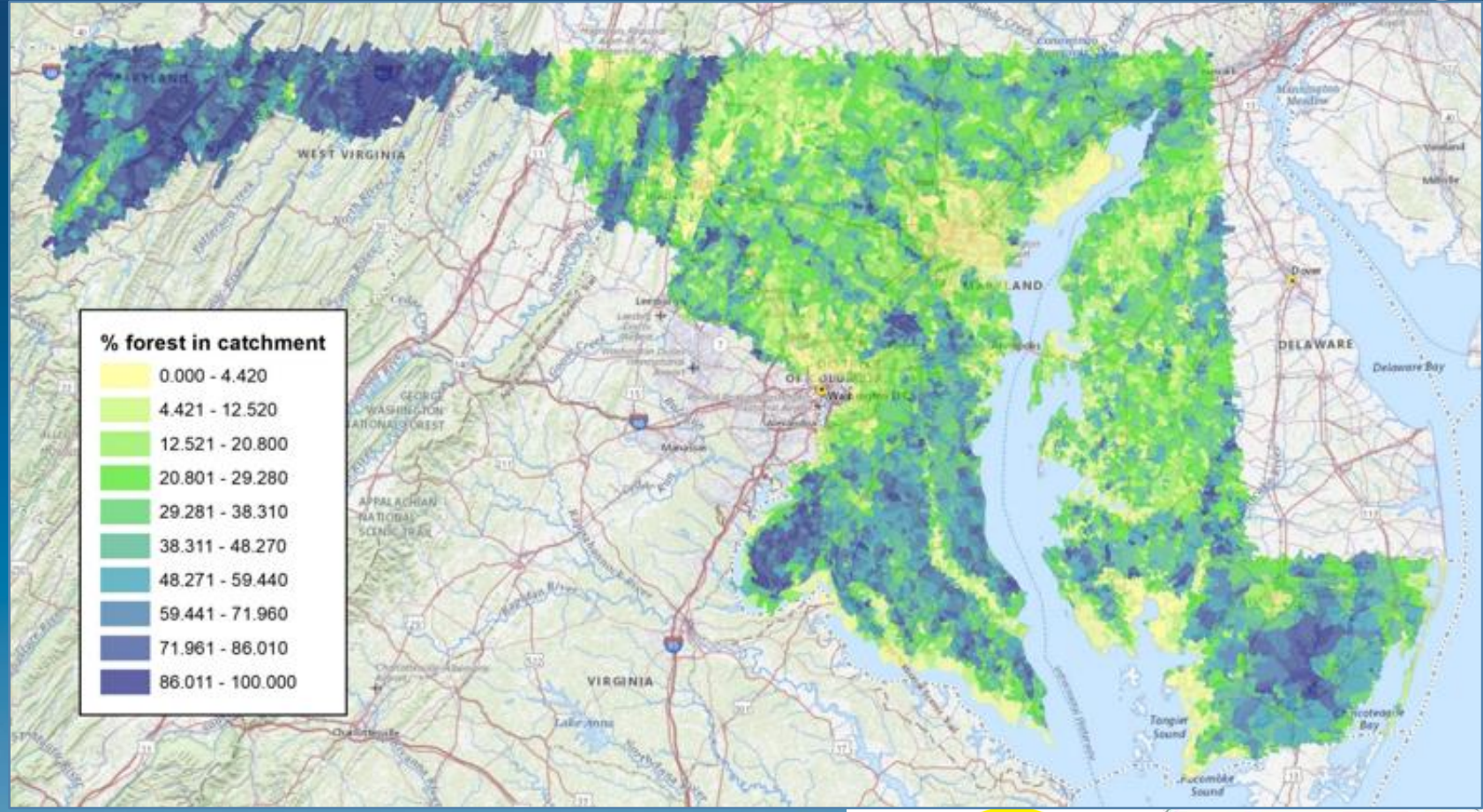
TETRA TECH

Implementing a Healthy Watersheds Assessment for Maryland Tier II Waters



Nancy Roth, Brian Pickard, Mark Southerland, and Paige Hobaugh, Tetra Tech
Renee Thompson, USGS/Chesapeake Bay Program

Land Use Workgroup Meeting
June 15, 2022

Chesapeake Bay Program
Science. Restoration. Partnership.

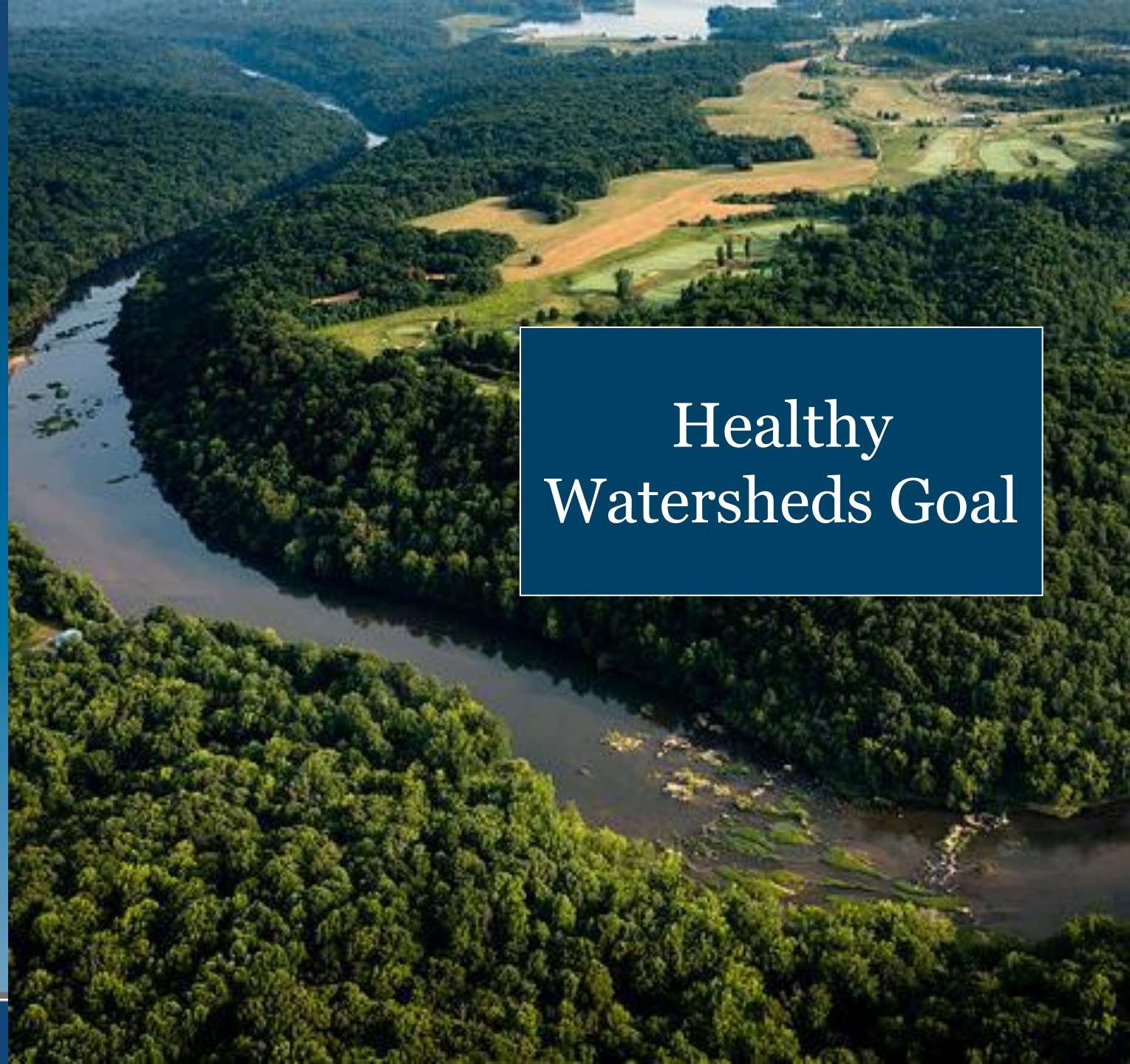
CBTRUST
Chesapeake Bay Trust

Chesapeake Bay Program
Science. Restoration. Partnership.

Healthy Watersheds Goal

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.

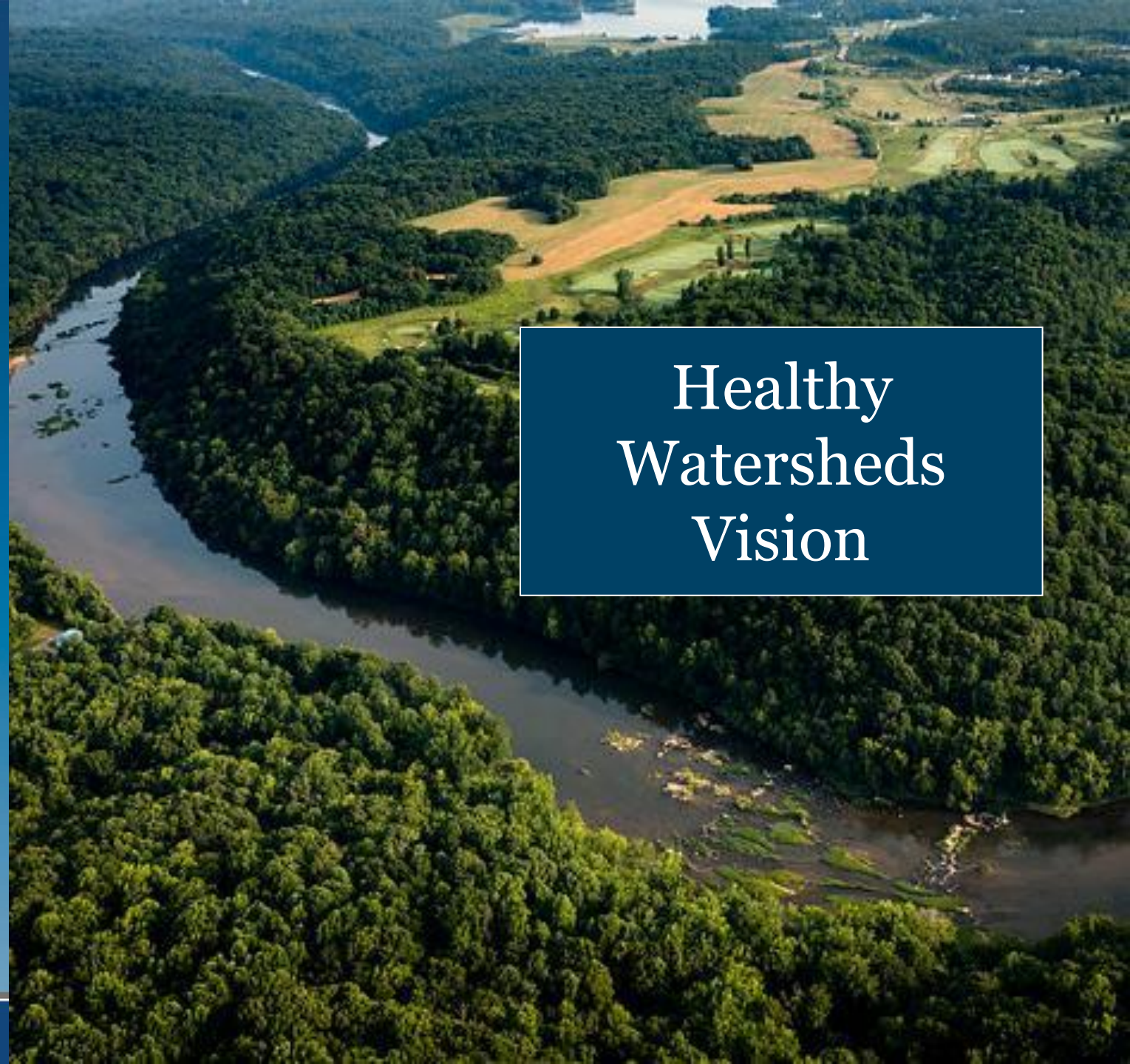


Sustain watershed health where it is ***high, exceptional and/or outstanding…***

to ***increase the number of healthy watersheds*** in the future…

Provide the forum for mutual shared learning…

Develop information resources…
and
Promote the science

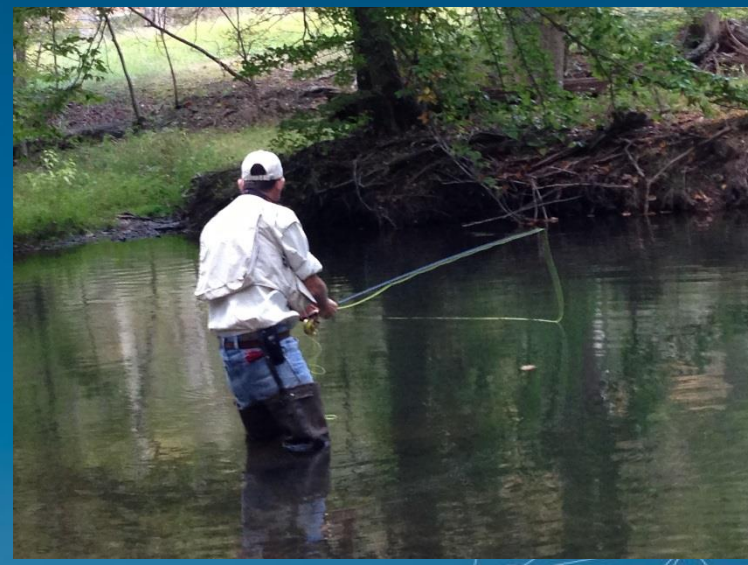


Healthy Watersheds Vision

Healthy Watersheds, Healthy Streams

EPA defines a healthy watershed as one in which natural land cover supports:

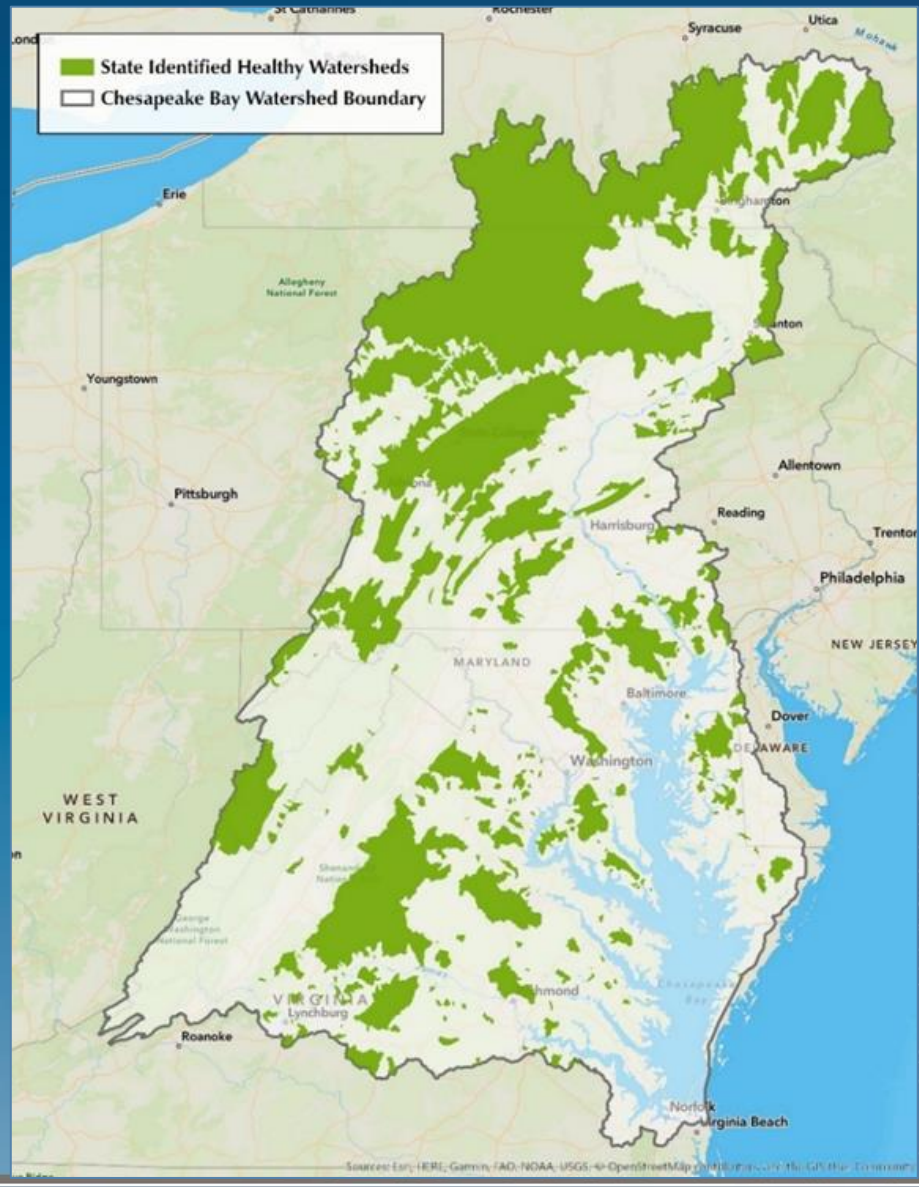
- Dynamic hydrologic and geomorphic processes within their natural range of variation,
- Habitat of sufficient size and connectivity to support native aquatic and riparian species, and
- Physical and chemical water quality conditions able to support healthy biological communities.



Source: EPA, Healthy Watersheds Protection

Purpose/Motivation: Maintaining Healthy Watersheds

- Individual Bay states have identified healthy watersheds
- Bay Program goal is to work with states to maintain the health of 100% of these watersheds
- Maryland Healthy Watershed Assessment to support protections for Tier II High Quality Waters (through project reviews and antidegradation policy)



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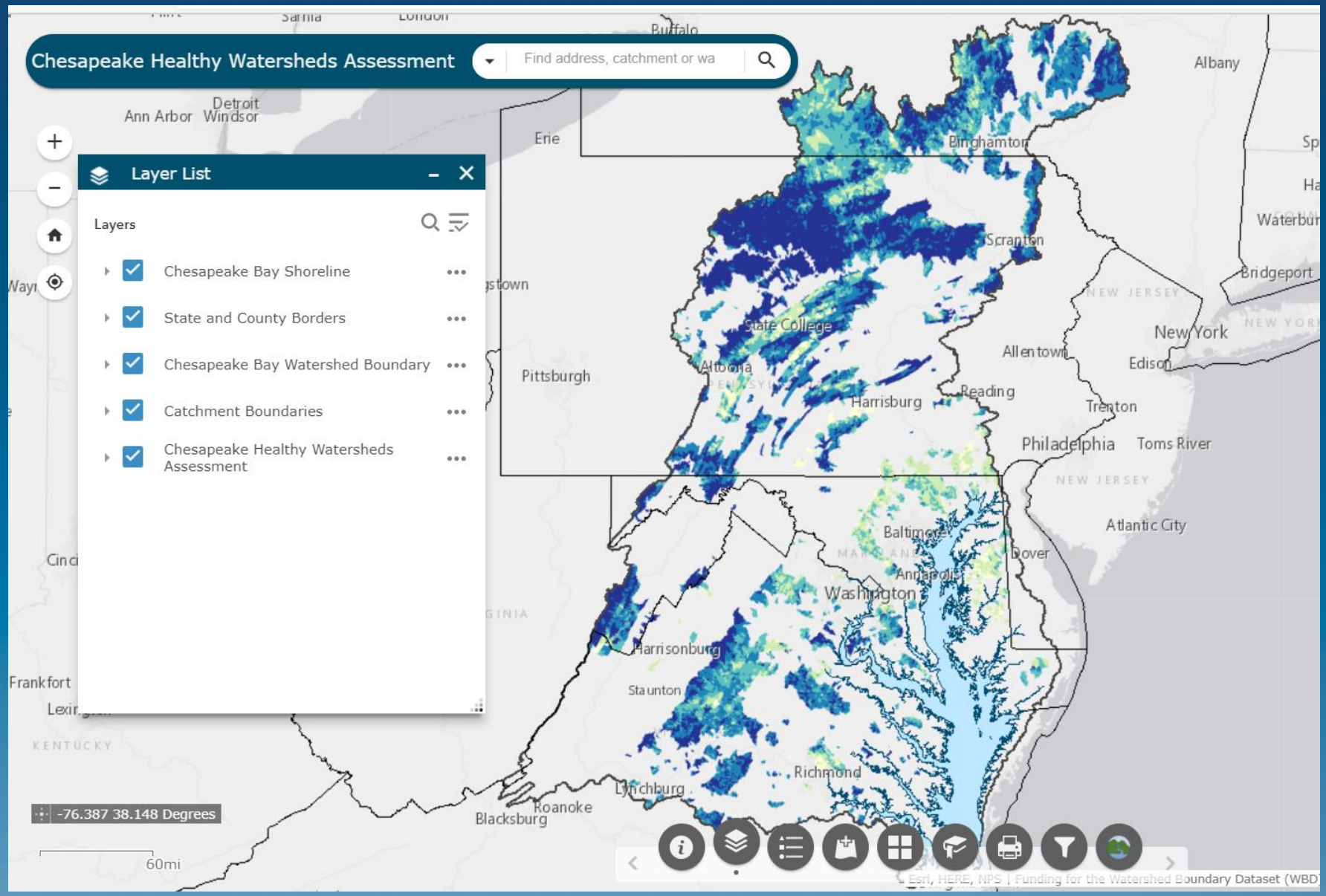
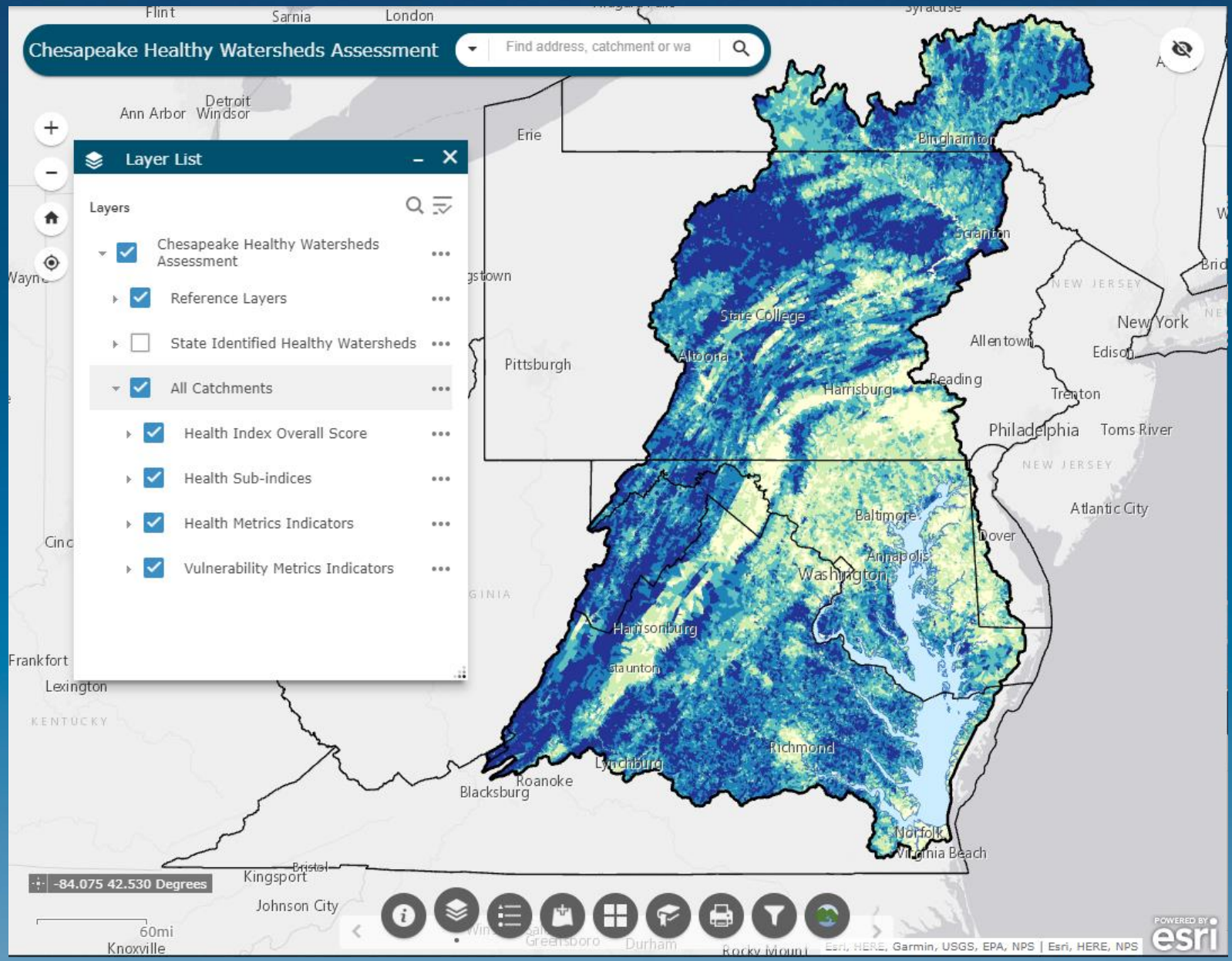
Chesapeake Healthy Watersheds Assessment



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



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Chesapeake Healthy Watersheds Assessment

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

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Chesapeake Healthy Watersheds Assessment

Condition Metrics

Landscape Condition
Subindex score:

Metric values
- % Natural Land Cover (Ws)*
- **% Forest in Riparian Zone (Ws)**
- Population Density (Ws)
- **Housing Unit Density (Ws)**
- Mining Density (Ws)
- **% Managed Turf Grass in Hydrologically Connected Zone (Ws)***
- **Historic Forest Loss (Ws)**

Hydrology
Subindex score:

Metric values
- % Agriculture on Hydric Soil (Ws)
- **% Forest (Ws)***
- % Forest Remaining (Ws)
- % Wetlands Remaining (Ws)
- % Imperviousness Cover (Ws)*
- Road Stream Crossing Density (Ws)
- **% Wetlands (Ws)***

Habitat
Subindex Score:

Metric values
- National Fish Habitat Partnership (NFHP) Habitat Condition Index (Catchment)
- **% Natural Connectivity (Catchment)**
  - **Habitat Condition Index – Local**
  - **Habitat Condition Index – Network**
  - **Habitat Condition Index – Cumulative**

Geomorphology
Subindex Score:

Metric values
- Dam Density (Ws)
- % Vulnerable Geology (Ws)
- Road Density in Riparian Zone (Ws)
- % Impervious in Riparian Zone (Ws)*

Water Quality
Subindex score:

Metric values
- **% of Stream Length Impaired (Catchment)**
- **Estimated Nitrogen Load from SPARROW Model (lbs/acre/yr) (Ws)**
- **Nitrogen, Phosphorus, and Sediment Load from Chesapeake Bay Model, by Sector (Ws)**

Biological Condition
Subindex score:

Metric values
- **Outlet Aquatic Condition Score (Catchment)**

Bold = new metrics
* = from CBP high-resolution land use/cover

gis.chesapeakebay.net/healthywatersheds/imagemaps/healthindex.html

TETRA TECH

Chesapeake Healthy Watersheds Assessment

Vulnerability Metrics

Land Use Change

Metric values

- % Increase in Development (Catchment)
- Recent Forest Loss (Ws)
- % Protected Lands (Ws)

Wildfire

Metric value

- % Wildland Urban Interface (Ws)

Water Use

Metric values

- Agricultural Water Use (Catchment)
- Domestic Water Use (Catchment)
- Industrial Water Use (Catchment)

Climate Change

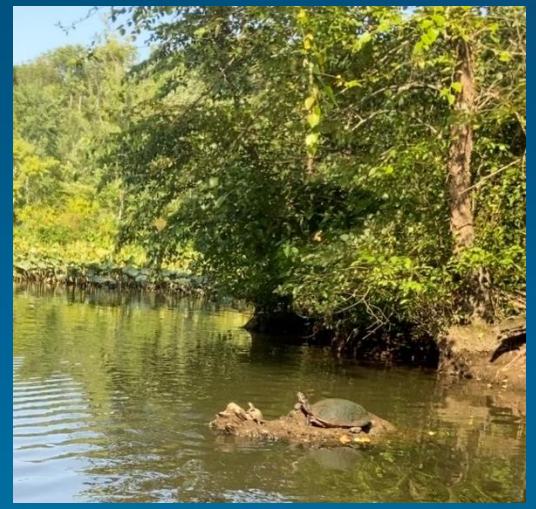
Metric values

- Brook Trout Occurrence – current (Catchment)
- Change in Probability of Brook Trout Occurrence with 6 C Temperature change (Catchment)
- NALCC Climate Stress Indicator (Catchment)

https://gis.chesapeakebay.net/healthywatersheds/imagemaps/vulnerabilityindex.html

Maryland Healthy Watersheds Assessment

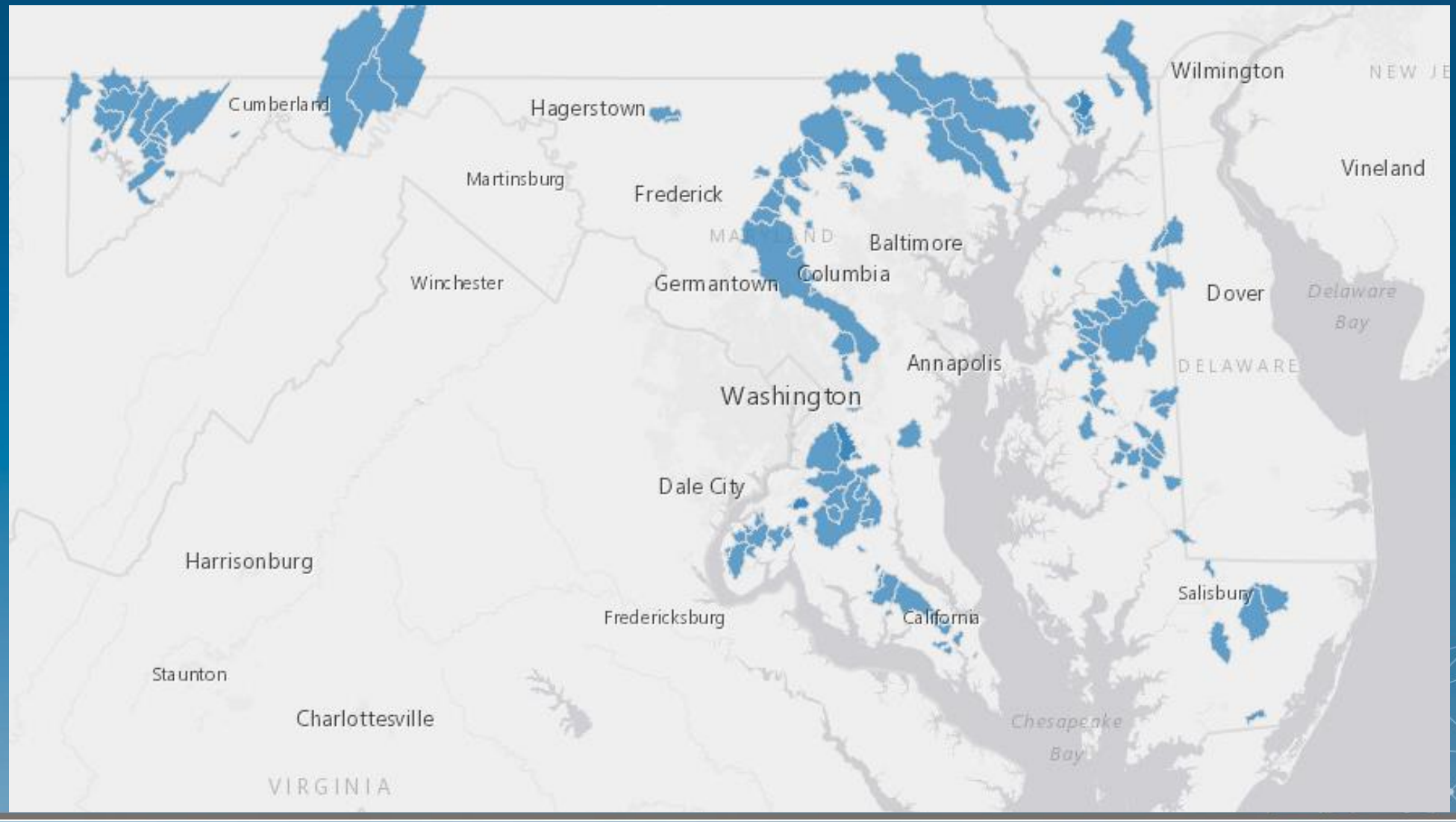
- Refine and customize the CHWA for application to Maryland
- Evaluate statistical relationships between landscape indicators and on-the-ground (*or better yet…in-the-stream!*) diagnostic measures of stream condition
- Develop approach that can be replicated in other jurisdictions using state, local, or regional data
- Provide new tool to support management of healthy watersheds (Tier II waters)



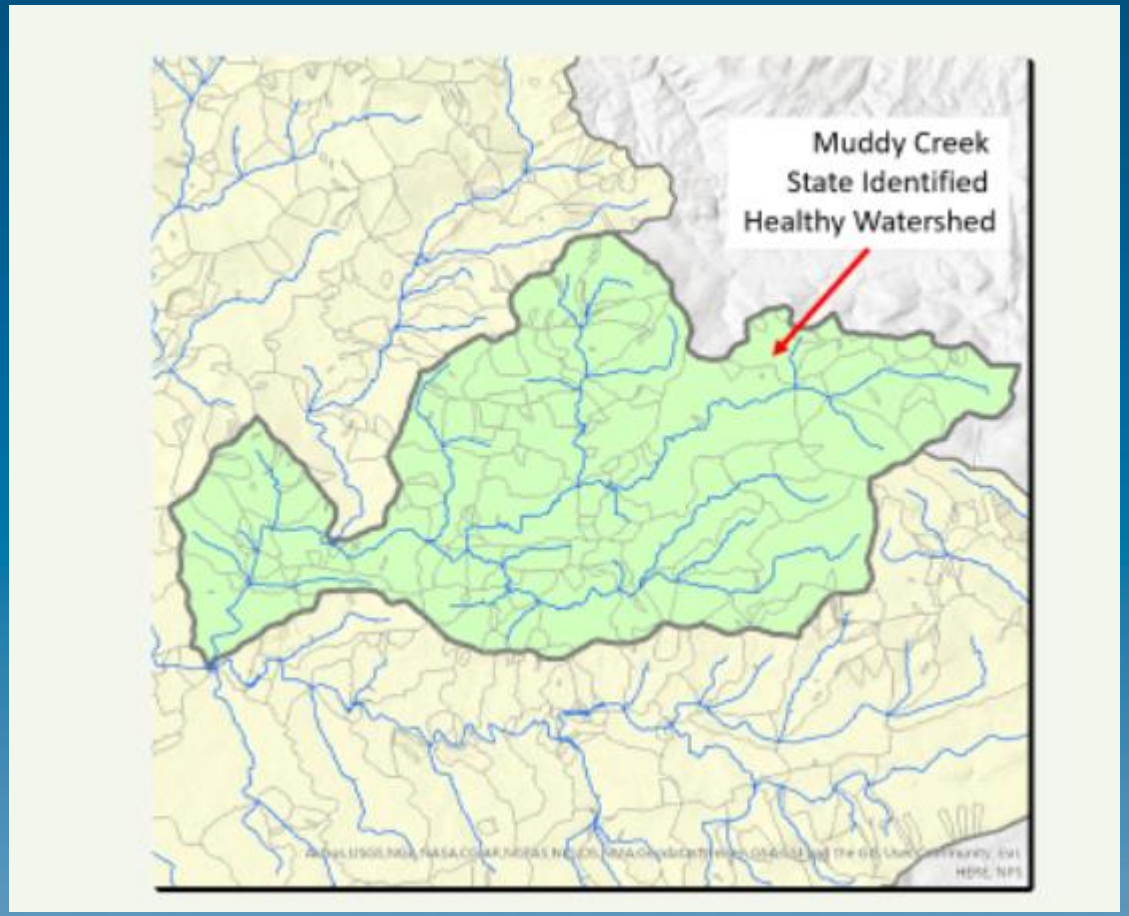
State-Identified Healthy Watersheds

Jurisdiction	Definition of Healthy Waters or Watersheds
New York	Waterbodies that have been categorized as "No Known Impact" because monitoring data and information indicate an absence of use restrictions are considered healthy.
Pennsylvania	Waters and watersheds that have been classified as High Quality or Exceptional Value are considered healthy.
Maryland	Tier II Waters: streams and their catchments are designated Tier II when their biological characteristics are significantly better than minimum water quality standards.
West Virginia	Waters that have been designated Tier 3 are known as outstanding national resource waters and are considered healthy.
Virginia	Waters and watersheds that are identified as having high aquatic integrity according to the Virginia Department of Conservation and Recreation's Division of Natural Heritage Healthy Waters Program are defined as ecologically healthy waters.
Delaware	Currently no healthy watersheds defined. All of the state's tributaries to the Chesapeake Bay are impaired by nitrogen, phosphorus, sediment and/or bacteria, and will only be considered healthy when their Total Maximum Daily Loads (TMDLs) are achieved and their surface water quality standards are met.
District of Columbia	Because the District primarily urbanized, it has not currently identified healthy watersheds.

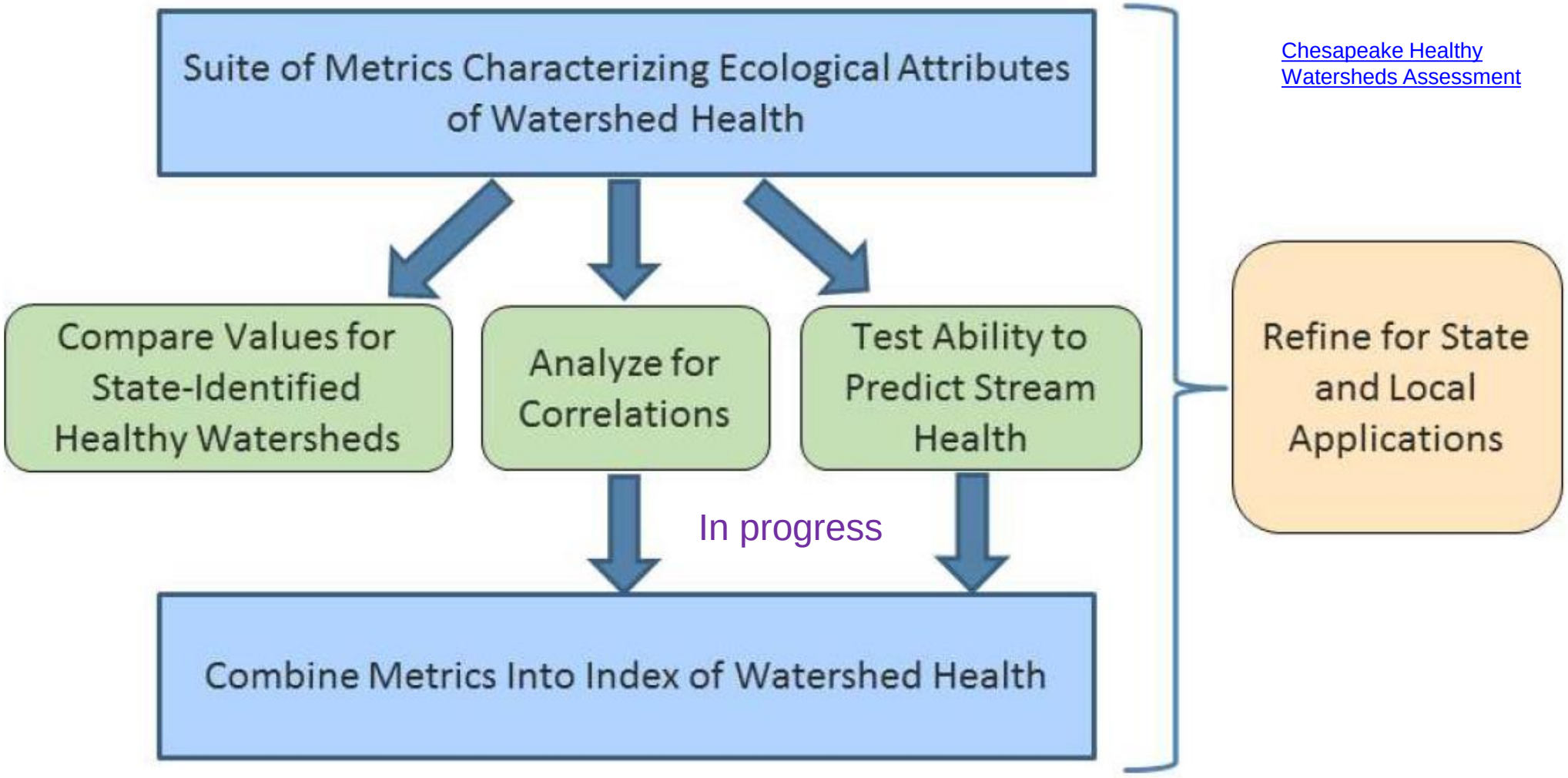
Maryland Tier II Waters



Scale of Assessment



- NHDPLus v2 catchments
- 83,000+ catchments throughout Bay watershed
- Average area 2.0 km^2 (0.79 mi^2),
- Catchments associated with each of the state-identified healthy watersheds (as defined by jurisdictional Chesapeake Bay Program partners) were delineated so that catchment-specific data can be examined for these watersheds of interest.

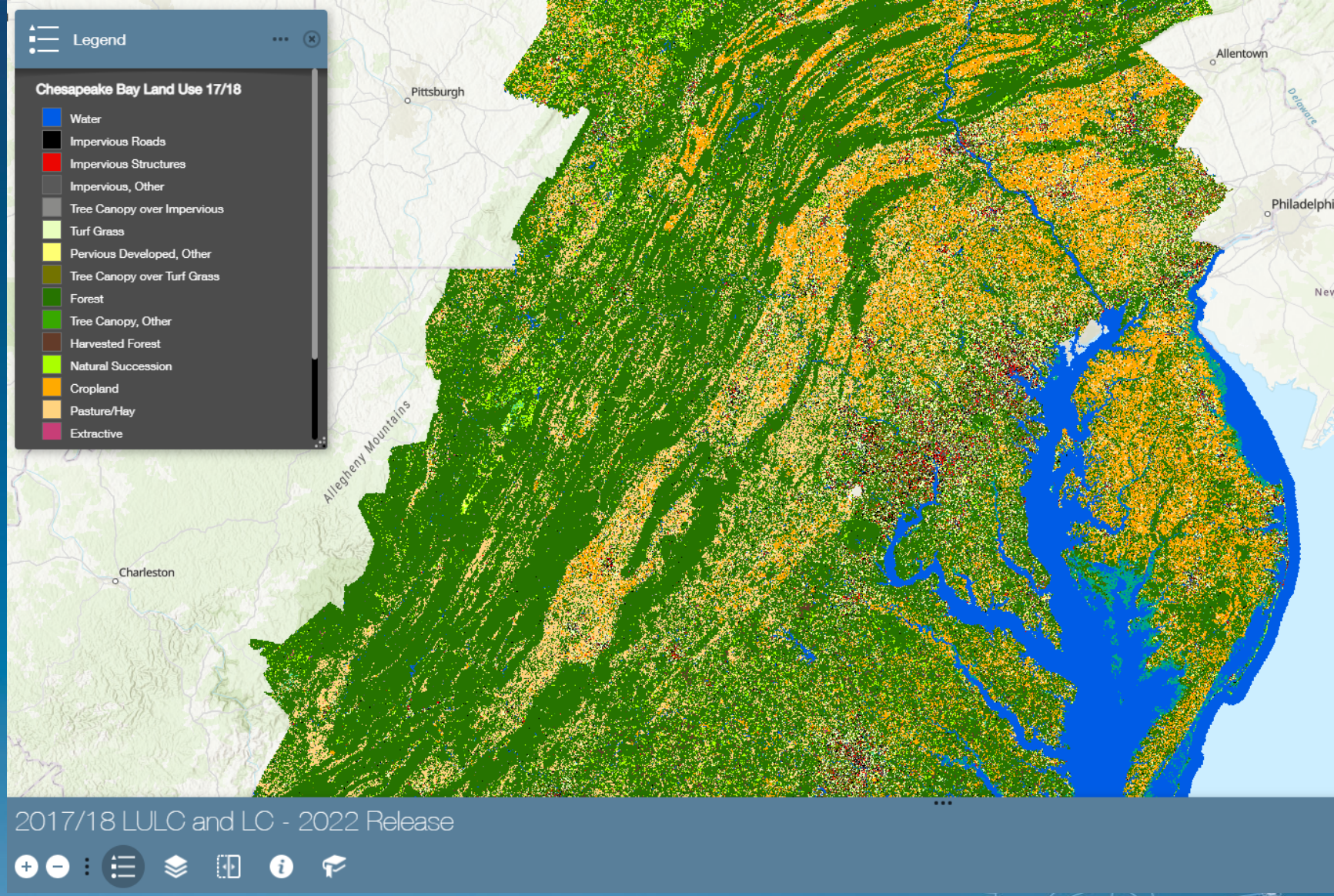


[Chesapeake Healthy Watersheds Assessment]

https://www.chesapeakebay.net/channel_files/26540/chesapeake_healthy_watersheds_assessment_report.pdf

Example Data Sources

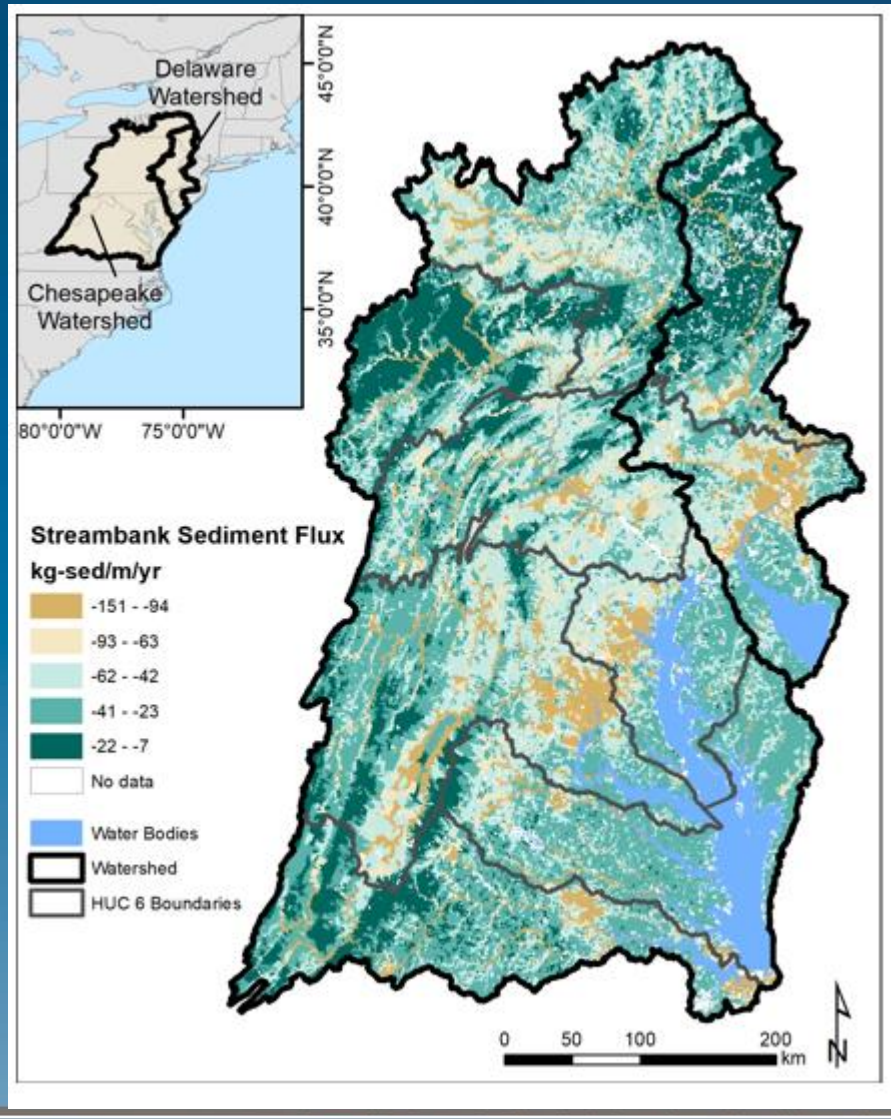
- Chesapeake Bay Program 2017-2018 1-m resolution land use / land cover



https://www.chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/lulc-data-project-2022/

Example Data Sources

- **USGS Floodplain and Channel Evaluation Tool (FACET)**
  - Geomorphic and sediment erosion metrics
  - Refined riparian zone

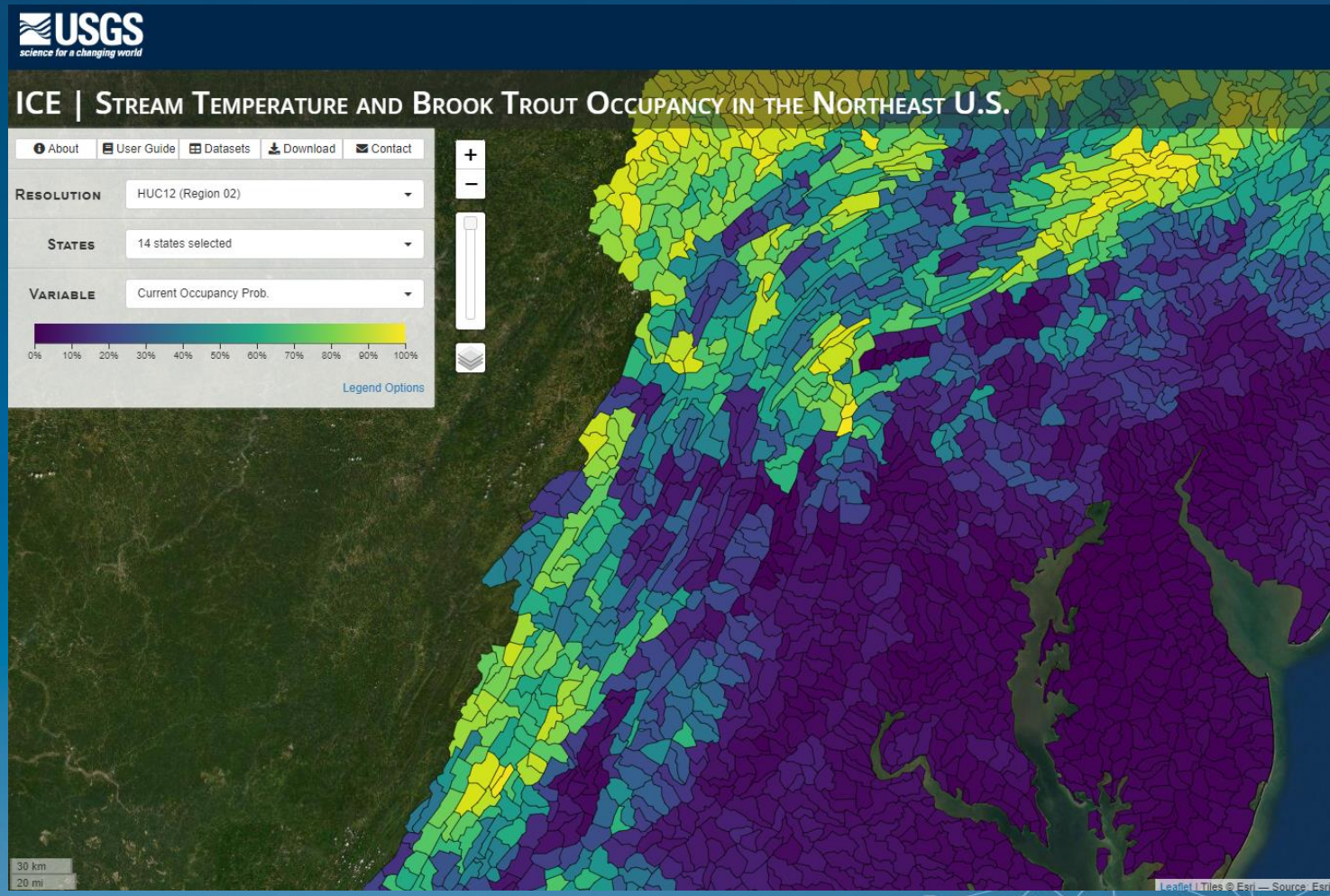


https://www.usgs.gov/software/floodplain-and-channel-evaluation-tool-facet

Noe, G.B., Hopkins, K.G., Metes, M.J., Ahmed, L., Claggett, P.R., Doody, T.R., Schenk, E.R., and Hupp, C.R., 2020, Predictions of floodplain and streambank geomorphic change and flux, streambed characteristics, and catchment inputs and exports of sediment and nutrients for stream reaches in the Chesapeake Bay and Delaware River watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P930UWYZ.

Example Data Sources

- **USGS stream temperature and brook trout occupancy**
  - Current and future temperature scenarios



https://www.usgs.gov/apps/ecosheds/ice-northeast/

Maryland Healthy Watersheds Assessment Metric Selection

- **Candidate watershed health metrics in five categories**
- **Input from partners and project advisory team**
- **Primarily regional and state data**
- **Criteria for selecting candidate metrics included**
  - relevance to characterizing watershed health and vulnerability
  - availability of data
  - consistency with other Bay Program efforts
  - appropriate spatial scale and resolution to support developing catchment-scale metrics
  - spatial coverage
  - appropriate temporal period

Metric Selection (cont.)

- **Some data not available at catchment scale, used instead as overlays providing context, for example:**
  - Source water protection areas
  - Coldwater protection areas
  - Environmental justice indicators
  - Specific locations of protected lands

Proposed New Metrics for MD HWA and Beyond

Active and Abandoned Mines
Chesapeake Conservancy, Conservation Innovation Center

Streambank Erosion, Streambank Change, and Sediment Flux
USGS Florence Bascom Geoscience Center

Forest Habitat
USGS CBP

MBSS Stronghold Watersheds
MD DNR

Maryland Biodiversity Conservation Network (BioNet)
MD Natural Heritage Program

Recent and Projected Future Land Change
USGS CBP

Flow Alteration
USGS Eastern Ecological Science Center, Leetown Research Laboratory

Conductivity
USGS South Atlantic Water Science Center

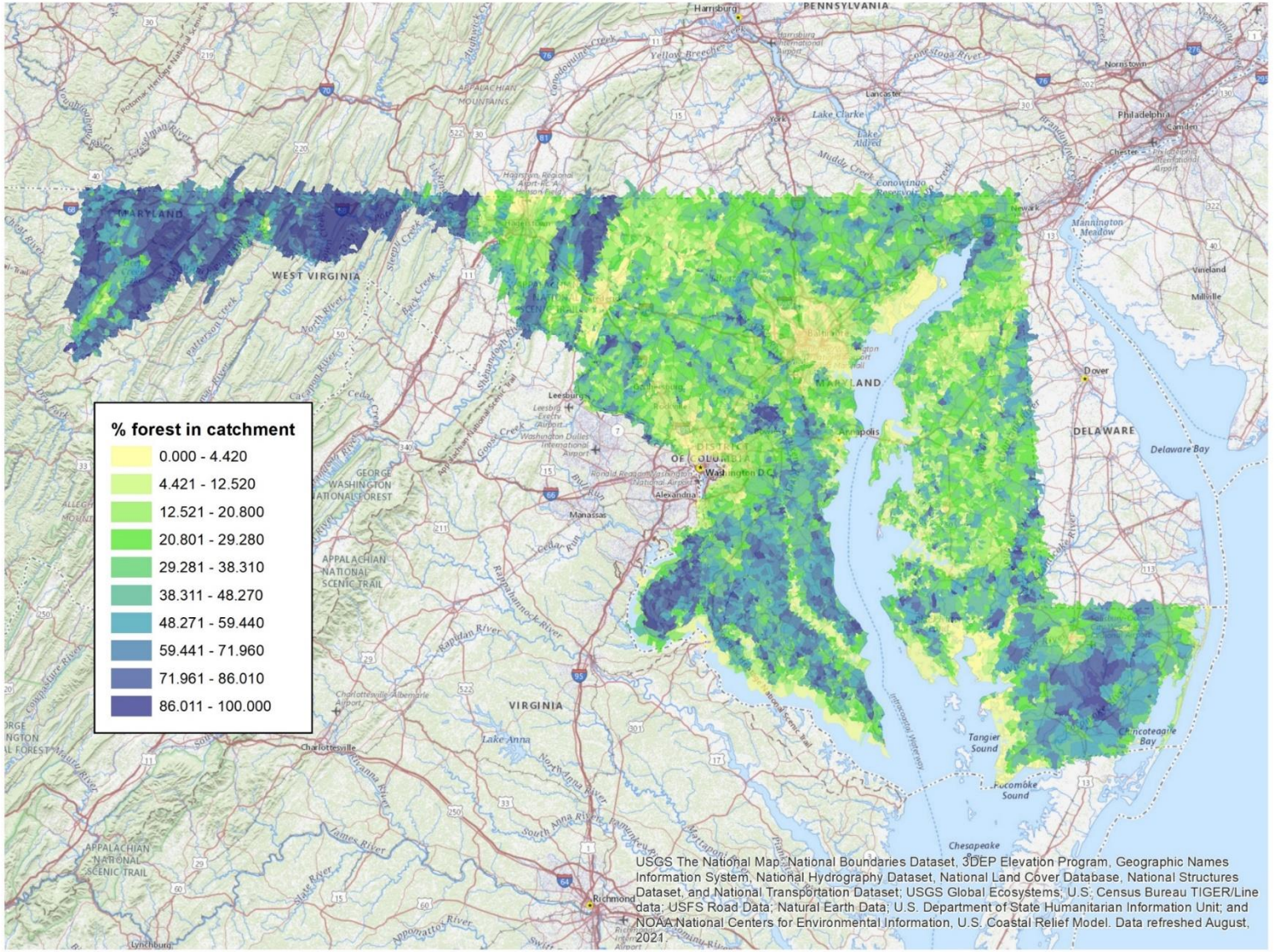
Stream Impairments
Maryland Integrated Report, MDE

USGS SPARROW sector specific loads (manure, fertilizer, urban wastewater, atmospheric, septic) for TN, TP, Sediment

Maryland Fire Priority Areas
MD DNR Forest Service

Example Watershed Health Metric

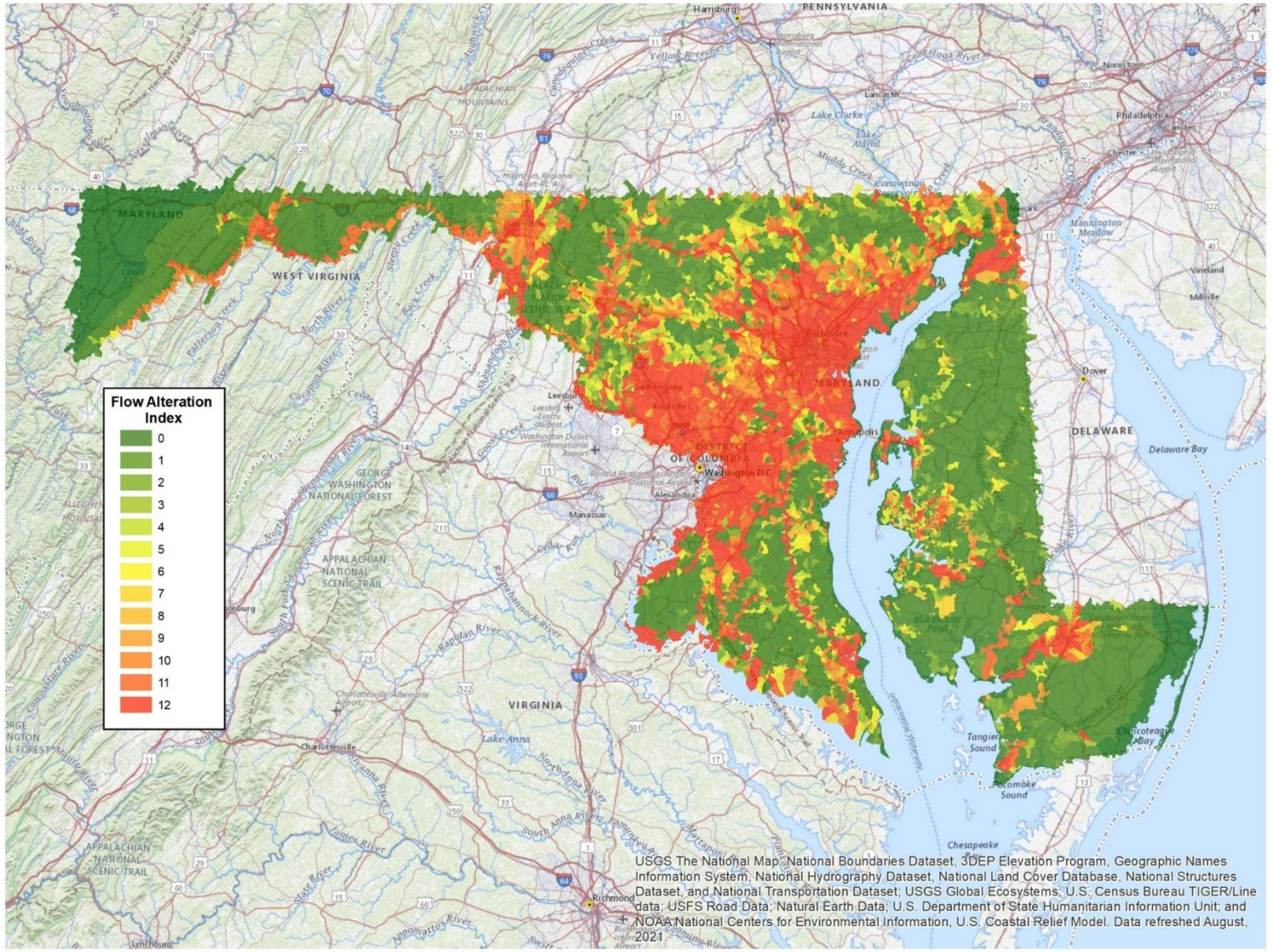
- Percent Forest



CBP 2017-2018 LULC

Example Watershed Health Metric

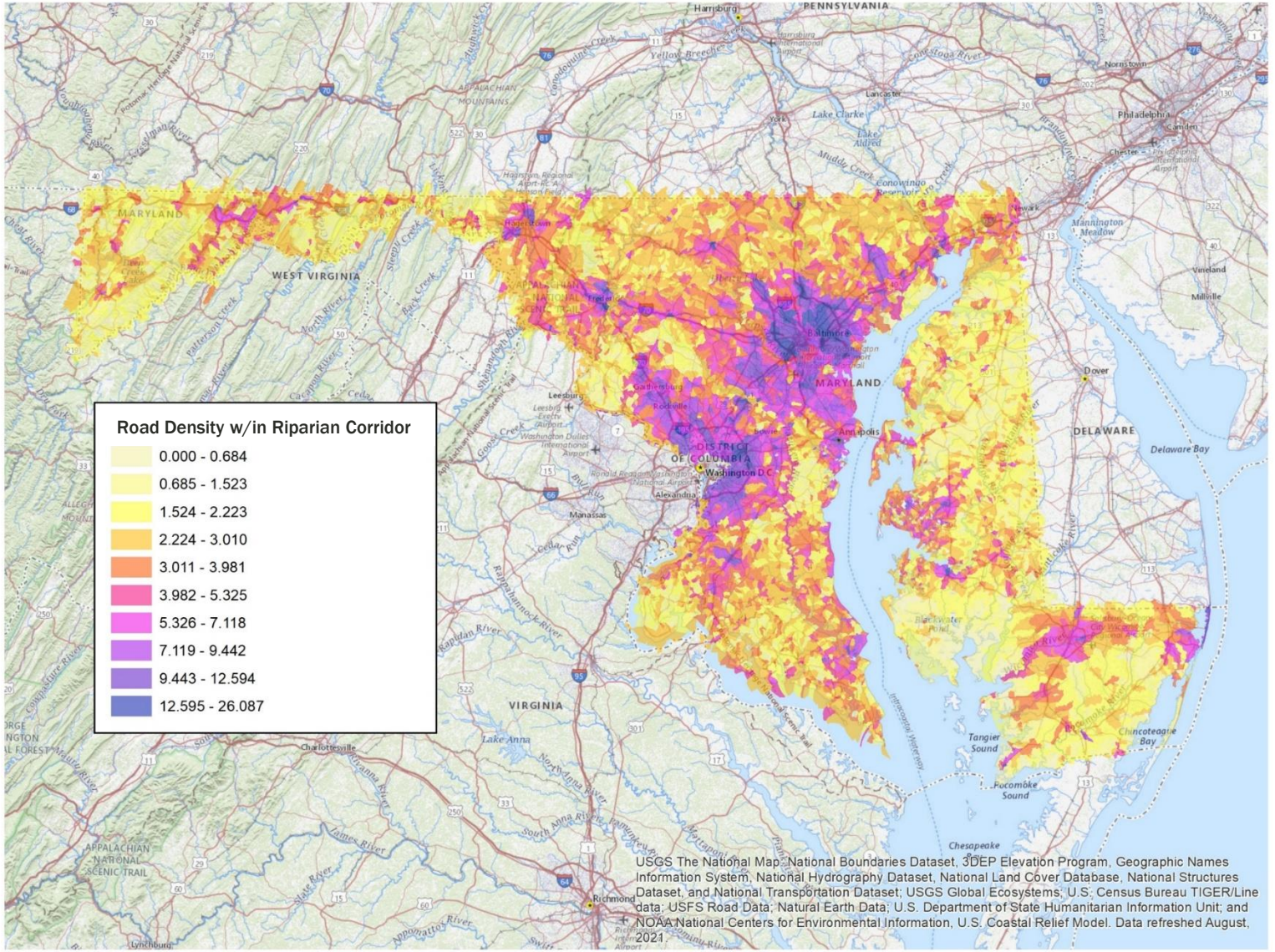
- Flow Alteration Index



Maloney, K.O., Carlisle, D.M., Buchanan, C., Rapp, J.L., Austin, S.H., Cashman, M.J., and Young, J. A. 2021. Linking Altered Flow Regimes to Biological Condition: An Example Using Benthic Macroinvertebrates in Small Streams of the Chesapeake Bay Watershed. *Environmental Management*.

Example Watershed Health Metric

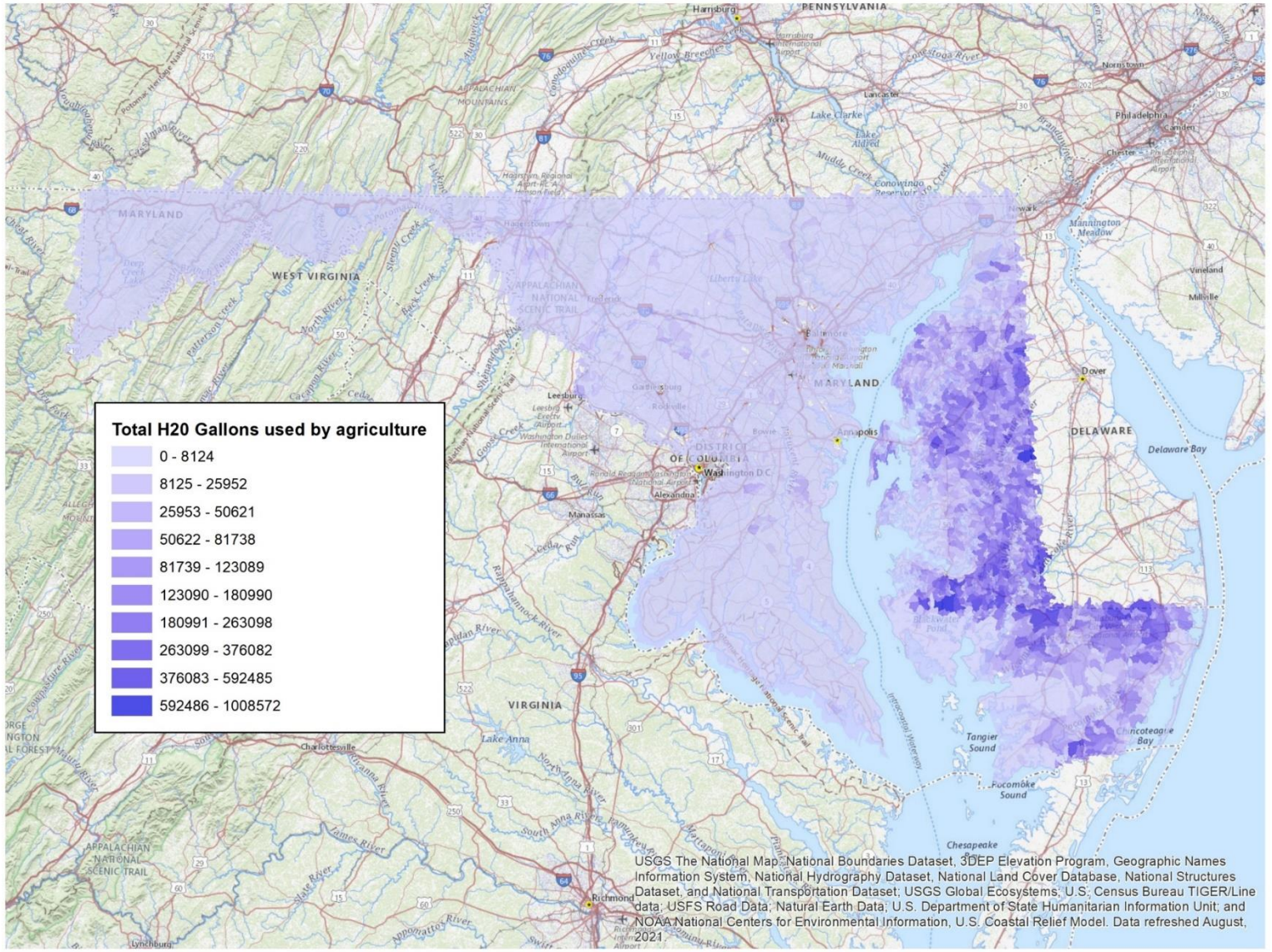
- Road Density within Riparian Corridor



EPA StreamCat

Example Watershed Vulnerability Metric

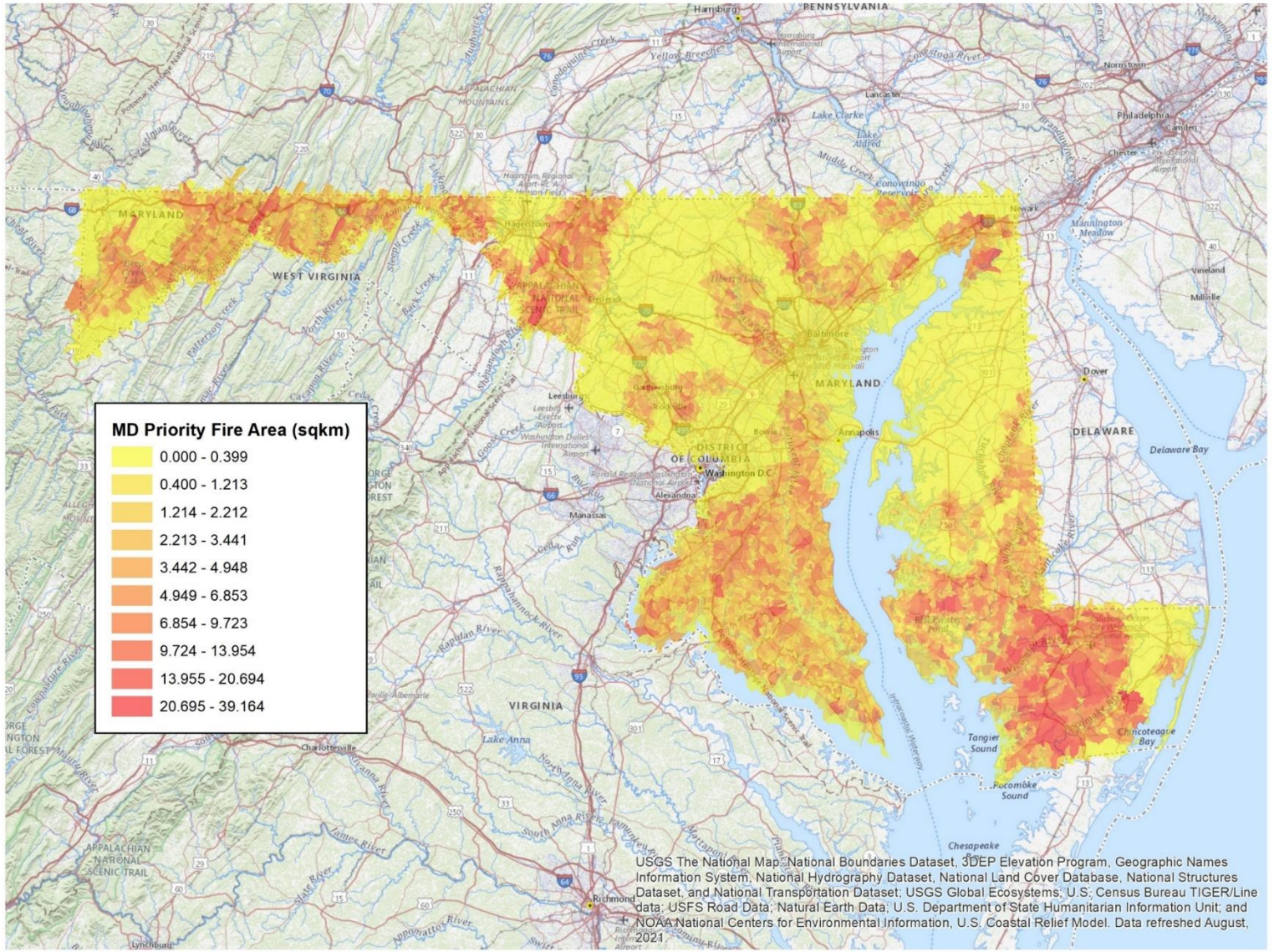
- Agricultural Water Use



EPA EnviroAtlas

Example Watershed Vulnerability Metric

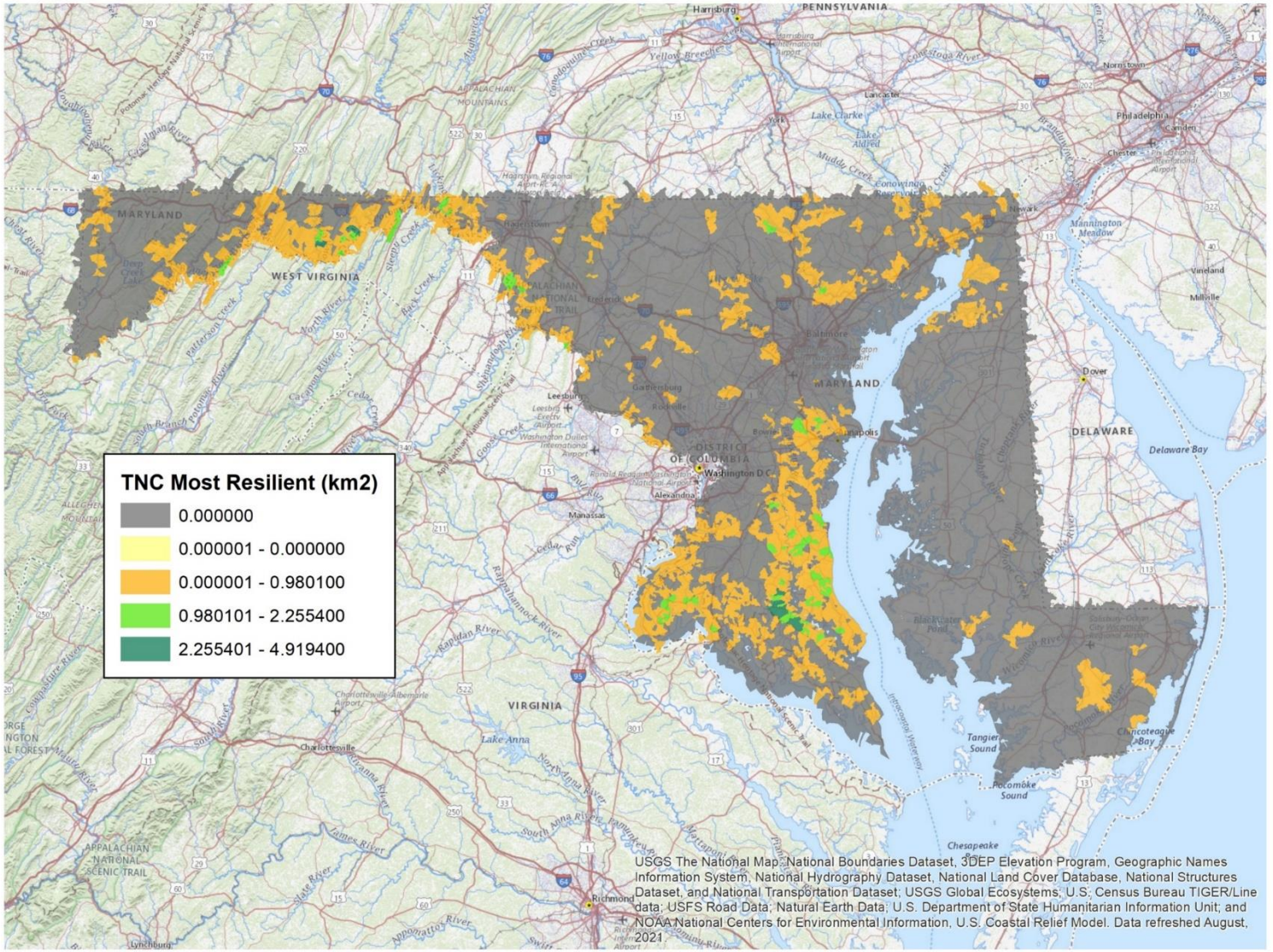
- Maryland Priority Fire Areas



Maryland Forest Service

Example Watershed Vulnerability Metric

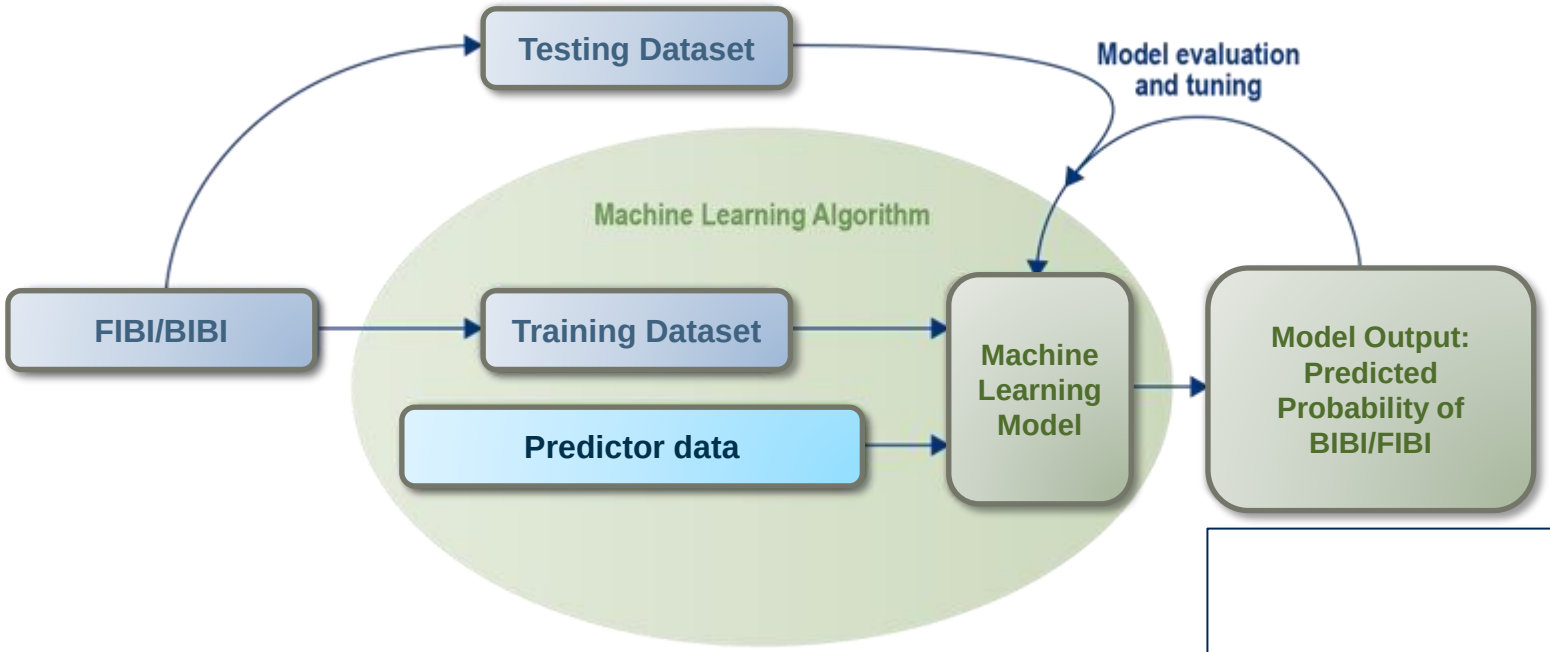
- Resilient Lands



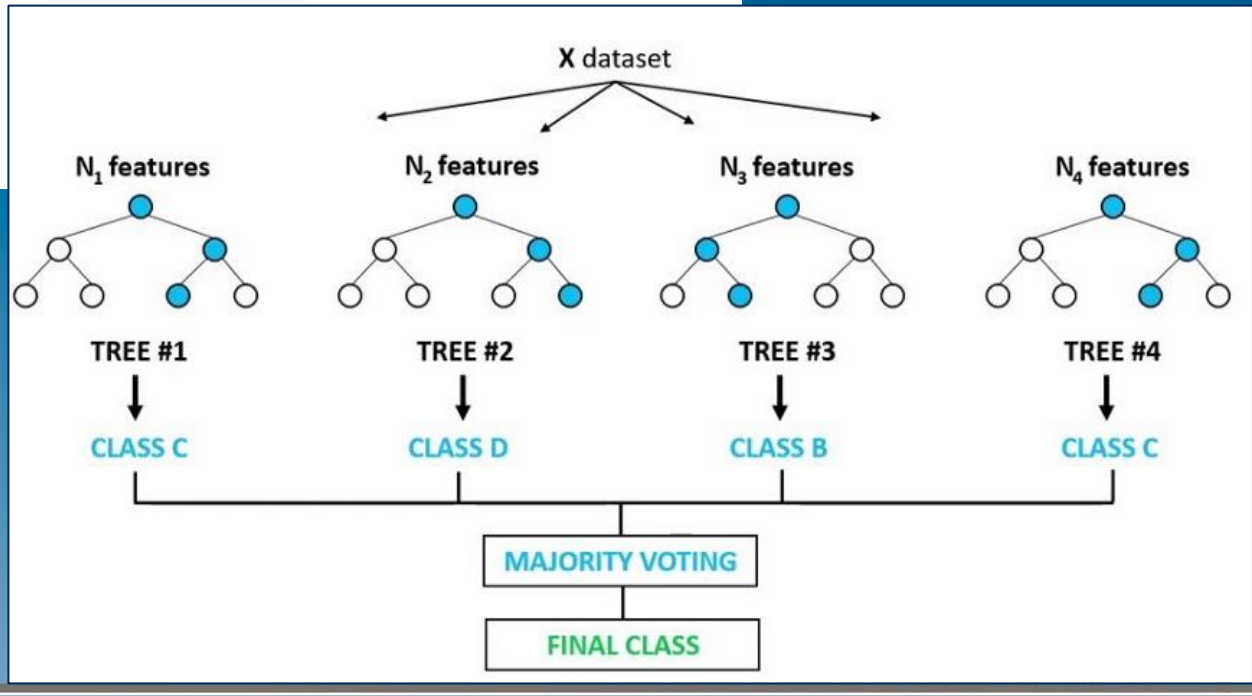
The Nature Conservancy (TNC). 2021. Terrestrial Resilience Core Concepts. https://maps.tnc.org/resilientland/coreConcepts.html

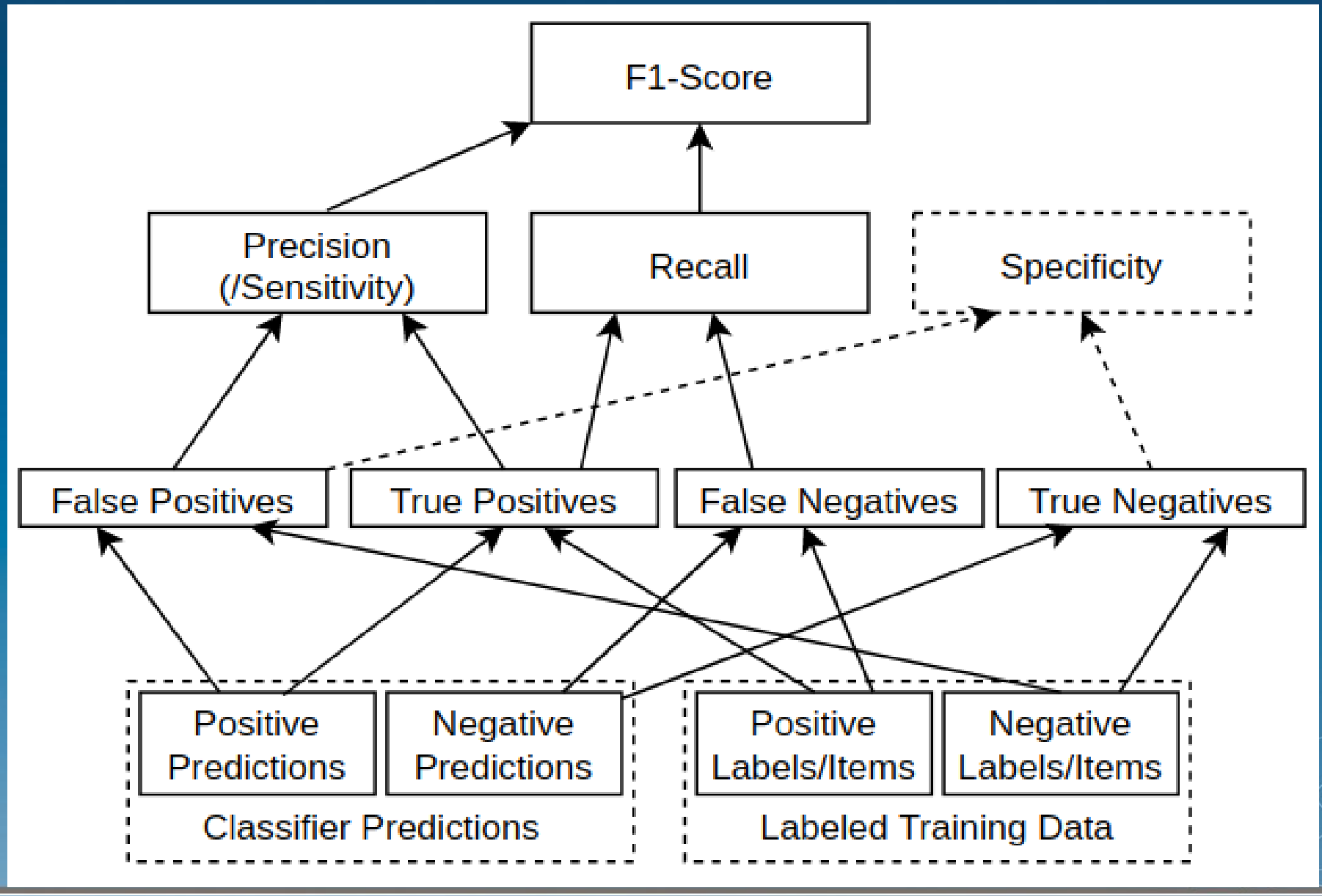
Testing Predictive Power of Metrics

- **Built Random Forest models to assess which watershed condition metrics were the best predictors of stream condition**
- **Maryland Biological Stream Survey**
  - >5,000 samples since 1990s
  - Monitoring of non-tidal stream communities – both benthic macroinvertebrate and fish Indices of Biotic Integrity (IBI)
  - IBIs as response variables



Random Forest Model




F1-Score
Precision
(/Sensitivity)
Recall
Specificity
False Positives
True Positives
False Negatives
True Negatives
Positive
Predictions
Negative
Predictions
Classifier Predictions
Positive
Labels/Items
Negative
Labels/Items
Labeled Training Data

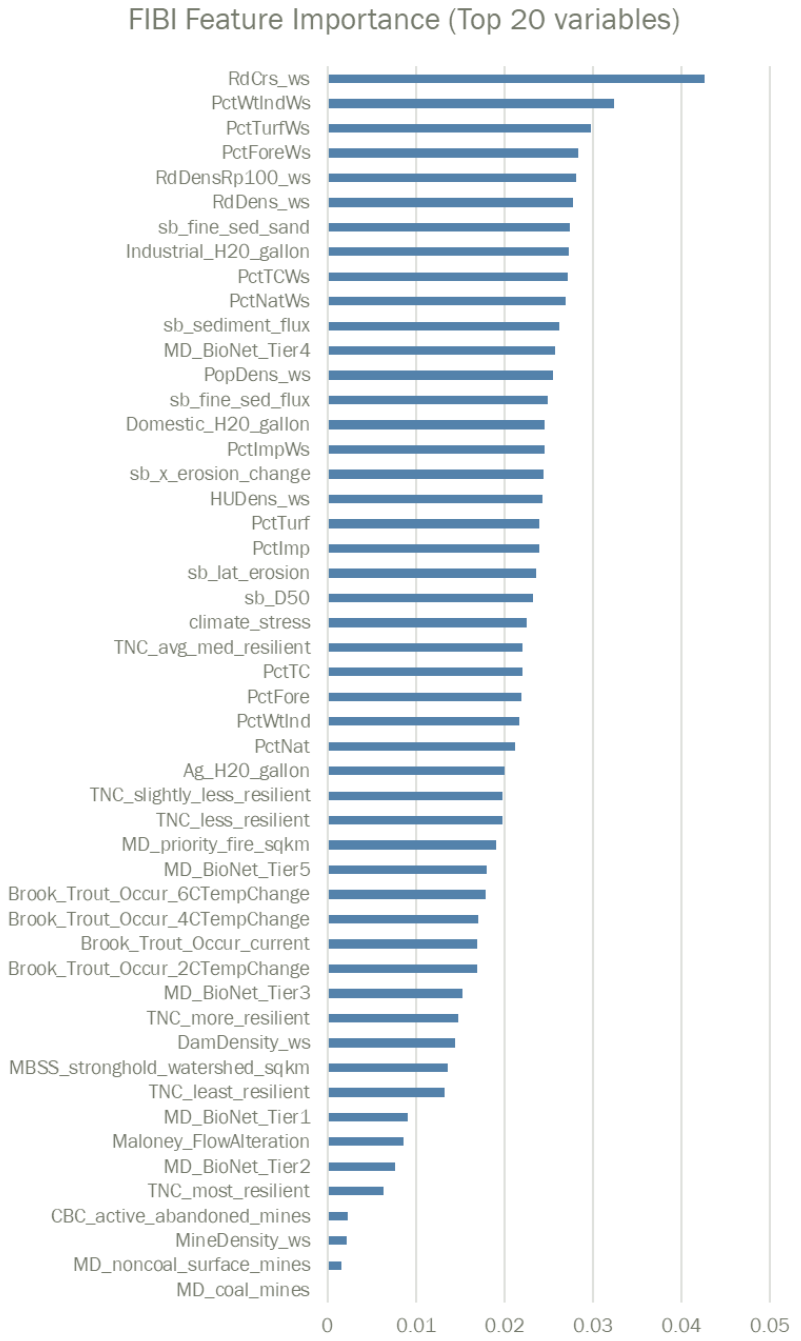
Preliminary Results

FIBI - Random Forest:
Accuracy: 0.6648199445983379

	precision	recall	f1-score	support
Poor	0.69	0.68	0.69	109
Fair	0.46	0.40	0.42	91
Good	0.74	0.81	0.77	161
accuracy			0.66	361
macro avg	0.63	0.63	0.63	361
weighted avg	0.65	0.66	0.66	361

Observed

Predicted	Poor	Fair	Good
Poor	74	22	13
Fair	23	36	32
Good	10	21	130



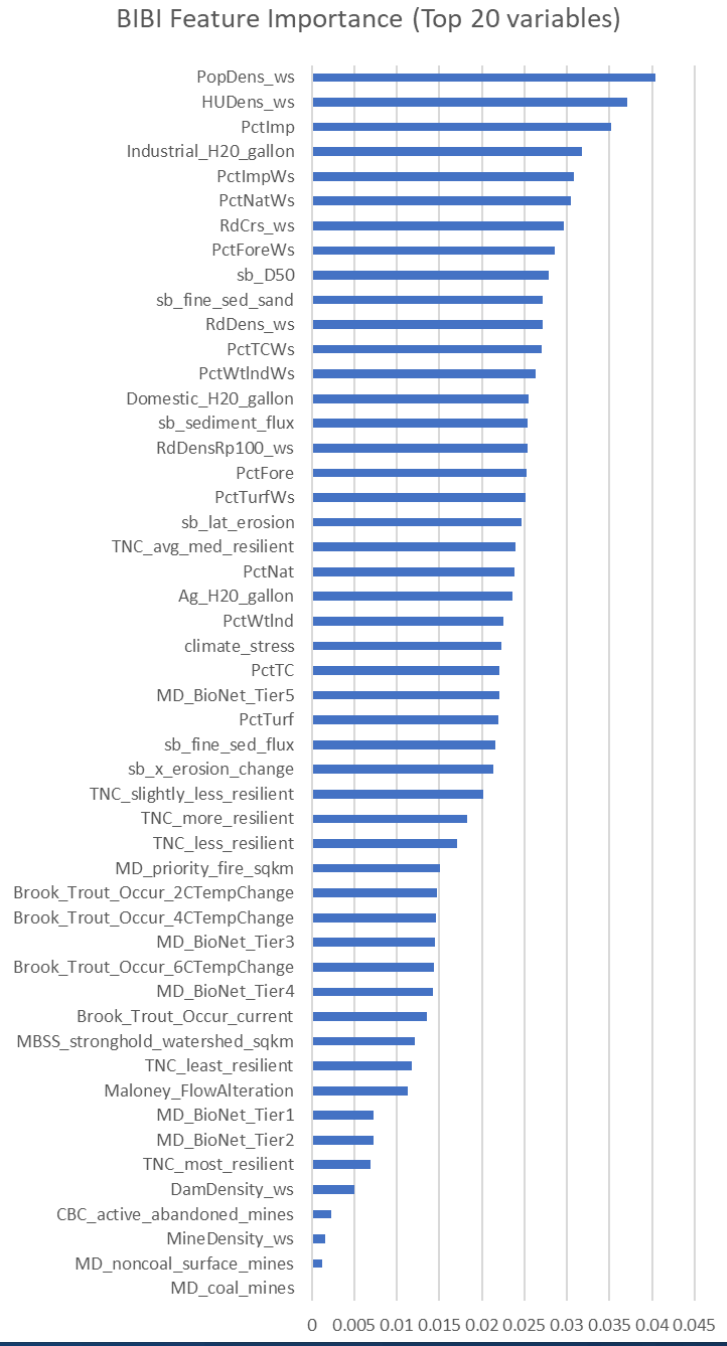
Preliminary Results

BIBI - Random Forest:
Accuracy: 0.6240694789081885

	precision	recall	f1-score	support
Poor	0.70	0.76	0.73	338
Fair	0.49	0.36	0.41	235
Good	0.61	0.69	0.65	233
accuracy			0.62	806
macro avg	0.60	0.60	0.60	806
weighted avg	0.61	0.62	0.61	806

Observed

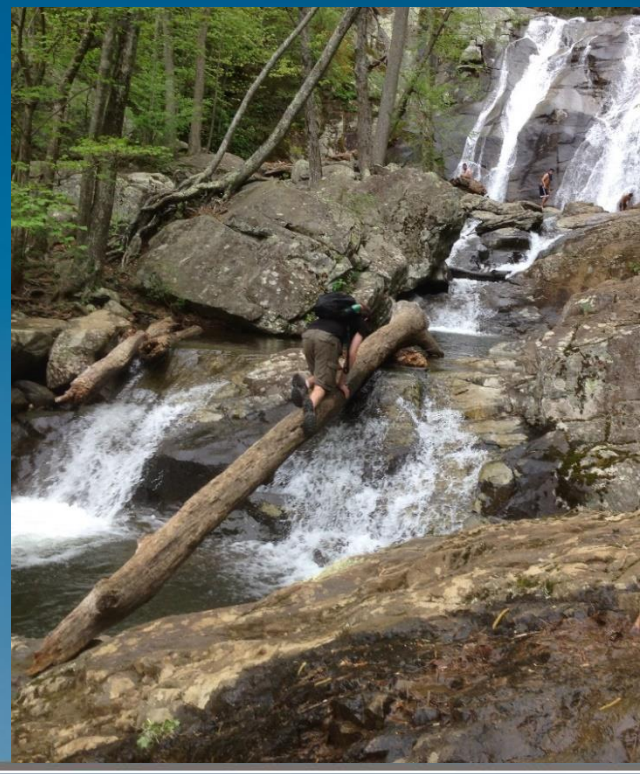
Predicted	Poor	Fair	Good
Poor	257	49	32
Fair	75	85	71
Good	31	41	161



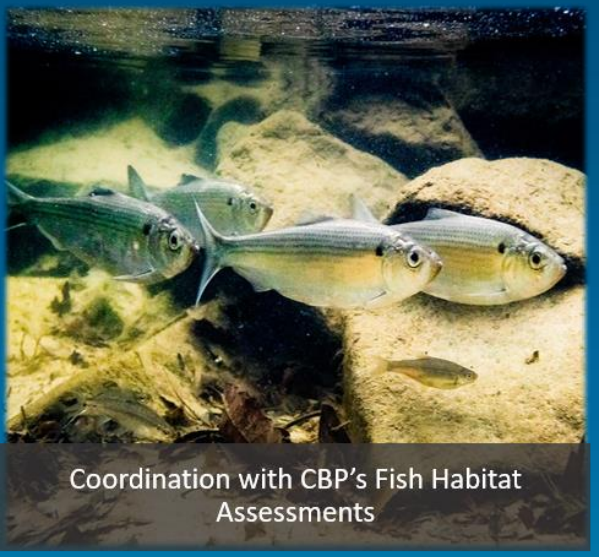
Applying the Healthy Watershed Assessments

Providing data to support management decision-making, particularly for maintaining the health of watersheds

- Assess current watershed condition
- Track condition over time
- Provide early warning signs – vulnerability to degradation
- Identify resiliency – ability to sustain good watershed health in spite of stressors



Management applications and additional stakeholders of the Chesapeake and Maryland HWAs include:

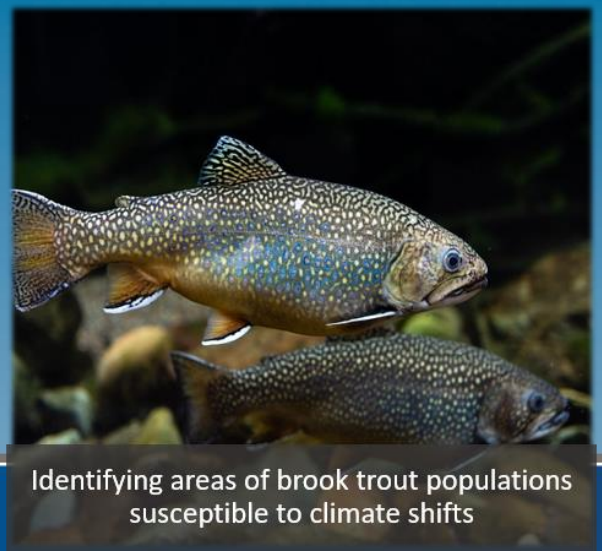


Coordination with CBP's Fish Habitat Assessments

Source water protection (drinking water)

Engagement with local governments to inform land use decisions

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



Identifying areas of brook trout populations susceptible to climate shifts

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

Supporting land trusts and other organizations managing protected lands

Co-Benefits and Collaboration

Diversity Outcome

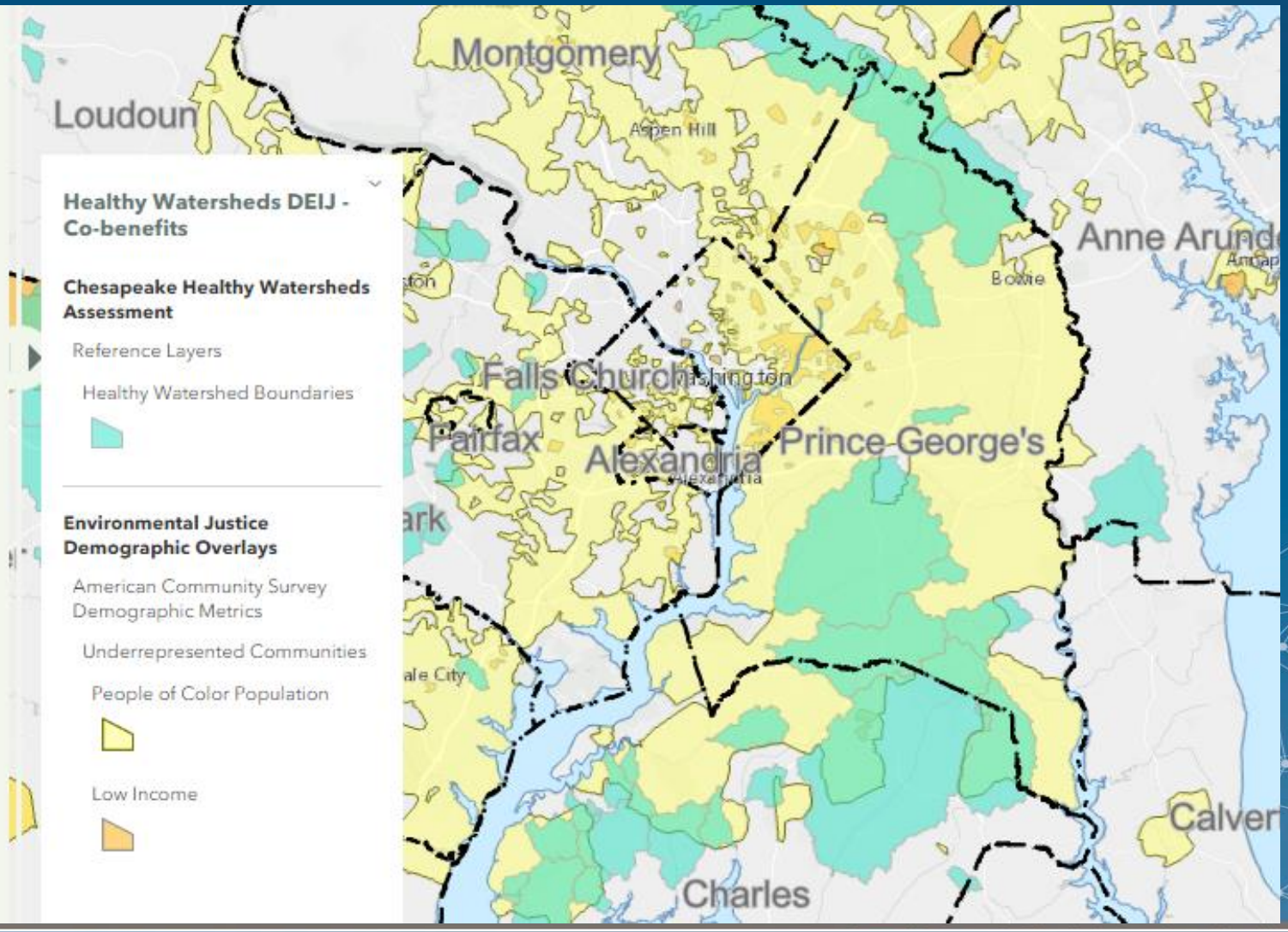
Identify stakeholder groups not currently represented in the leadership, decision-making or implementation of current conservation and restoration activities and create meaningful opportunities and programs to recruit and engage these groups in the Partnership's efforts.

Management Question

Do underrepresented communities have access to healthy watersheds?

Click symbol in lower left corner to expand map legend

Move Swipe bar to view State-Identified Healthy Watersheds



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USGS
Chesapeake Bay Program