A Summary of Identified Human and Natural Factors for the Chesapeake Bay Region

Chesapeake Watershed Regional Fish Habitat Assessment Workshop

25-26 April 2018

Richmond, Virginia

USGS

NOAA

Outline

AM Session

- Overall charge to USGS and NOAA.
- Overview of identified factors and how they differ from national assessment.
- Examples of inland relevant data sets and tools.
- Examples of estuarine relevant data sets and tools.
- Example assessments and importance of input variables and reporting of driving factors for inferences.
- High-level overview of provided summary spreadsheet.

PM Session

- Importance of scale in assessments.
- Definition of habitat classes.
- Detailed overview of summary spreadsheet.

Charge to USGS and NOAA

- Assemble information about available data sets that might be relevant for a Chesapeake Bay Fish Habitat Assessment.
- Compare the available data sets to those used in National Fish Habitat Assessment.
- Address issue of data scale and aggregation, providing example(s) of trade-offs.

Assembling Available Data

- Data collection effort started with Sustainable Fisheries GIT.
  - Provide evidence of variables that could support a Chesapeake Bay Assessment.
- USGS/NOAA team considered a broad range of variables, drawing examples from the National and Regional Assessments, existing habitat tools, and management goals.

National Assessment - Inland

Factors	Disturbance Category	Number of Variables
Human Landscape	Mines	4
	Fragmentation by Dams	2
	Water Withdrawal	5
	Human Population	1
	Road Length and Crossings	2
	Urban Land Use	3
	Agricultural Land Use	2
	Impervious Surface Cover	1
	Nutrient and Sediment Cover	3
	Point Source Pollution	3
Natural Landscape	(no categories)	5

National Assessment - Estuarine

Disturbance Category	Number of Variables
Land Use/ Land Cover	12
Alteration of Flows	11
Sources of Pollution	4
Eutrophication	1

Factors

- Our effort resulted in the assembly of numerous variables grouped into broad categories called Factors
  - 15 Factors
  - Based on topic area
  - Similar to those for National Fish Habitat Inland Assessment
  - Includes Biological Factor with fish abundance, benthic IBI, etc.
  - Land cover separated into multiple factors

Chesapeake Bay Factors

Factors	Description/ Examples
Watershed	Layers and information used to delienate watershed boundaries, salinity zones, drainage or catchment areas, stream order
Pollution	Toxic Release Inventory, nitrate deposition, NPDES major sites, pesticide applied
Dams	Number of dams, type, habitat fragmentation due to dams
Mines	Mine density and type, abandoned areas, unconventional/conventional wells, pipelines
Water_Use	Water withdrawal information
Human	Population density information
Urban	Road length/crossing density, urban areas, impervious surface cover, landfills
Ag	Percent hay/agriculture, pesticide use, confined animal feeding operation information
Natural	Elevation, slope, habitat, runoff, soil information, geology, stream density, ecoregions
Nutrient	Nitrogen and Phosphorus amounts, 303(d)
Water_Quality	Salinity, water temperature, dissolved oxygen
Climate	Precipitation, temperature, sea level rise, number of wet days
Habitat	Bathymetry, wetlands, tidal marsh vegetation
Biological	Fish abundance, stream IBI, biological condition
Miscellaneous	Shoreline Structure/erosion, dredging
Total = 15	

Inland Data and Tools

- There are many examples of data available for the inland Chesapeake Bay
  - US EPA StreamCat (national, 1:100,000)
  - USGS NAWQA (national, 1:100,000)
  - SHEDS (Northeast, 1:24,000)
  - Endocrine Disrupting Chemicals (Chesapeake Bay watershed, 1:100,000)
  - Biological data: fish, benthic Chessie-BIBI
  - etc.

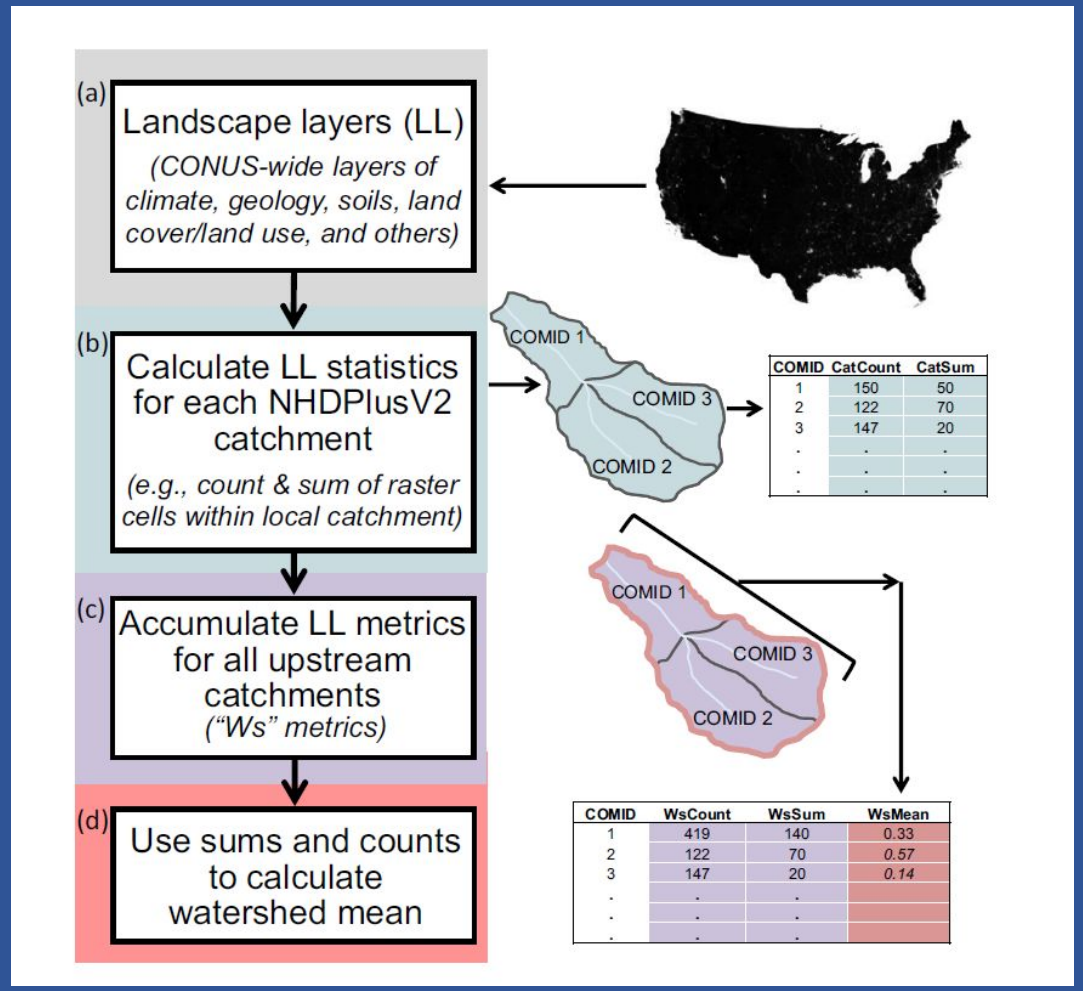
- Several existing tools have been built for habitat classification or assessments. A Chesapeake Bay Fish Habitat Assessment may be able to draw data and/or ideas from these.
  - Eastern Brook Trout Joint Venture
  - Downstream Strategies
  - TNC Northeastern Aquatic Habitat Classification System
  - etc.

Inland Data and Tools

Example of Available Data Sets: U.S. EPA's StreamCat

Data Details:

- Source: EPA's Office of Research and Development (ORD)
- Extent: National
- Period of record: varied
- Spatial Scale: Catchments; 1:100,000 NHDplusV2
- Extensive collection of 242 natural and human-related landscape variables for 2.6 million streams and associated catchments within the conterminous U.S.
- Data are being utilized to develop national maps of aquatic condition and watershed integrity



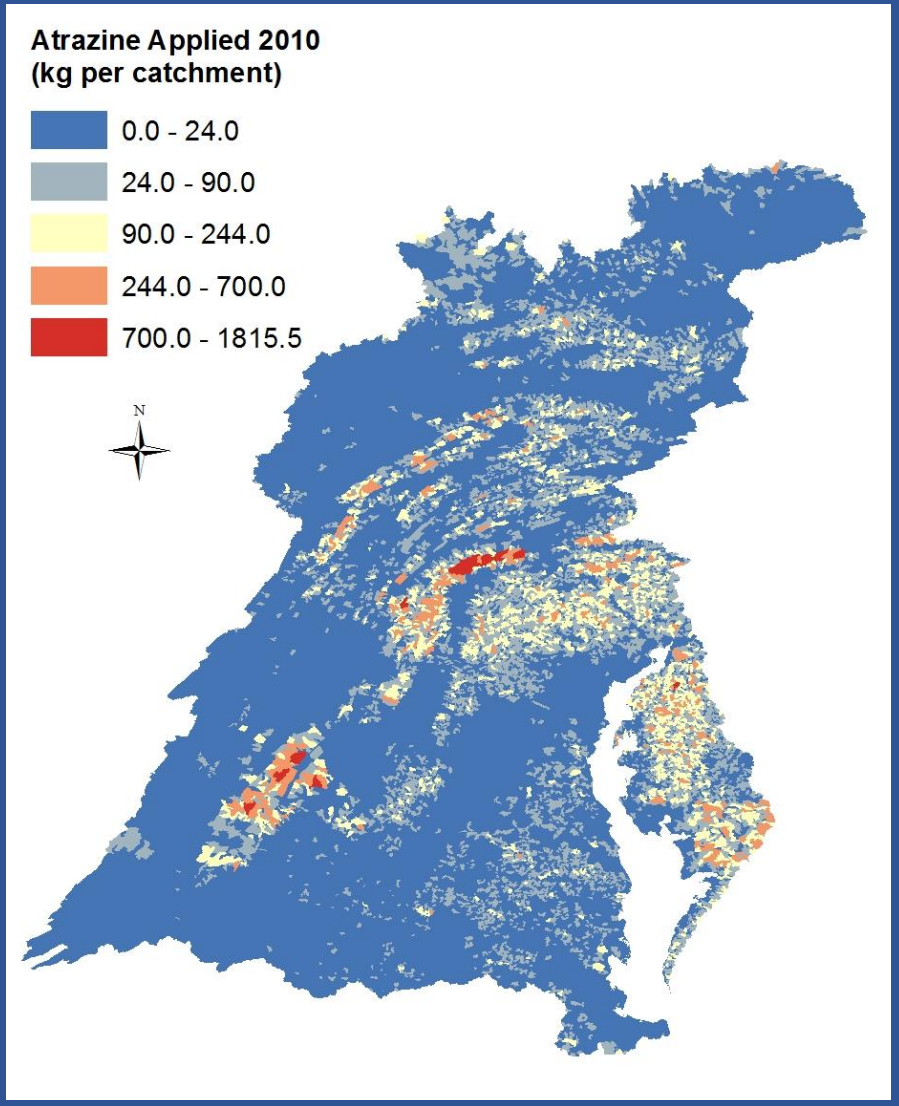
Hill, Ryan A., Marc H. Weber, Scott G. Leibowitz, Anthony R. Olsen, and Darren J. Thornbrugh, 2016. The Stream-Catchment (StreamCat) Dataset: A Database of Watershed Metrics for the Conterminous United States. Journal of the American Water Resources Association (JAWRA) 52:120-128. DOI: 10.1111/1752-1688.12372.

Inland Data and Tools

Example of Available Data Sets: USGS Potential Contaminant Sources and other Landscape Variables (Endocrine Disrupting Chemicals)

Data Details:

- Source: U.S. Geological Survey
- Extent: Chesapeake Bay Watershed
- Period of record: varied
- Spatial Scale: Catchments; 1:100,000 NHDplusV2.1
- Consists of 262 variables that describe various known and suspected point and non-point sources of contaminants and endocrine disrupting compounds (EDCs).
- Data are being used to investigate source-sink linkages between contaminant sources, water quality issues, and impacted receptor populations (e.g., smallmouth bass) throughout the Bay Watershed.



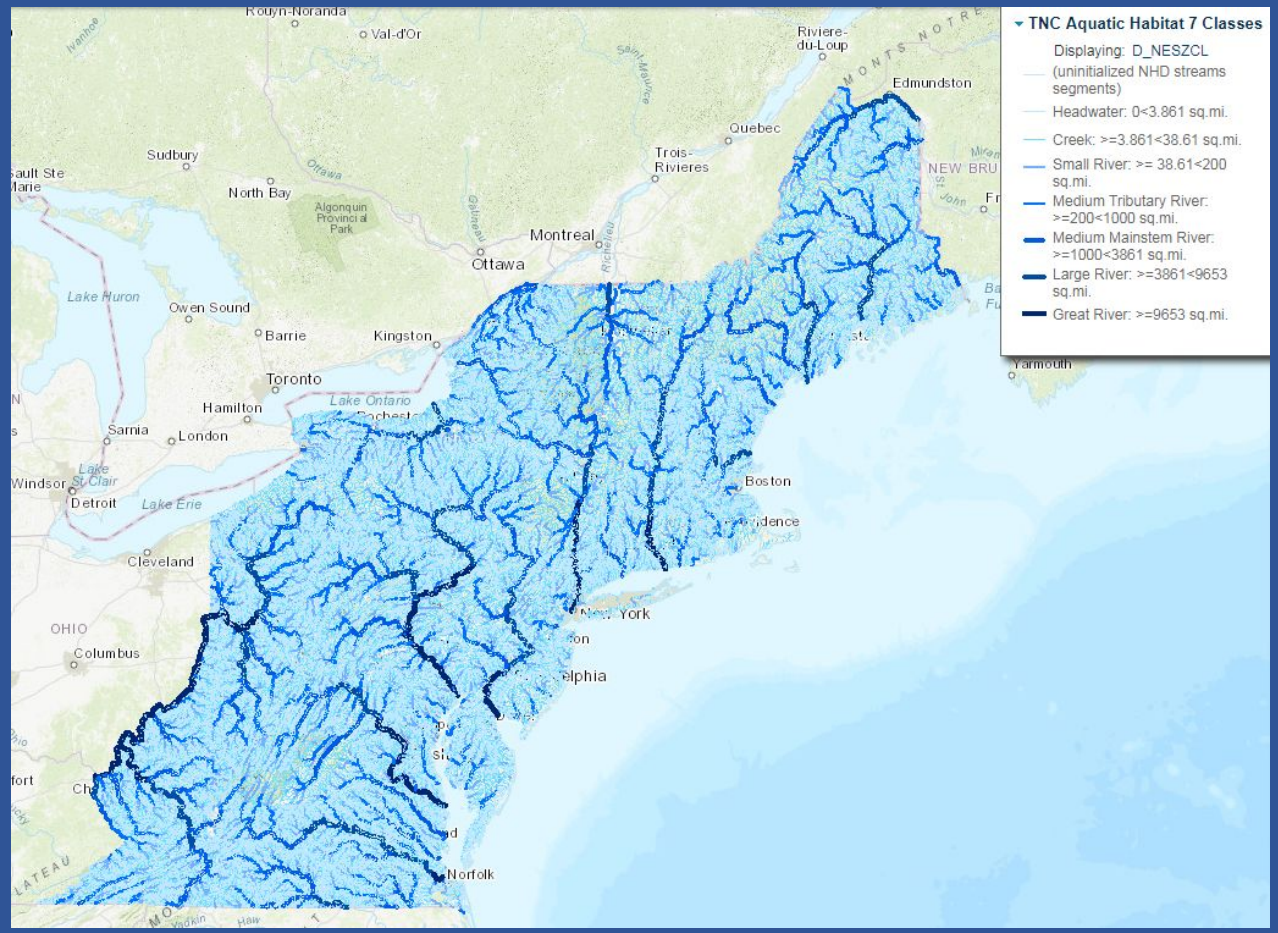
Gordon, S.E., Jones, D.K., Williams, B.M., and Wright, Christopher, 2017, Potential contaminant sources and other landscape variables summarized for NHDPlus Version 2.1 catchments within the Chesapeake Bay Watershed: U.S. Geological Survey data release, https://doi.org/10.5066/F7SQ8ZB3.

Inland Data and Tools

Example of Available Data Sets: TNC Aquatic Habitat 7 Classes

Data Details:

- Source: USGS, USEPA, NALCC, TNC
- Extent: ME, NH, VT, MA, CT, RI, NY, NJ, PA, MD, DC, DE, VA, WV
- Period of record: varied
- Spatial Scale: Catchments; 1:100,000 NHDplus
- Uses 4 primary variables to define aquatic habitat types in northeast streams and rivers - stream size, gradient, geologic buffering capacity, and natural stream temperature regime.



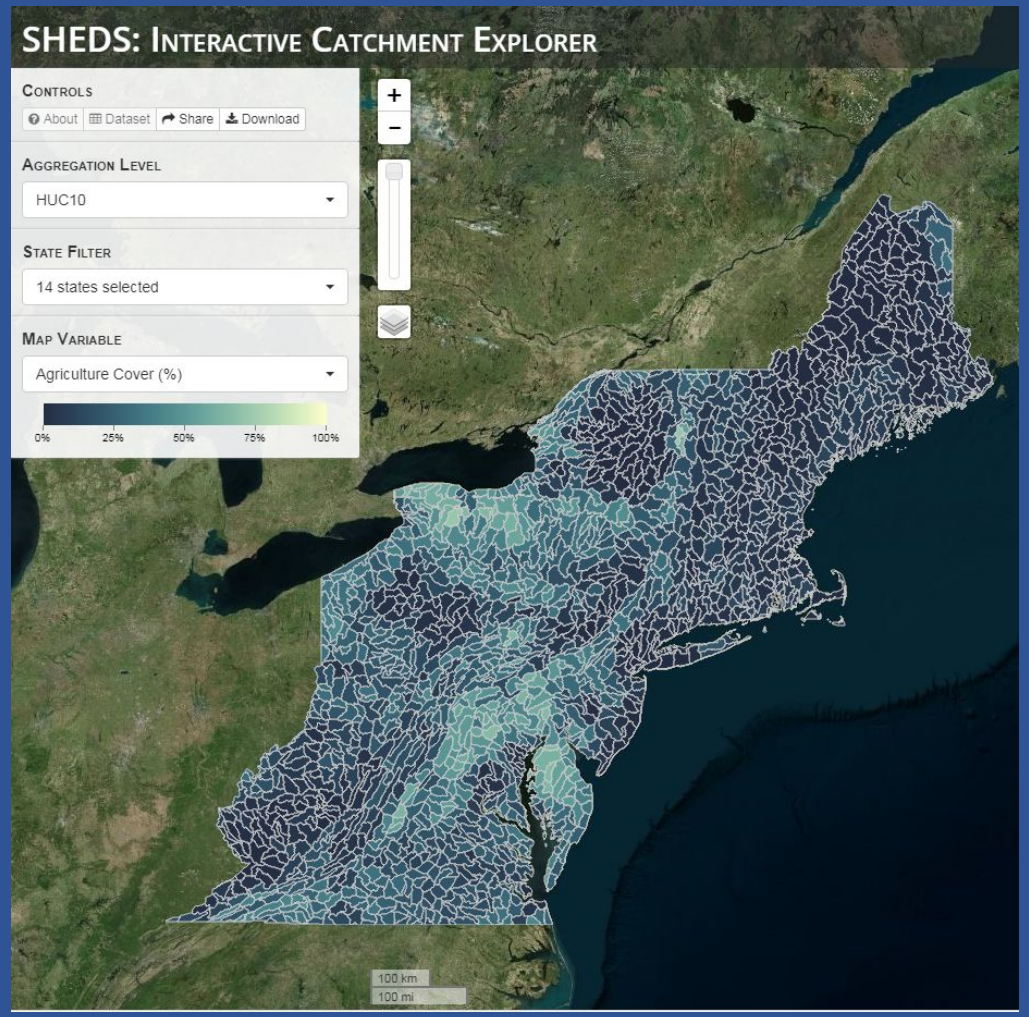
U.S. Geological Survey(Cooperator/Partner), U.S. Environmental Protection Agency (USEPA)(Cooperator/Partner), Arlene P. Olivero(Originator), North Atlantic Landscape Conservation Cooperative(administrator), 2013-09-09(creation), 2017-08-22(lastUpdate), 2008-01-01(Publication), TNC Aquatic Habitat 7 Classes

Inland Data and Tools

Example of Available Data Sets: Spatial Hydro-Ecological Decision System (SHEDS)

Data Details:

- Source: Northeast Climate Science Center, NALCC, USGS, USDOI, EBTJV, massDOT, Columbia Habitat Monitoring Program
- Extent: Northeastern United States
- Period of record: varied
- Spatial Scale: 1:24,000 NHD High Resolution V2
- Uses NHD High Resolution V2 to identify catchments and uses information such as basin characteristics, climate records, and tidal influence for modeling and visualization
- Links datasets and models in order to aid in decision making for hydro-ecological resources



Northeast Climate Science Center (Cooperator/Partner), North Atlantic Landscape Conservation Cooperative (Cooperator/Partner), U.S. Geological Survey (Cooperator/Partner), U.S. Department of Interior (Cooperator/Partner), Eastern Brook Trout Joint Venture (Cooperator/Partner), Massachusetts Department of Transportation (Cooperator/Partner), Columbia Habitat Monitoring Program (Cooperator/Partner), SHEDS Development Team (Originator), Spatial Hydro-Ecological Decision System (SHEDS), http://ecosheds.org/ accessed 4/11/18

Estuarine Data and Tools

- There are many examples of data available in tidal Chesapeake Bay not available nationally
  - Chesapeake Bay water quality data - already used by Maryland to assess current and 'restored' habitat for specific species
  - Chesapeake Commons $1m^2$ land cover data
  - VIMS shoreline structure data
  - Benthic structure (sediment type and shellfish beds)
  - Biological data: fish abundance, benthic IBI, phytoplankton IBI
  - etc.

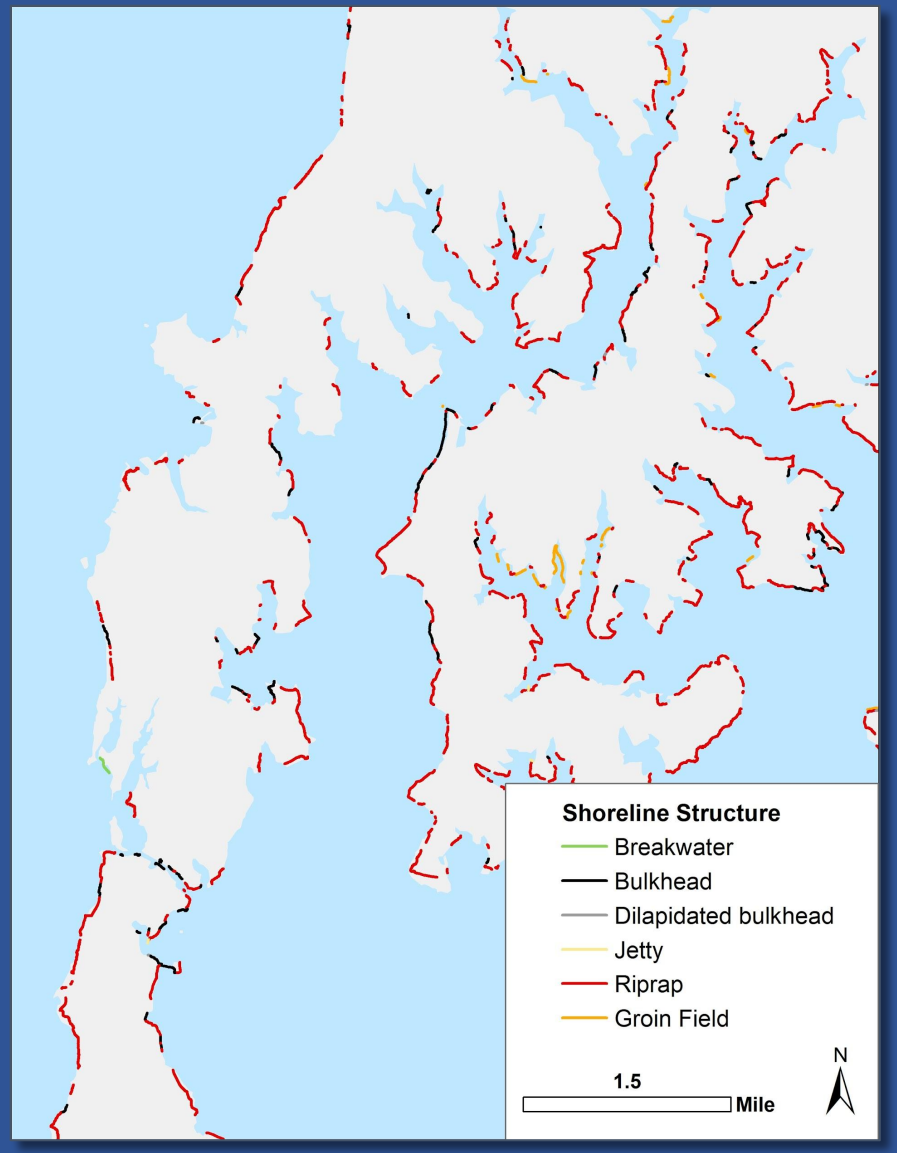
- Several existing tools have been built for habitat assessments. A Chesapeake Bay Fish Habitat Assessment may be able to draw data and/or ideas from these.
  - TNC Chesapeake Bay Habitat Tool
  - Blue Infrastructure
  - etc.

Estuarine Data and Tools

Example of Available Data Sets: Shoreline Structure

Data Details:

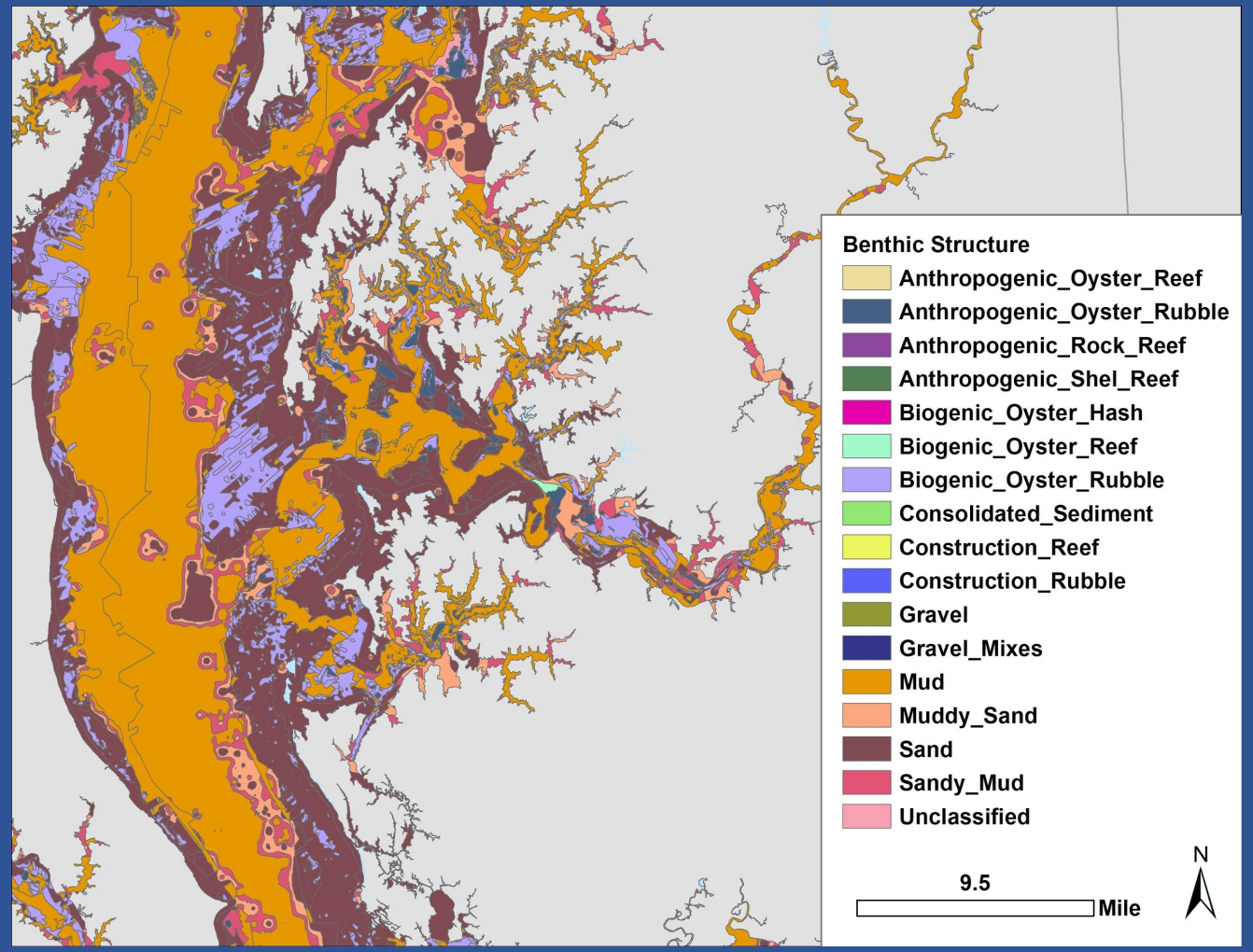
- Source: Virginia Institute of Marine Science
- Extent: Baywide
- Period of record: 2005-2015
- Spatial Scale: Lines
- Mentioned by National Assessment as important variable not available nationally
- Included in CBP Fish Habitat Outcome - Management Strategy, TetraTech Stressors, existing habitat tools



Estuarine Data and Tools

Example of Available Data Sets: Benthic Structure

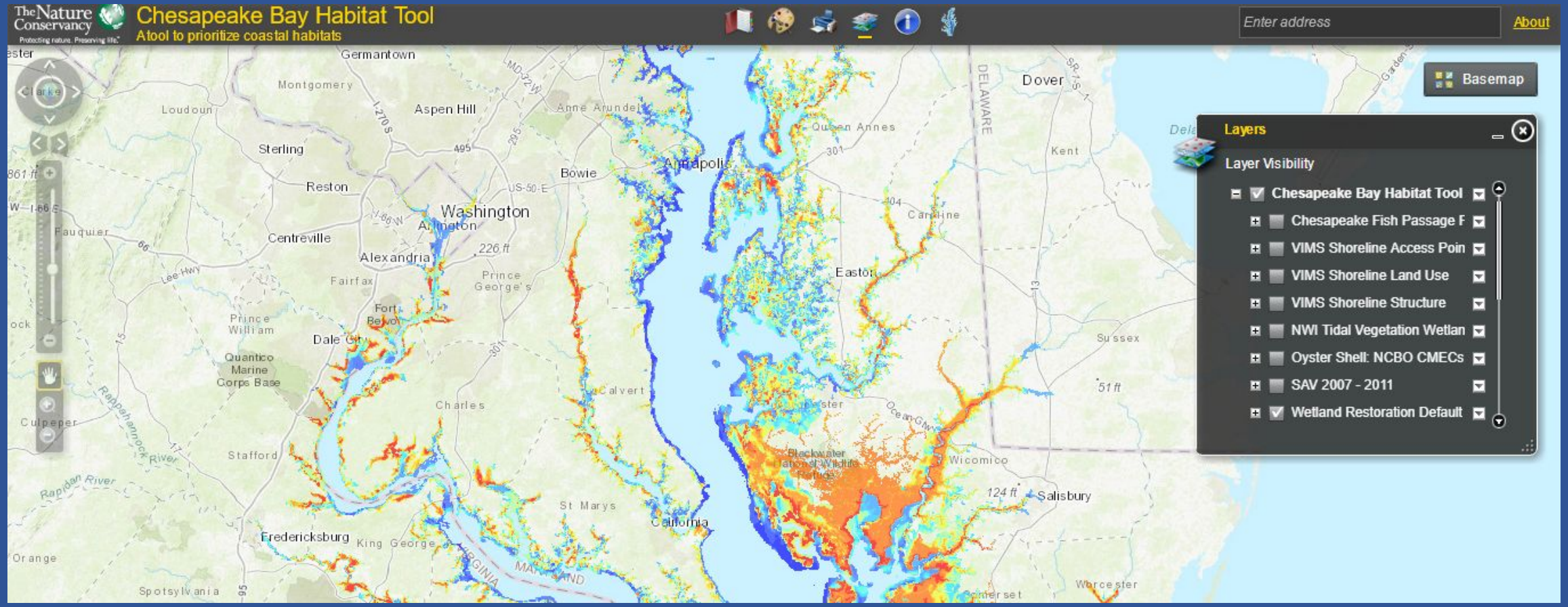
- Source: NOAA/Chesapeake Bay Office
- Extent: Baywide
- Period of record: 1842-2015
- Spatial Scale: 1:5,000
- Included in CBP Fish Habitat Outcome - Management Strategy, existing Chesapeake Bay spatial tools



Estuarine Data and Tools

Example of Existing Tool: TNC Chesapeake Bay Habitat Tool

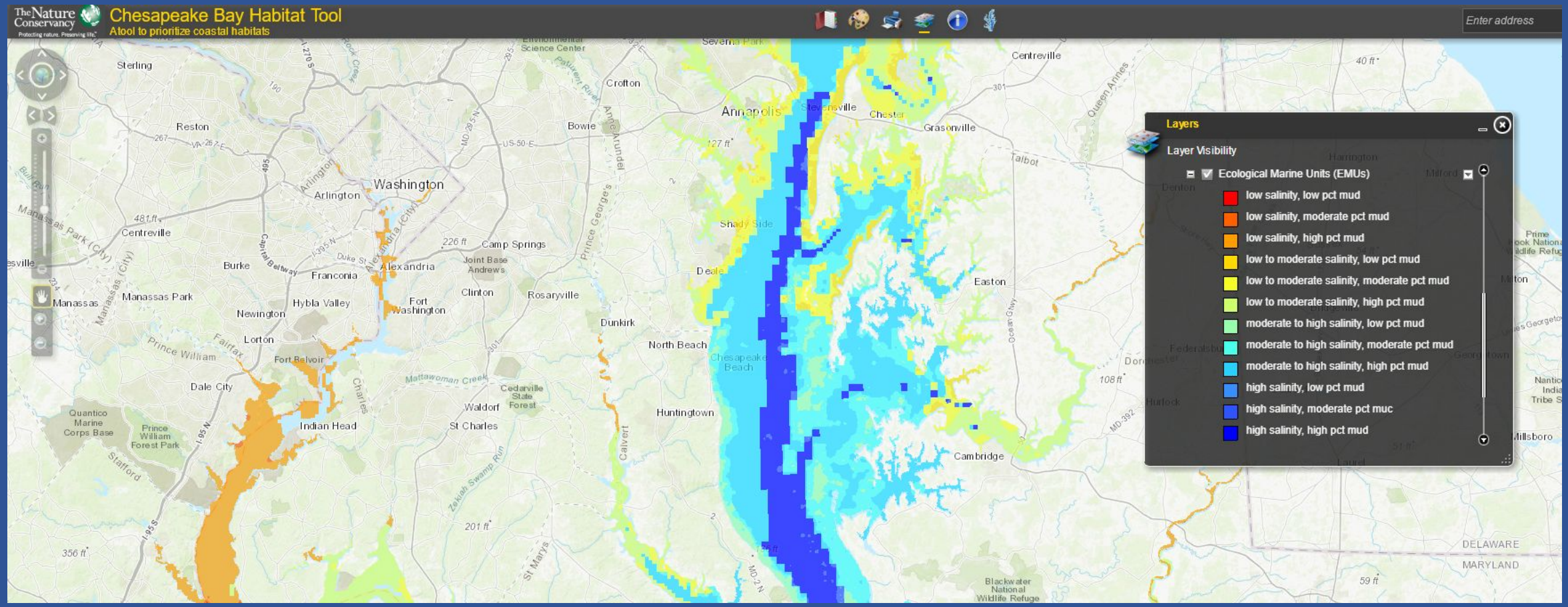
- Purpose: “Provide spatial context for multi-habitat conservation opportunities in the Bay”
- Includes: 18 Factors, including watershed boundaries, water quality, benthic habitat characterization, land cover, fish passage blockages, and shoreline characteristics



Estuarine Data and Tools

Working Example: TNC Chesapeake Bay Habitat Tool

- Includes aggregate variables such as Ecological Marine Units - composed of salinity and benthic sediments
- National Estuarine Assessment included aggregate variable ‘Overall Eutrophic Condition’
- Aggregation might be considered for variables in a Chesapeake Bay Assessment

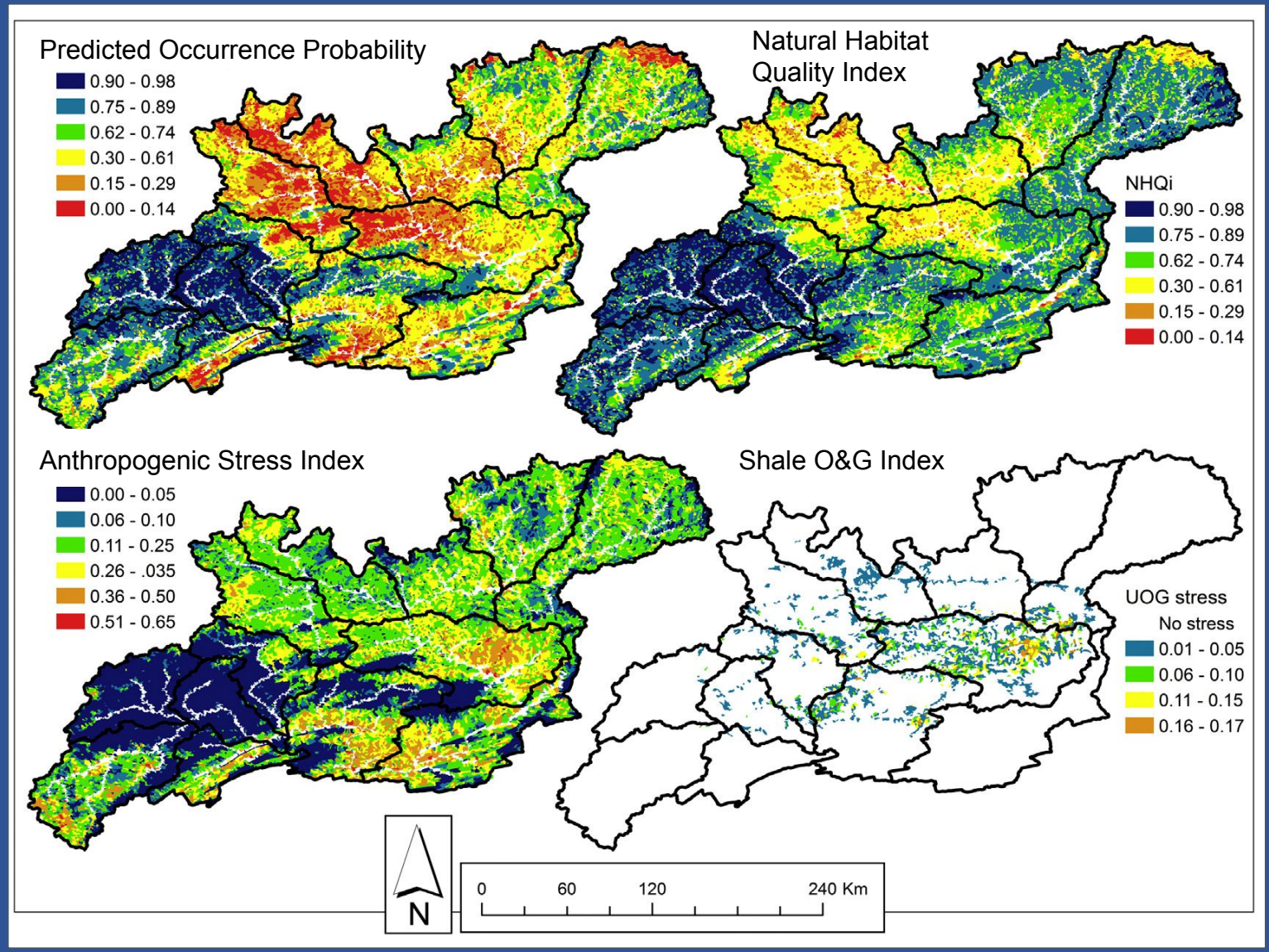


Influence of Data Choices

Example: Assessment of Shale Oil and Gas (O&G) in the Upper Susquehanna River Basin on Brook Trout Occupancy

Data Details:

- Source: Merriam et al. 2018, PADEP, SHEDS
- Extent: NY, PA
- Period of record: Shale oil and gas well pads through 2013
- Spatial Scale: Catchments; 1:24,000
- Including shale O&G the model predicted a shift in occupancy in 126 streams (4 of which where designated PA Class A streams)

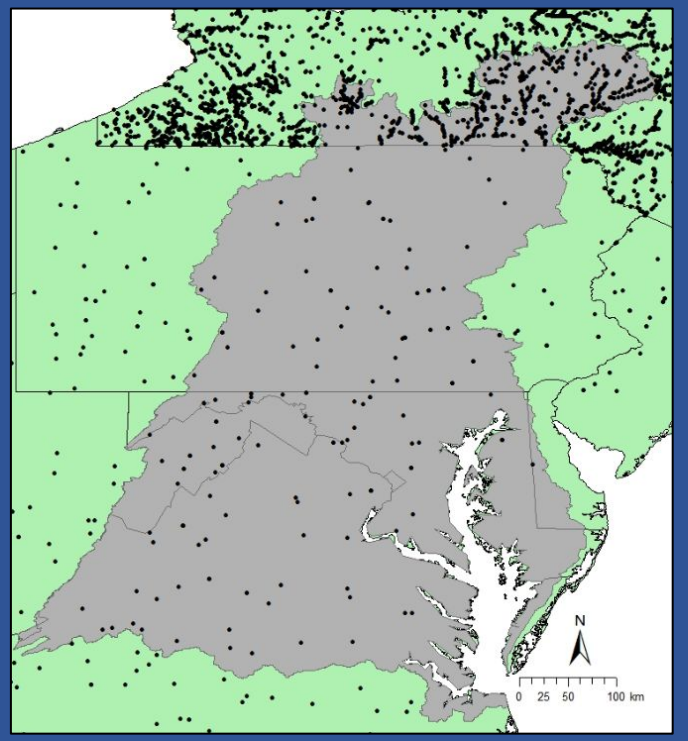


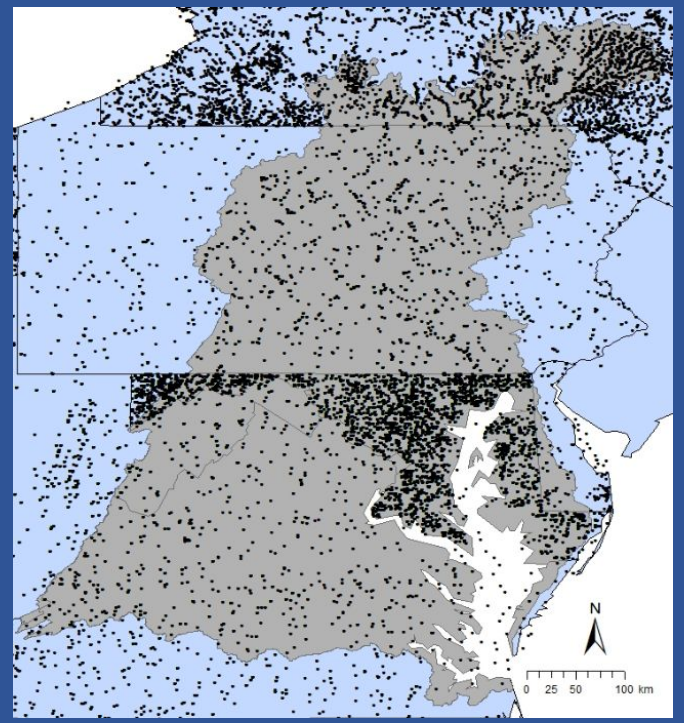
Merriam, E. R., J. T. Petty, K. O. Maloney, J. A. Young, S. P. Faulkner, E. T. Slonecker, L. E. Milheim, A. Hailegiorgis, and J. Niles. 2018. Brook trout distributional response to unconventional oil and gas development: Landscape context matters. Science of The Total Environment 628-629:338-349.

Fish Data

Available Raw Data			
Source	**Extent**	**Year**	**Number of Sites**
VADEQ	VA	1993-2017	791
MDDNR	MD	1995-2014	3,437
NYDEC	NY	1982-2011	9,493
WVDEP	WV	2006-2014	305
PADEP	PA	2008-2015	173
SRBC	PA, NY	2008-2015	414
USGS BIODATA	Watershed	1993-2017	133
EPA EMAP	Watershed	1993-1996	274
EPA EMAP	Watershed	1997-1998	297
EPA NRSA	Watershed	2008-2009	222

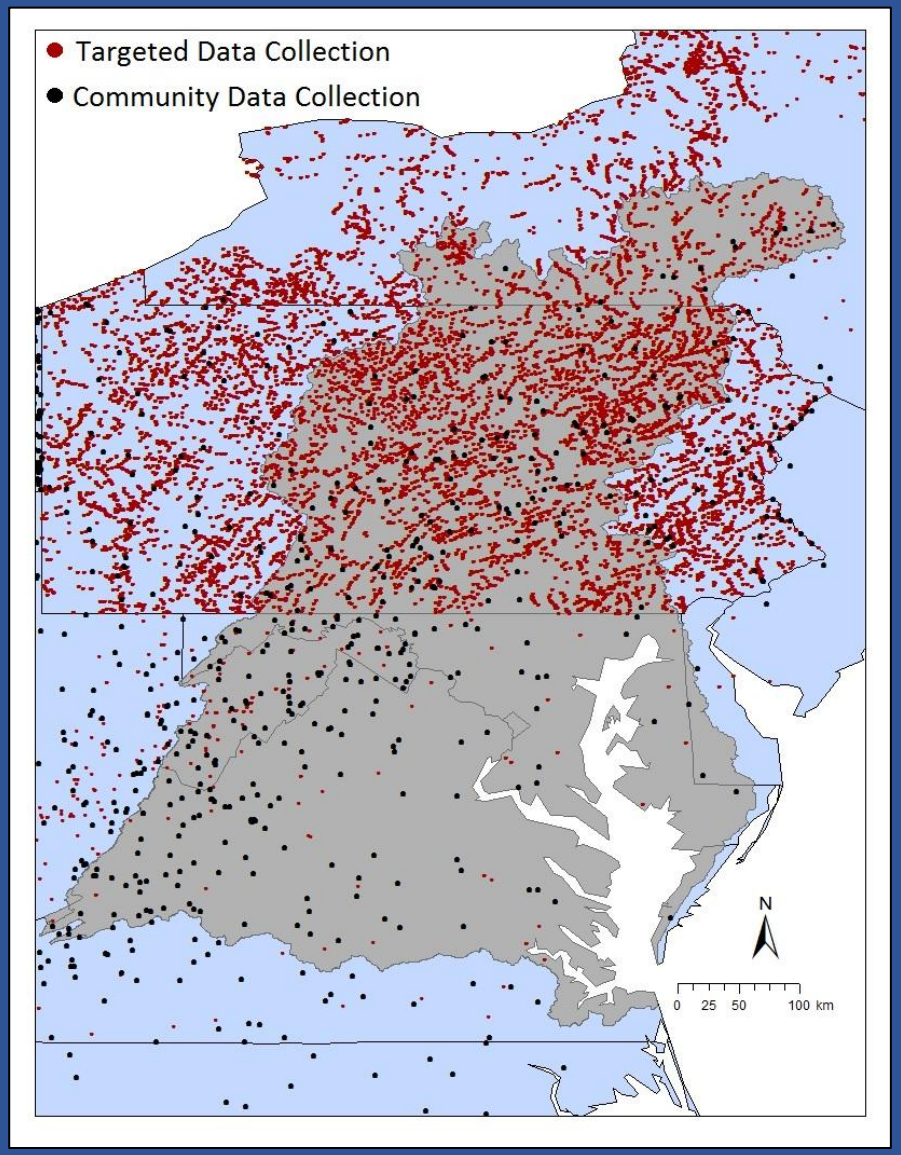
NFHP Data by State		
State	**Year**	**Number of Sites**
DE	1998	1
VA	1993-2008	128
MD	1993-1998	31
NY	1991-2008	7,315
WV	1993-2008	109
PA	1993-2008	175





Fish Data

Summarized Data Sources					
Source	**Extent**	**Year**	**Number of Sites**	**Datasets Summarized**	**Dataset also used for 2015 NFHP?**
Water Quality Portal	Watershed	1977-2017	1,255	BIODATA, NAWQA, USEPA	Yes
MARIS	MD, VA, WV, PA, NY	1974-2013	20,517	MDDNR, VADEQ, WVDEP, PFBC	Yes
AppLCC	Watershed	1976-2012	20,714	NYDEC, PFBC, WVDEP, OEPA, USEPA, USGS	Yes



Spreadsheet Summary

- Collected variable list from:
  - National Assessment
  - Regional Assessments
  - Fisheries Goal Implementation Team Fish Habitat Management Strategy
  - Existing Tools
- Did not restrict to variables available over entire watershed. Most data sets available ‘Baywide’, some only available for specific habitats and/or geographies (eg. State data)

Spreadsheet Summary

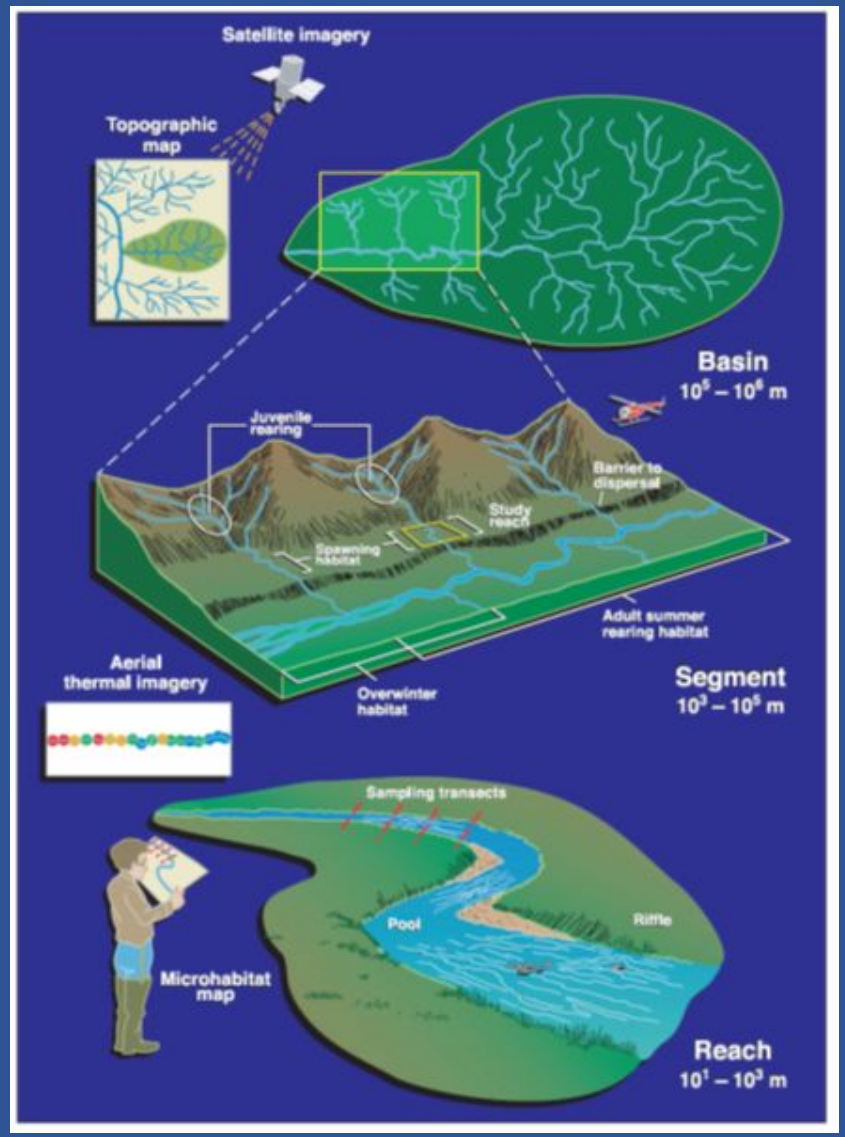
Factors	# Variables	# Variables NFHP Inland	# Variables NFHP Estuary	Description/ Examples
Watershed	18	0	0	Layers and information used to delienate watershed boundaries, salinity
Pollution	38	3	1	Toxic Release Inventory, nitrate deposition, NPDES major sites, pesticide applied
Dams	12	2	1	Number of dams, type, habitat fragmentation due to dams
Mines	53	4	1	Mine density and type, abandoned areas, unconventional/conventional wells, pipelines
Water_Use	7	5	1	Water withdrawal information
Human	5	1	1	Population density information
Urban	34	6	7	Road length/crossing density, urban areas, impervious surface cover,
Ag	26	2	2	Percent hay/agriculture, pesticide use, confined animal feeding operation
Natural	86	3	13	Elevation, slope, habitat, runoff, soil information, geology, stream density, ecoregions
Nutrient	29	3	0	Nitrogen and Phosphorus amounts, 303(d)
Water_Quality	19	0	1	Salinity, water temperature, dissolved oxygen
Climate	20	2	0	Precipitation, temperature, sea level rise, number of wet days
Habitat	38	0	0	Bathymetry, wetlands, tidal marsh vegetation
Biological (Response and Predictor)	46	11*	0	Fish abundance, stream IBI, biological condition
Miscellaneous	10	0	0	Shoreline Structure/erosion, dredging
Total = 15	**441**	**31**	**28**	
				* denotes sources for response data relevant to Chesapeake Bay watershed

Afternoon Session

- Importance of scale in assessments.
- Definition of habitat classes.
- Detailed overview of summary spreadsheet.

Spatial Scale: Concepts

- Scale = resolution of data, smallest features captured
- Extent = area covered by data
- Aggregation = data summary unit (county, catchment*, reach, etc.)



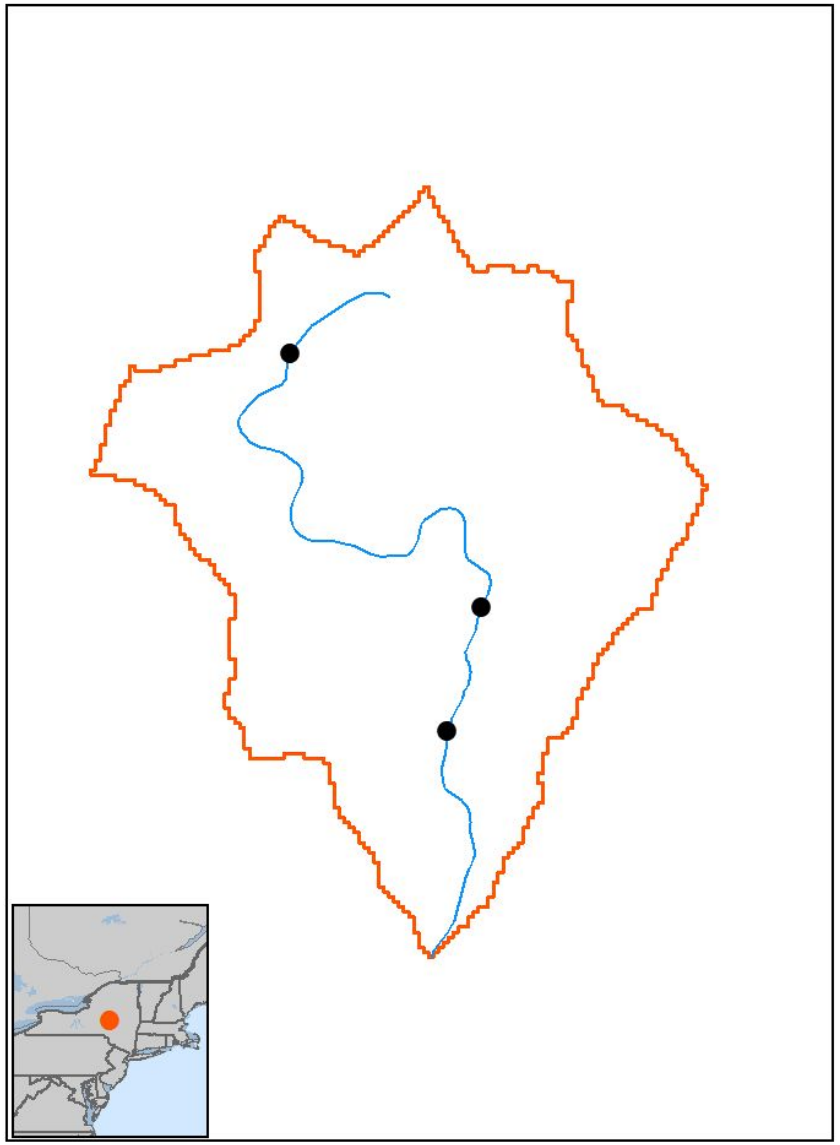
From: Fausch et al. (2002)

* Can include upstream accumulation for streams

Why does spatial scale matter?

- Finer scale = less generalization
- Ability to represent factors influencing fish habitat at management relevant scales
- More accurate depiction of landscape factors (location, edge effects, fragmentation, coverage)
- Potentially better models relating fish habitat to fish populations

1:100,000



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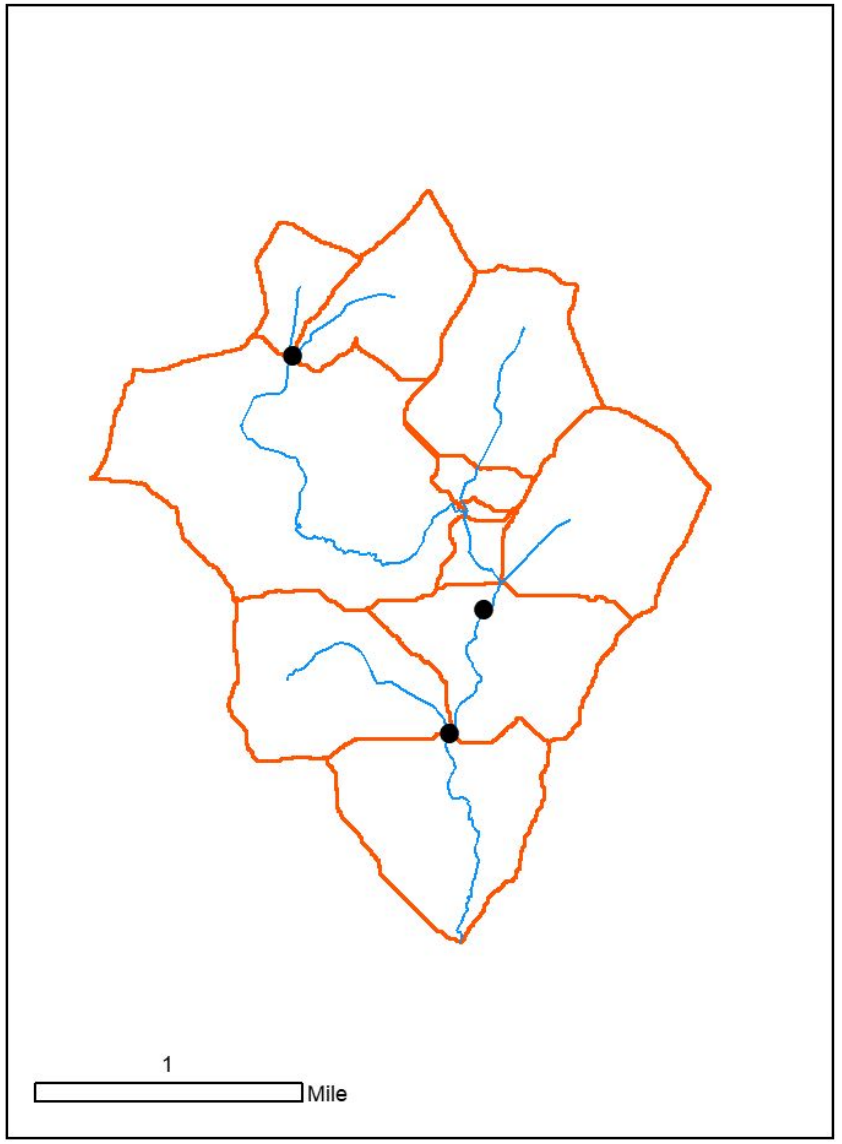
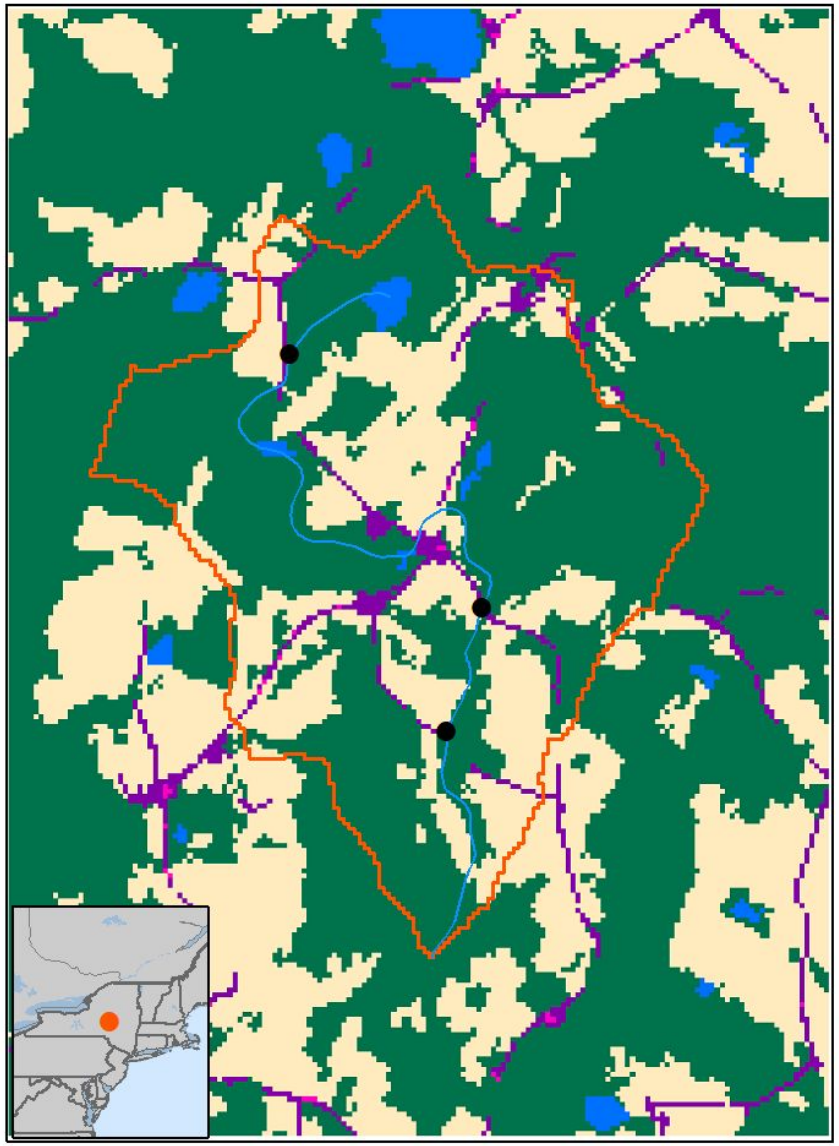


NHDPlus v2

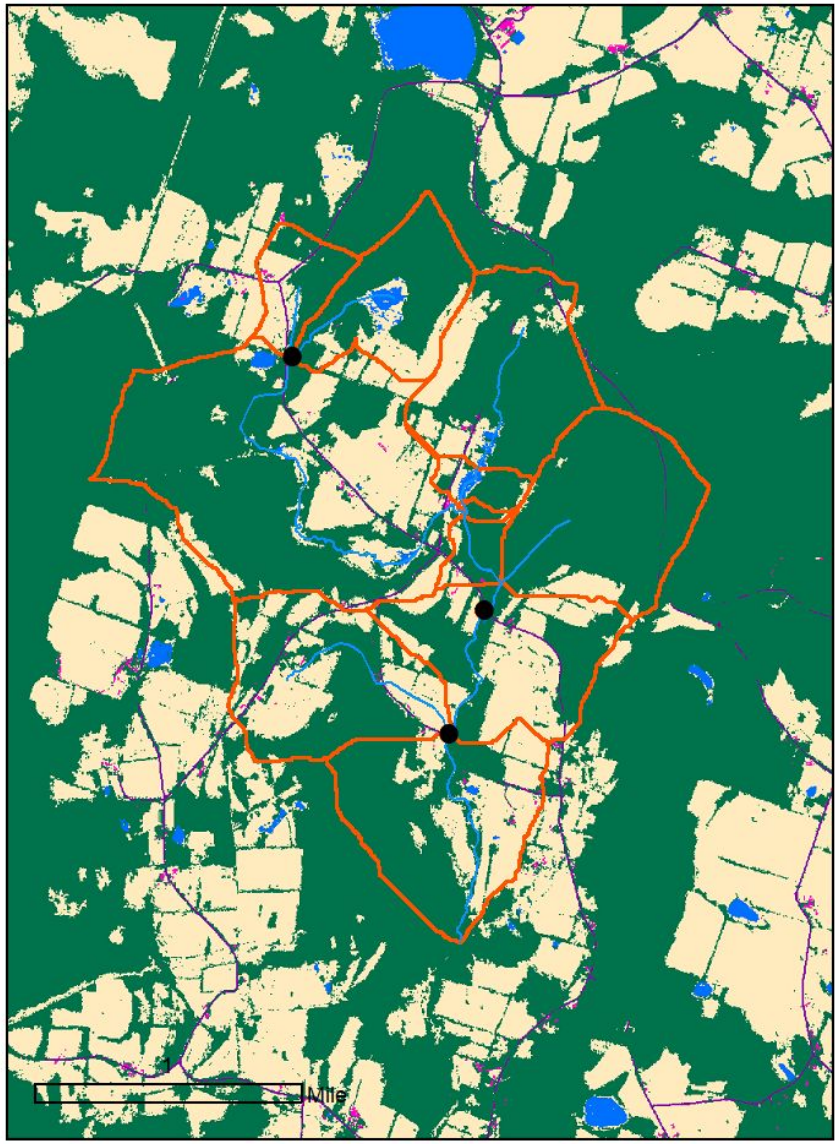
NHDPlus High Res

1:100,000



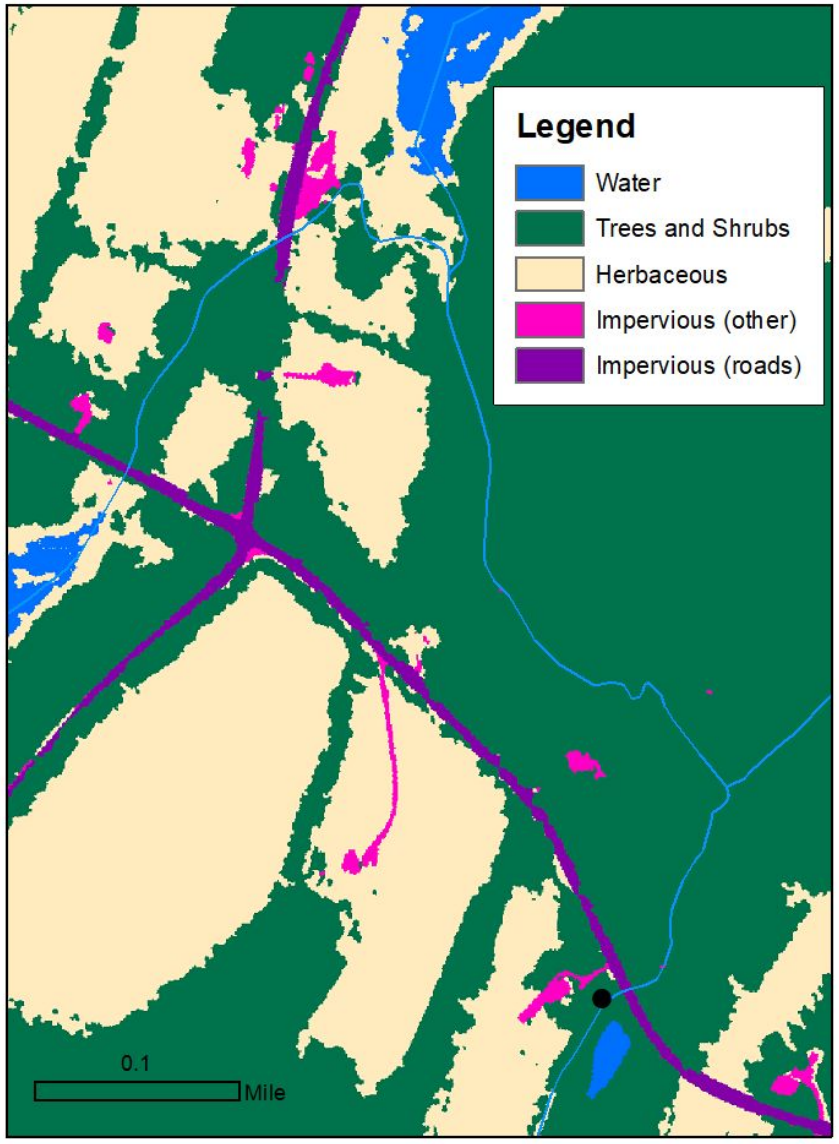
NLCD 30 m

1:24,000

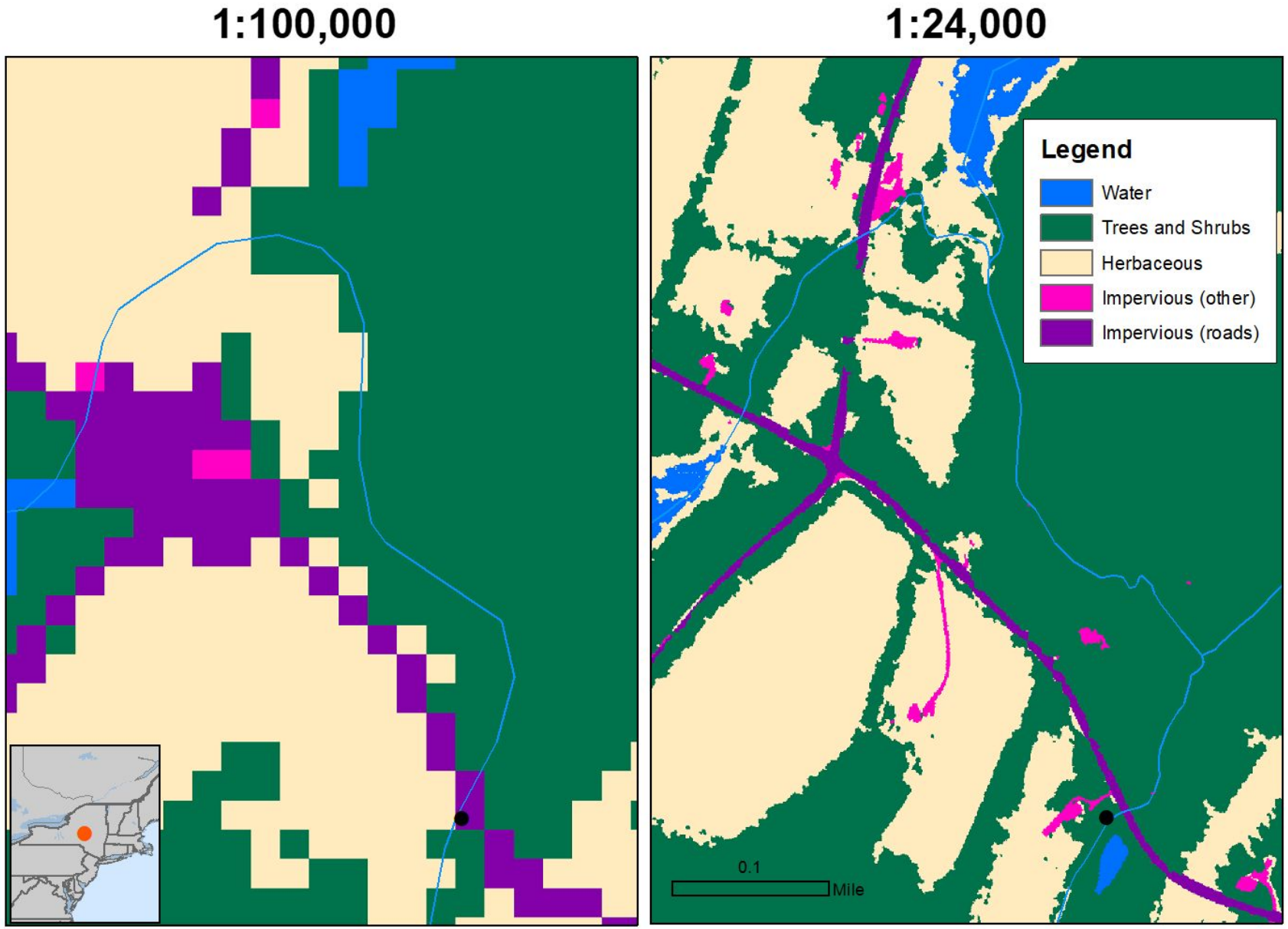


Chesapeake Conservancy 1 m

1:24,000



Chesapeake Conservancy 1 m

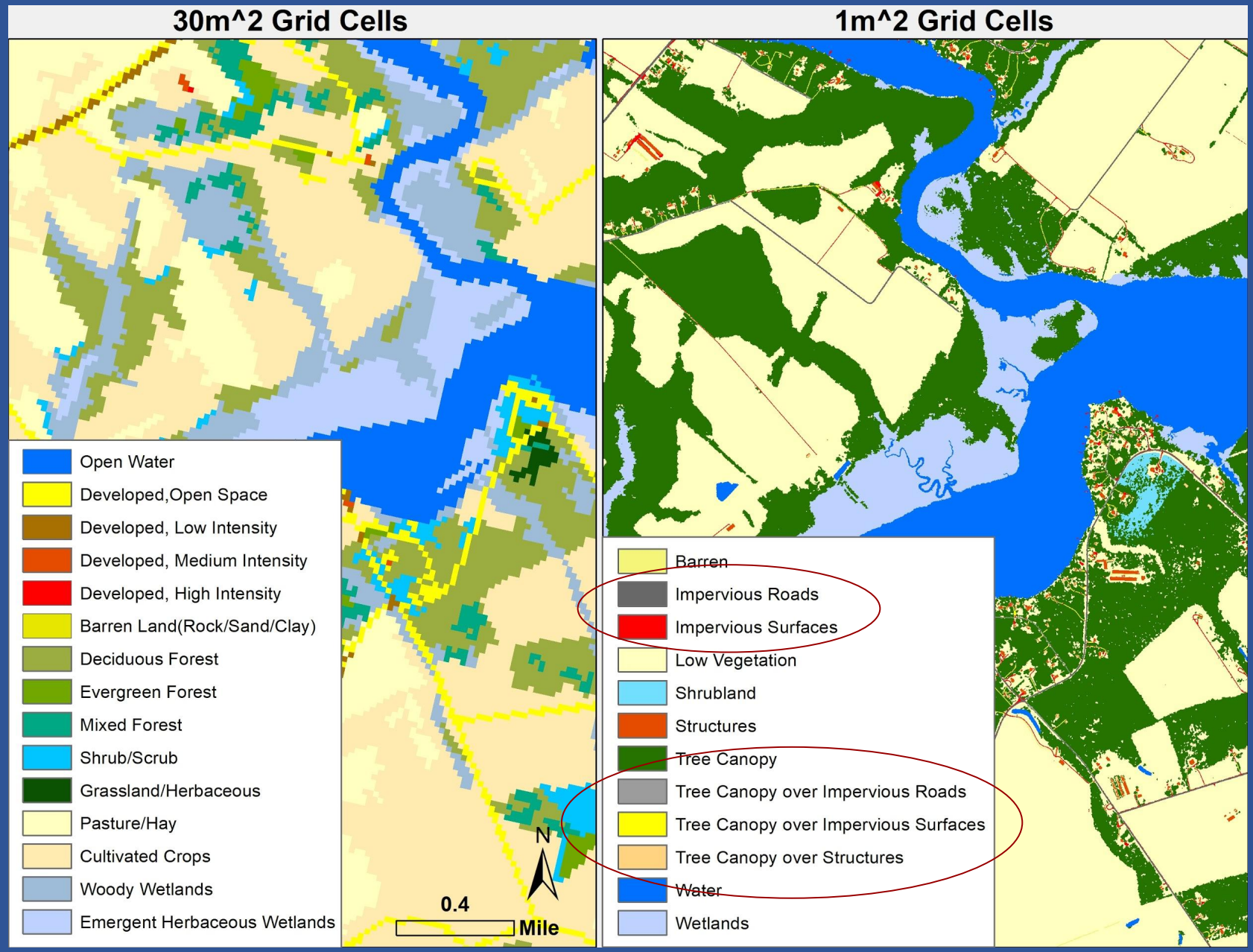


NLCD 30 m

Chesapeake Conservancy 1 m

Example of data scale for the upper Choptank River, an important area for striped bass spawning

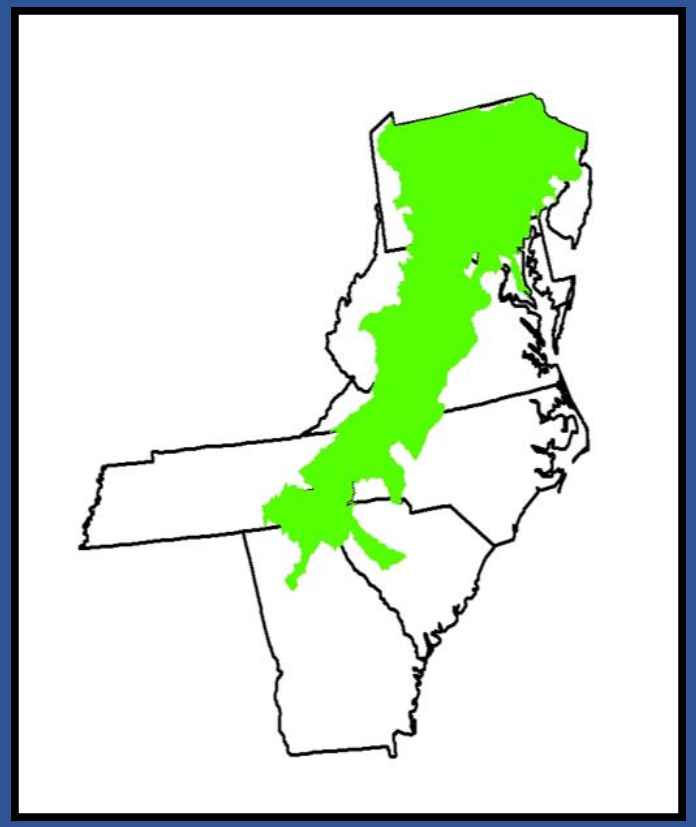
Chesapeake Bay data set has 1) smaller scale (finer resolution), and 2) calculated land cover types not present in national data set



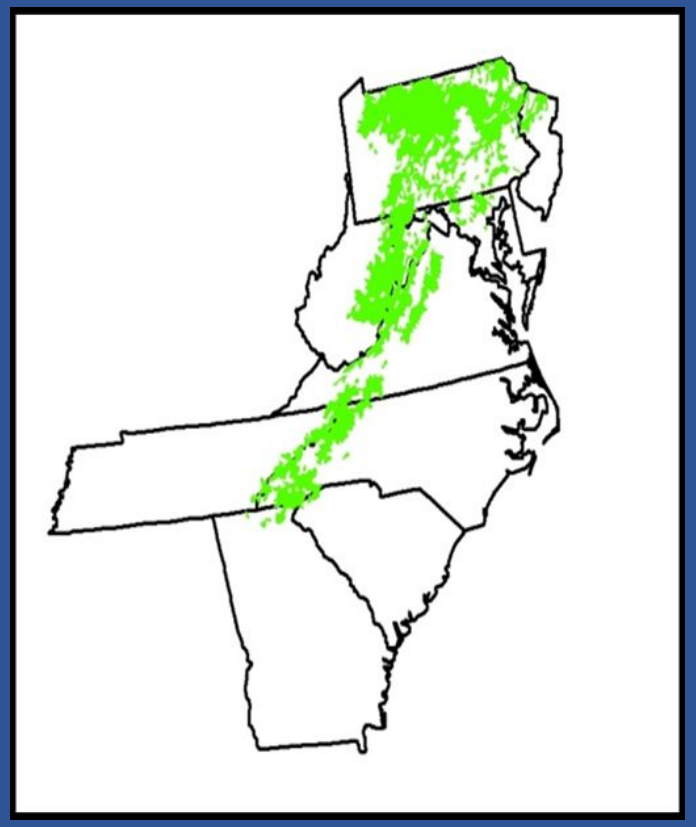
Scale (Aggregation) Effects:

Brook Trout Occupancy

Sub-basin (HUC8): 78% of 107 sub-basins "Brook trout are well distributed throughout their native range"



Watershed (HUC10): 52% of 808 watersheds - "Brook trout are still found in half of their range"

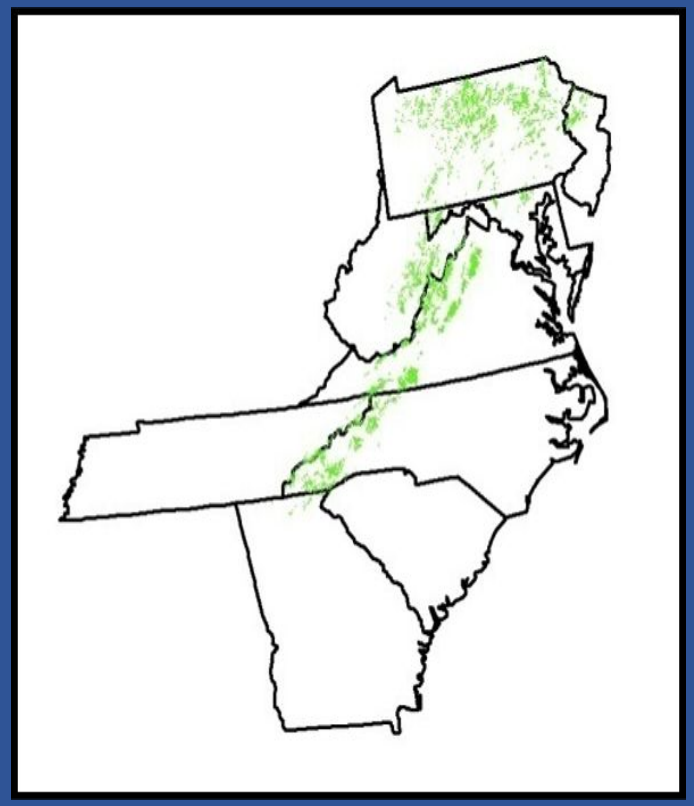


Adapted from Hudy et al. 2013

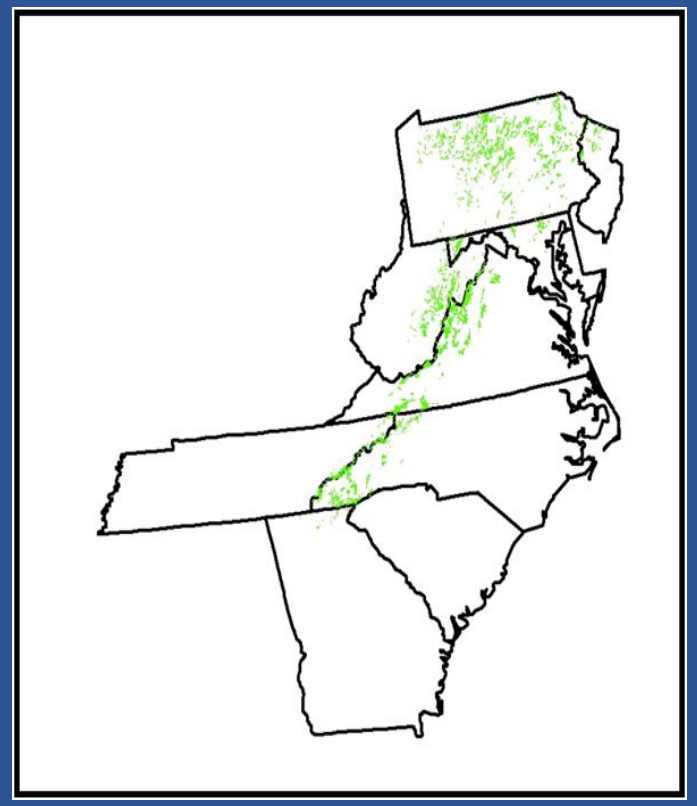
Scale (Aggregation) Effects:

Brook Trout Occupancy

Subwatershed (HUC12): 32% of 3,804 subwatersheds - “Brook trout are still found in half of their range”



Catchments (HUC14): 14% of 132,321 catchments - “Brook trout have been extirpated from 86% of their historic catchments



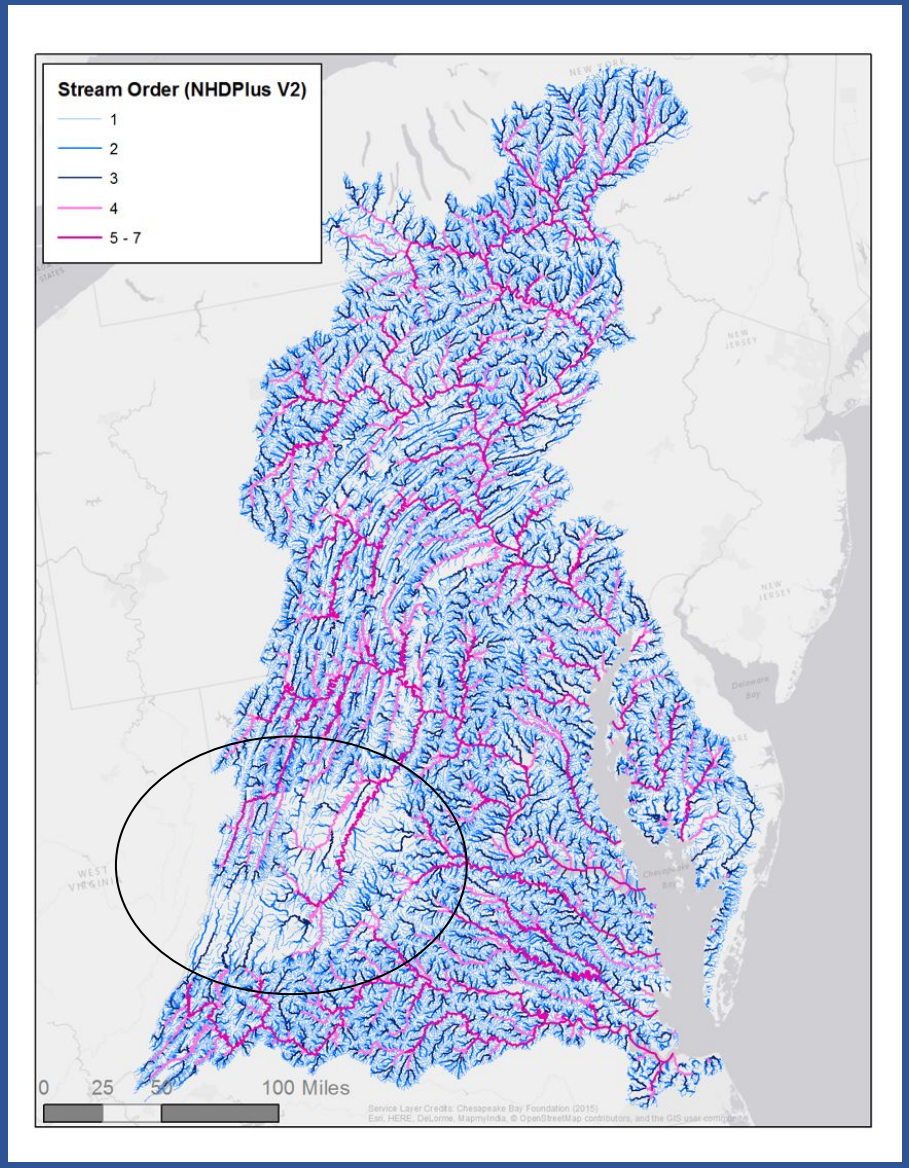
Adapted from Hudy et al. 2013

Other Data Considerations:

- Completeness: data covers full extent?
- Consistency: same methodology used throughout the extent?

*If fine scale data not complete or consistent, may have to use coarser scale data for some or all factors

* Possible to conduct a hierarchical assessment: coarse scale “report card”, fine scale “management relevant”



Other Data Considerations

- What is the appropriate geographic area to calculate land-based stressors? (HUC 12?)
- How is the shoreline habitat extent defined?
- Can general stressor variables be refined?
    - For example, the Fish Habitat Outcome Management Strategy and TetraTech Species Habitat Requirements include coarsely defined variables like ‘climate change’ and ‘water quality’. Can these be refined?
- A combination of some variables may be important. For example the Ecological Units layer in the TNC tool includes salinity, depth, percent mud, and dissolved oxygen

Scale questionnaire

"What map scale is most appropriate so you could use a regional Habitat Assessment to improve your work? "

	Respondents	Percentage
< 1:24,000 eg. Google Earth image	45	49%
1:100,000 eg. State Atlas, Gazetteer	5	5%
1:24,000 eg. USGS Topo map	17	18%
Don't know	18	20%
Other	7	8%

Habitat Classes

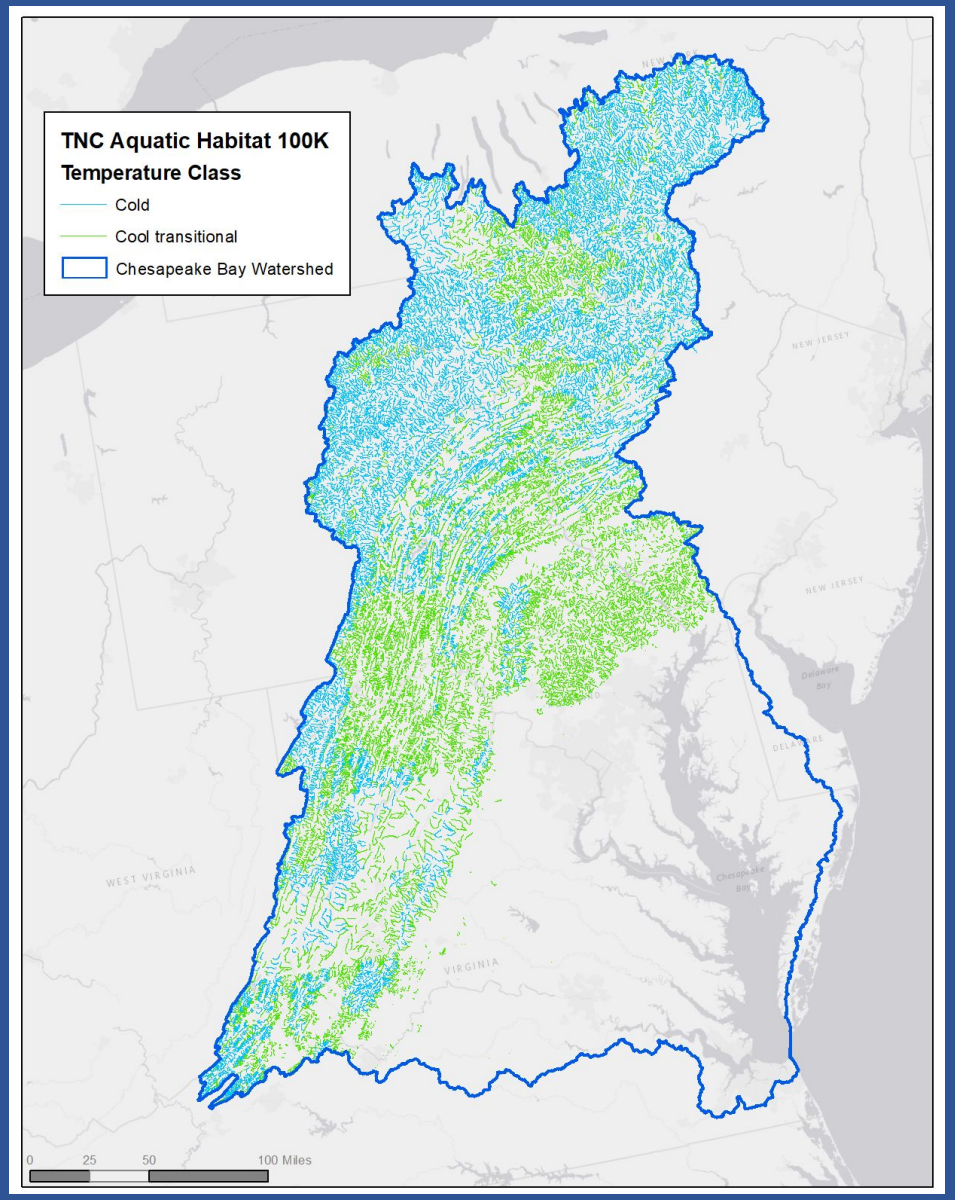
1. Headwaters (3rd order and lower)
   a. Freshwater nontidal (cold and upstream waters)
   b. Freshwater nontidal (warm)

2. Warm Nontidal Freshwaters (4th order and larger)

3. Tidal Freshwater

4. Tidal Estuarine
   a. Tidal saltwater nearshore and intertidal (ex. marshes, SAV)
   b. Saltwater subtidal (ex. oyster reefs, open water)

Headwaters

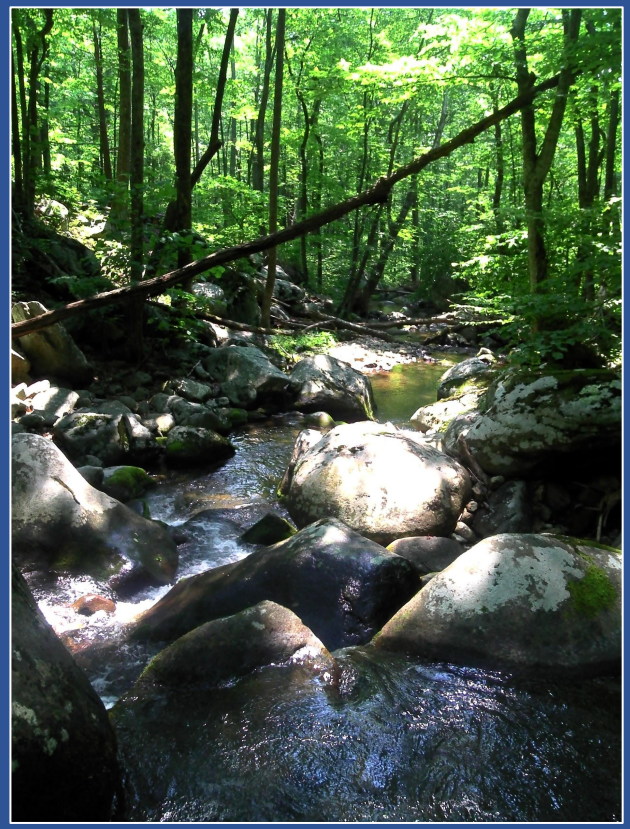


Freshwater, nontidal, cold and cool upstream habitats (~ 3rd order or lower)

Species of Interest:

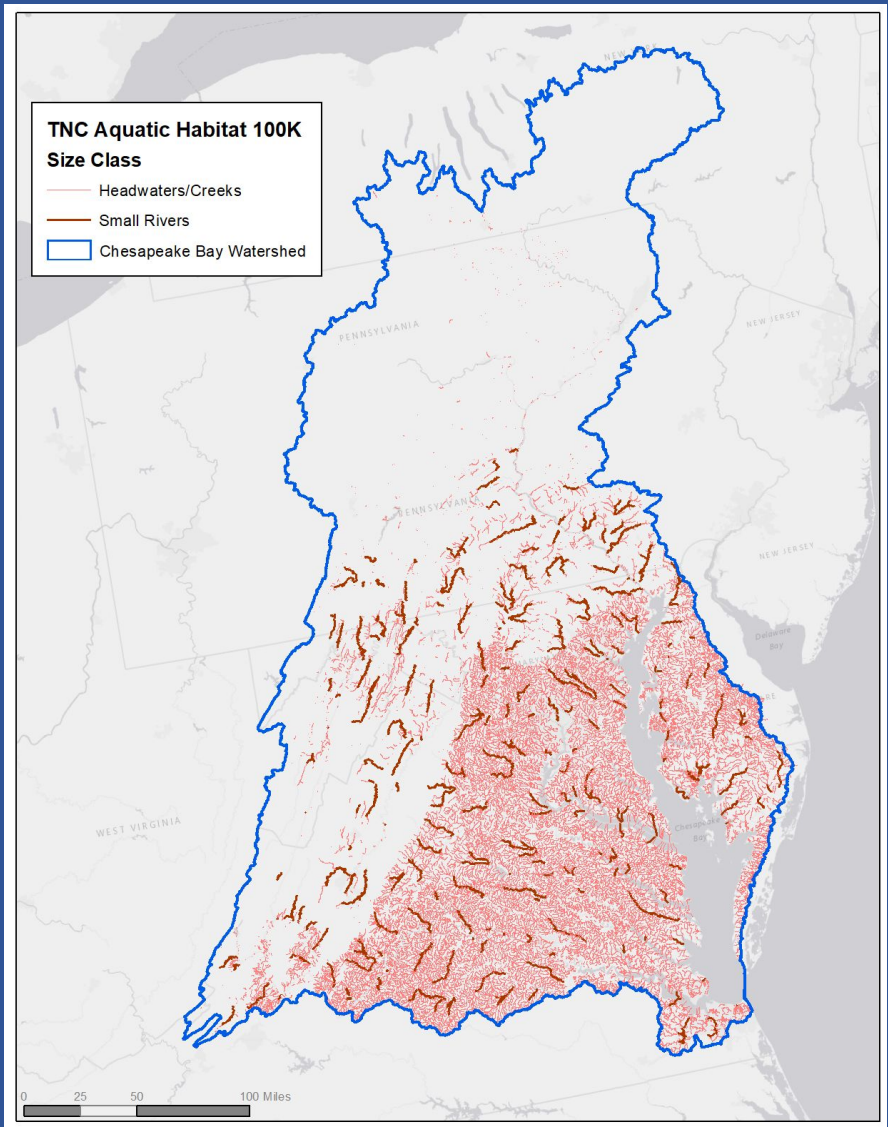
- Brook trout
- Trout (general)

Md DNR



USGS-LSC

Headwaters



Freshwater, nontidal, warm upstream habitats (~ 3rd order or lower)

Species of Interest:

- *Nocomis* chubs
  - Bluehead chub
  - Bull chub
  - River chub
- Sculpin
  - Potomac
  - Checkered
  - Blue RIdge
- Blue-spotted sunfish

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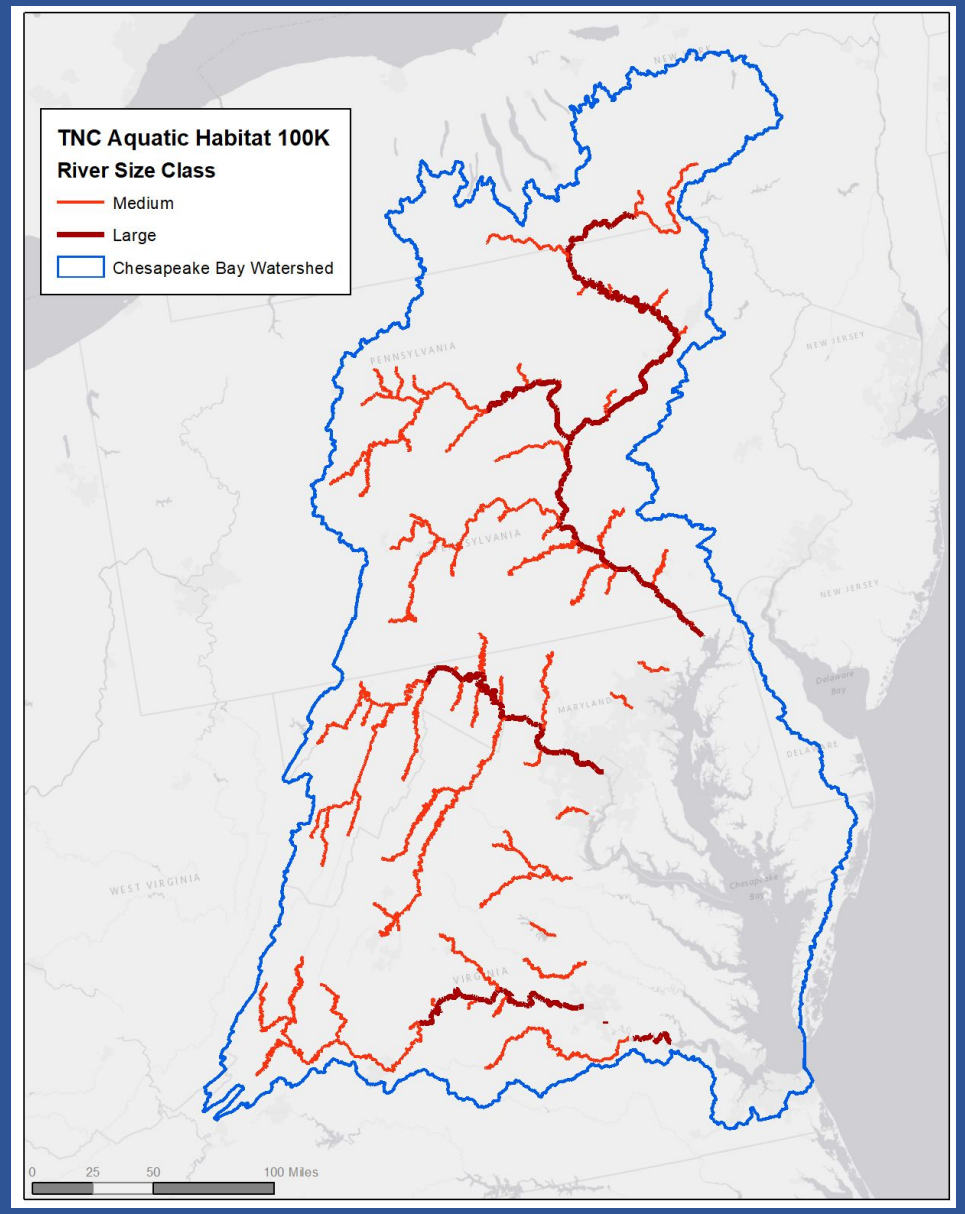
Nontidal Rivers



Freshwater, nontidal, warm habitats
(~ 4th order or greater)

Species of Interest:

- Freshwater mussels
- Black basses
- American shad
- American eel
- River herring

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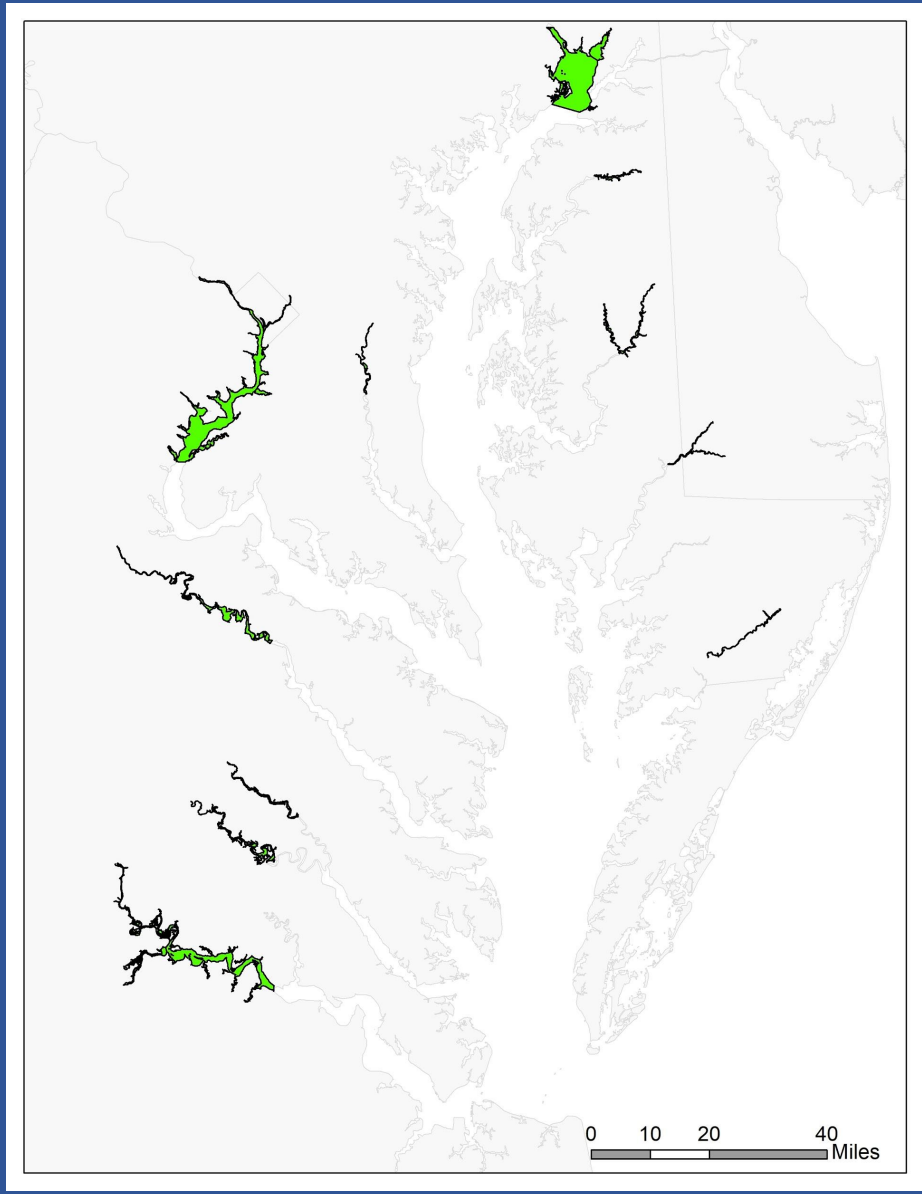
Tidal Freshwater



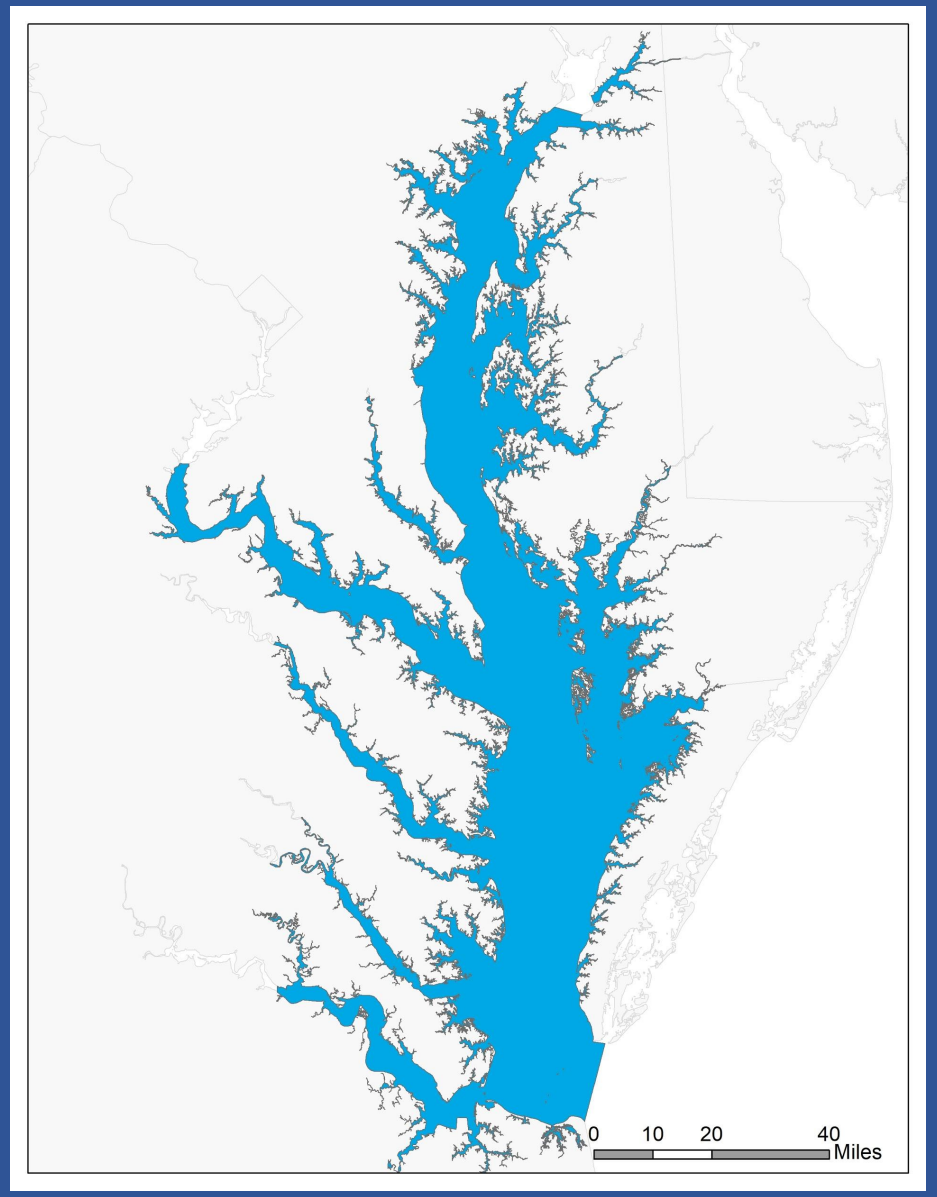
Species of Interest:

- Striped Bass
- Atlantic Sturgeon
- Largemouth Bass
- American Shad
- River Herring
- American Eel
- White Perch
- Yellow Perch

Harvard

USFWS

Tidal Estuarine



1. Nearshore and intertidal
2. Saltwater subtidal

Species of Interest:

- Bay Anchovy
- Atlantic Sturgeon
- Blue Crab
- Oyster
- Spot
- Croaker
- Summer Flounder
- Striped Bass
- Juvenile Sciaenids
- Horseshoe Crab
- Forage species

Metadata Spreadsheet

- Provide detailed overview of summary spreadsheet
- Walk through the Summary and Example slide
- Walk through one or more of the tabs (factor group) describing the columns

How to Read this Database

Each tab represents a factor with current potential variables that can be used for the fish habitat model. Along with the information for available variables (the green header, Columns A-H), where the data was previously identified or summarized (blue header, Columns J-Y) is also recorded. Under the "previously identified in" header, the year(s) used by a study/database have been recorded along with a number in brackets referring to a code for how the variable was summarized. Columns with red headers (columns Z-AC) list the habitat types (this list may change) and whether or not data for the variable is available for that habitat. Factors are flexible and some variables may fit into multiple categories. Red rows at the bottom of some tabs indicate variables that were identified by a previous effort as being potentially important variables for fish habitat, but for which data sources have not yet been located.

For more information and an example, please go to the Example tab.

Factors	# Variables	# Variables NFHP Inland	# Variables NFHP Estuary	Description/ Examples
Watershed	18	0	0	Layers and information used to delienate watershed boundaries, salinity zones, drainage or catchment areas, stream order
Pollution	38	3	1	Toxic Release Inventory, nitrate deposition, NPDES major sites, pesticide applied
Dams	12	2	1	Number of dams, type, habitat fragmentation due to dams
Mines	53	4	1	Mine density and type, abandoned areas, unconventional/conventional wells, pipelines
Water_Use	7	5	1	Water withdrawal information
Human	5	1	1	Population density information
Urban	34	6	7	Road length/crossing density, urban areas, impervious surface cover, landfills
Ag	26	2	2	Percent hay/agriculture, pesticide use, confined animal feeding operation information
Natural	86	3	13	Elevation, slope, habitat, runoff, soil information, geology, stream density, ecoregions
Nutrient	29	3	0	Nitrogen and Phosphorus amounts, 303(d)
Water_Quality	19	0	1	Salinity, water temperature, dissolved oxygen
Climate	20	2	0	Precipitation, temperature, sea level rise, number of wet days
Habitat	38	0	0	Bathymetry, wetlands, tidal marsh vegetation
Biological (Response and Predictor)	46	11*	0	Fish abundance, stream IBI, biological condition
Miscellaneous	10	0	0	Shoreline Structure/erosion, dredging
Total = 15	**441**	**31**	**28**	

* denotes sources for response data relevant to Chesapeake Bay watershed