CHESAPEAKE BAY

DRAFT Planning Analyses Appendix

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NFWF

US Army Corps of Engineers®

This document was developed in coordination with multiple stakeholders, including the Chesapeake Bay Program, U.S. Fish and Wildlife Service, District of Columbia, states of Delaware, Maryland, New York, Virginia, West Virginia, and commonwealths of Pennsylvania and Virginia.

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Introduction

The Chesapeake Bay Program (CBP) along with federal, regional, state, local, and non-governmental organizations (the Partnership) have been collaborating on the restoration of this national treasure, culminating most recently in the development of the 2014 Chesapeake Bay Watershed Agreement (2014 Bay Agreement). The 2014 Bay Agreement established comprehensive goals and outcomes for the watershed by the year 2025.

The Chesapeake Bay Comprehensive Water Resources and Restoration Plan (CBCP) is a watershed assessment intended to inform multiple audiences and decision-makers at all levels of government, and provide a strategic roadmap for future investments into aquatic ecosystem restoration. The U.S. Army Corps of Engineers (USACE) and the National Fish and Wildlife Foundation (NFWF), the non-federal sponsor, led the completion of the CBCP. The U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service (USFWS), and the Chesapeake Bay Commission were stakeholders and were included in the development of the CBCP.

Geospatial analyses were the primary methodology used to investigate the Chesapeake Bay Watershed problems, needs, and opportunities. The intent of the analyses was to identify high-quality areas for potential conservation, degraded areas for restoration, gaps in restoration actions, and duplication of efforts. This Planning Analyses Appendix presents the CBCP baywide analysis. The baywide analysis was conducted at a hydrologic unit code (HUC) 10 subwatershed scale. For this discussion, a HUC 10 subwatershed will be referred to as "subwatershed." The objective of the baywide analysis was to identify focal locations for undertaking opportunities to meet the 2014 Bay Agreement goals and outcomes and to help achieve an environmentally and economically sustainable and resilient Chesapeake Bay Watershed. Planning level costs and benefits are considered, as are the appropriate agencies to implement the work.

The CBCP was developed using geospatial analyses of the Chesapeake Bay Watershed at three scales: (1) a baywide analysis (Restoration Roadmap), (2) a jurisdiction (state and District of Columbia jurisdictional boundary) analysis (State and the District of Columbia Annex), and (3) a watershed analysis (state-selected watershed action plans). The CBCP State and District of Columbia analyses are the results of the baywide analysis "clipped" per jurisdiction. State-selected watersheds were identified by each jurisdiction for finer-scale analyses. These finer-scale analyses and results are presented in the State-Selected Watershed Action Plans. The State and District of Columbia Analyses and the State-Selected Watershed Action Plans are presented in the State and District of Columbia Annex.

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Section 2

Plan Formulation Framework

2.1 Vision

The Chesapeake Bay is a watershed of national significance. The preamble of Executive Order (EO) 13508, Chesapeake Bay Protection and Restoration, states that the Chesapeake Bay is a national treasure constituting the largest estuary in the United States. and one of the largest and most biologically productive estuaries in the world (EO 13508, 2009). The EO identifies that to restore the health, heritage, natural resources, social and economic value, and natural sustainability of the Chesapeake Bay Waterhsed will require protecting and restoring habitat and living resources, and conserving lands and improving management of the natural resources. The CBCP integrates the EO's strategies into the CBCP's overall watershed vision, which is aligned with the Bay Agreement vision, and includes the term *resilient* into the CBCP vision statement, thus aligning it to the need to adapt the health of the watershed to future stressors.

> ***"We envision an environmentally and economically sustainable and resilient Chesapeake Bay Watershed with a clean water, abundant life, conserved lands and access to the water, a vibrant cultural heritage, and a diversity of engaged citizens and stakeholders."***

2.2 Primary Goal and Objectives

The CBCP's primary goal is to provide a comprehensive and integrated water resources management plan to assist with implementation of the 2014 Bay Agreement where the goals align with the USACE missions, processes, skill sets, and authorities. Throughout the CBCP effort, USACE and the NFWF staff engaged stakeholders to identify problems, needs, and opportunities and avoid duplication of ongoing or planned actions by others. The CBP Office, particularly the goal implementation teams (GITs), were instrumental in providing feedback during development of the CBCP. The geospatial analyses completed as part of the CBCP, along with agency collaboration, resulted in an integrated water resources management plan. This plan determines where and how USACE mission areas can be used to complement the ongoing efforts to achieve the Bay Agreement goals. **Table 1** summarizes the objectives of the CBCP to achieve the Bay Agreement's goals.

Table 1. Overview of CBCP Objectives

Objectives	
1.	**Develop a comprehensive, strategic, and integrated water resources plan to guide the implementation of projects to assist in meeting the 2014 Bay Agreement objectives.**
2.	**Identify areas for aquatic ecosystem restoration, protection, or preservation to assist in meeting the 2014 Bay Agreement objectives.**
3.	**Identify at least one project in each of the six states and District of Columbia that can be considered for implementation or technical assistance by USACE and that supports the 2014 Bay Agreement objectives.**
4.	**Identify new policies or programs or improve upon existing policies and programs that will help achieve an environmentally and economically sustainable and resilient Chesapeake Bay Watershed.**

Objectives 1 and 2 are fulfilled by the content of the CBCP and it various products. Objective 3 is met by the State-Selected Watershed Action Plans and the incorporated candidate restoration projects submitted by stakeholders. Objective 4 is addressed in the CBCP Implementation Strategy, which is presented in the CBCP Main Report.

2.3 Primary Problem

Since the signing of the 1983 Chesapeake Bay Agreement, the problems affecting the Chesapeake Bay have been well-documented. The primary problem is degradation of the structure and function of the Chesapeake Bay aquatic ecosystem from human actions in and around the Chesapeake Bay Watershed, which leads to a less resilient Chesapeake Bay

Solutions to the problem are two-fold, requiring both implementation and coordination. For solutions to succeed within an integrated water resources management framework, it is necessary to (1) enhance interagency collaboration between agency programs and projects to streamline data sharing, reduce costs, and increase implementation of restoration and conservation actions, and (2) identify strategies and projects for ecosystem restoration that may reduce flood risk, increase ecosystem and community resilience, support sustainable fisheries, promote environmental education and stewardship, and provide recreation and public access. The CBCP seeks to facilitate both needs.

Section 3

Geodatabase Development and Geospatial Analyses

The first step of the CBCP geospatial analysis was to compile an extensive database of existing relevant data, referred to as the Geodatabase. The Geodatabase includes all maps generated, details of the development of each map, and geographic information system (GIS) data used. The Geodatabase is available online at the CBCP webpage: http://www.nab.usace.army.mil/Missions/Civil-Works/Chesapeake-Bay-Comprehensive-Plan/.

Attached to this appendix is a list of all GIS data layers used for the CBCP geospatial analyses (**Annex 3**).

3.1 Identification of Measures

A management measure is defined in the U.S. Army Corps of Engineers (USACE) planning process as an action (e.g., features, activity, strategy, policy) that can be undertaken to meet planning objectives.

3.2 Development of Management Measures for the CBCP

A comprehensive list of measures was generated that could be employed for the restoration, conservation, and protection of the Chesapeake Bay Watershed (**Annex 1**). This list includes measures that could be implemented by USACE that are within USACE authority, as well as those that could be implemented by other entities.

Prior to development of the CBCP, there was extensive stakeholder collaboration and interagency governmental coordination to identify goals, strategies, and measures as part of strategic watershed planning efforts conducted by the CBP and the Partnership. The CBP facilitates the Partnership and has led the direction and restoration of the Chesapeake Bay Watershed since 1983. USACE is an active participant in the CBP.

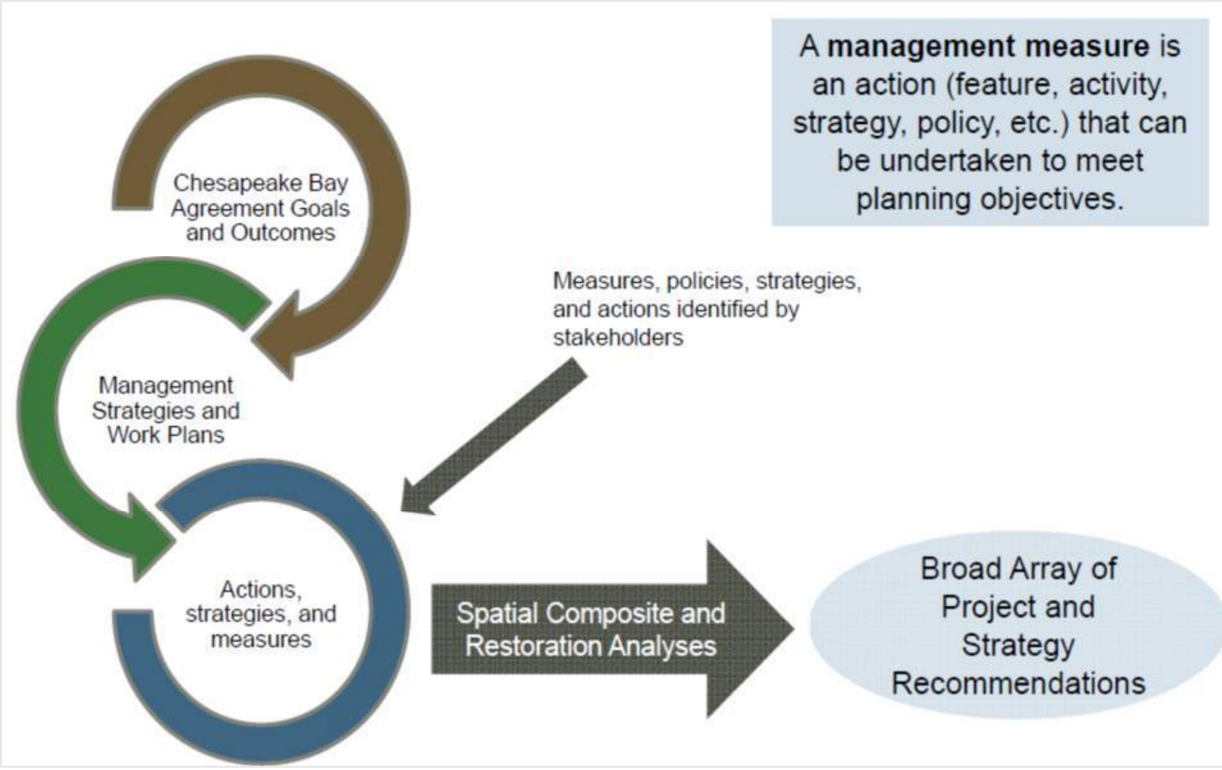


Figure 1. CBCP measure development process

Measure categories for the CBCP were identified as specified in the 2014 Bay Agreement goals and outcomes. The 2014 Bay Agreement has signatories from representatives across the watershed. The agreement established 10 goals and 31 outcomes to restore the Chesapeake Bay Watershed. CBP GITs developed management strategies and work plans to outline the steps and work needed to restore the watershed. The work plans specify specific commitments, short-term actions, and resources required for the watershed's restoration efforts. The management strategies and work plans developed by the Partnership were carefully reviewed to identify any potential measures and to develop measures that align with the management strategies and work plans. **Figure 1** is a visual depiction of the process used to identify measures for the CBCP.

Some additional measures were identified during the CBCP stakeholder workshops held from November 2016 through April 2017.

Based on the results of the reviews, a comprehensive listing of measures for the Chesapeake Bay Watershed is provided in **Annex1**.

3.3 Application of Measures in the Chesapeake Bay Watershed

Ultimately, within a watershed management plan, measures are tied to a geographically specific area. Due to the size of the Chesapeake Bay Watershed, the CBCP has an extensive scope. The geographic resolution within the baywide analyses is provided at the subwatershed level.

However, this analysis is limited to the resolution and quality of the geospatial data, and therefore, at the subwatershed scale, the measures are more accurately presented as 'strategies'. The State-Selected Watershed Action Plans develop these strategies further and provide a portfolio of geospatially-referenced measures (projects) for each of the state-selected watersheds. As implementation proceeds throughout the watershed, additional refinement of measure locations will be needed, and these action plans provide a demonstration of how that specificity could be achieved.

3.4 Formulate and Refine Strategies

The CBCP geospatial analyses were formulated to identify problems, needs, and opportunities from a multi-scalar approach, recognizing that a finer level of detail and granularity is required at a smaller scale to determine specific actionable recommendations. By structuring scientific questions to align with available data and collaboration with watershed stakeholders, the results present opportunities that align with 2014 Bay Agreement goals and outcomes so that restoration and conservation actions with a spatial component could be pursued for implementation as part of EPA's Phase III initiative.

The CBCP baywide analyses are centered around the development of composite analyses and their application in the CBCP Restoration Opportunities Analysis to identify a select group of subwatersheds. Using existing spatial data layers obtained from many sources (federal, state, and local agencies; academia; and NGOs), specific questions were identified to provide responses to address problems and identify opportunities within the Chesapeake Bay Watershed. Stakeholder meetings and webinars were used as question-answer platforms to identify, coordinate, and solicit feedback among NFWF, stakeholders, and other interested parties. The select group of subwatersheds are referred to as *Opportunities*. For each Restoration Opportunity Analysis question, *Opportunities* are identified. These subwatersheds represent areas that the analysis identifies as principal potential areas for implementation based on 1) the current condition of the subwatershed (quality) or 2) the potential to implement measures (quantity), based on acreage or linear feet of opportunities. **Figure 2** displays a flowchart of the process described above – using existing spatial data to arrive at a Restoration Roadmap.

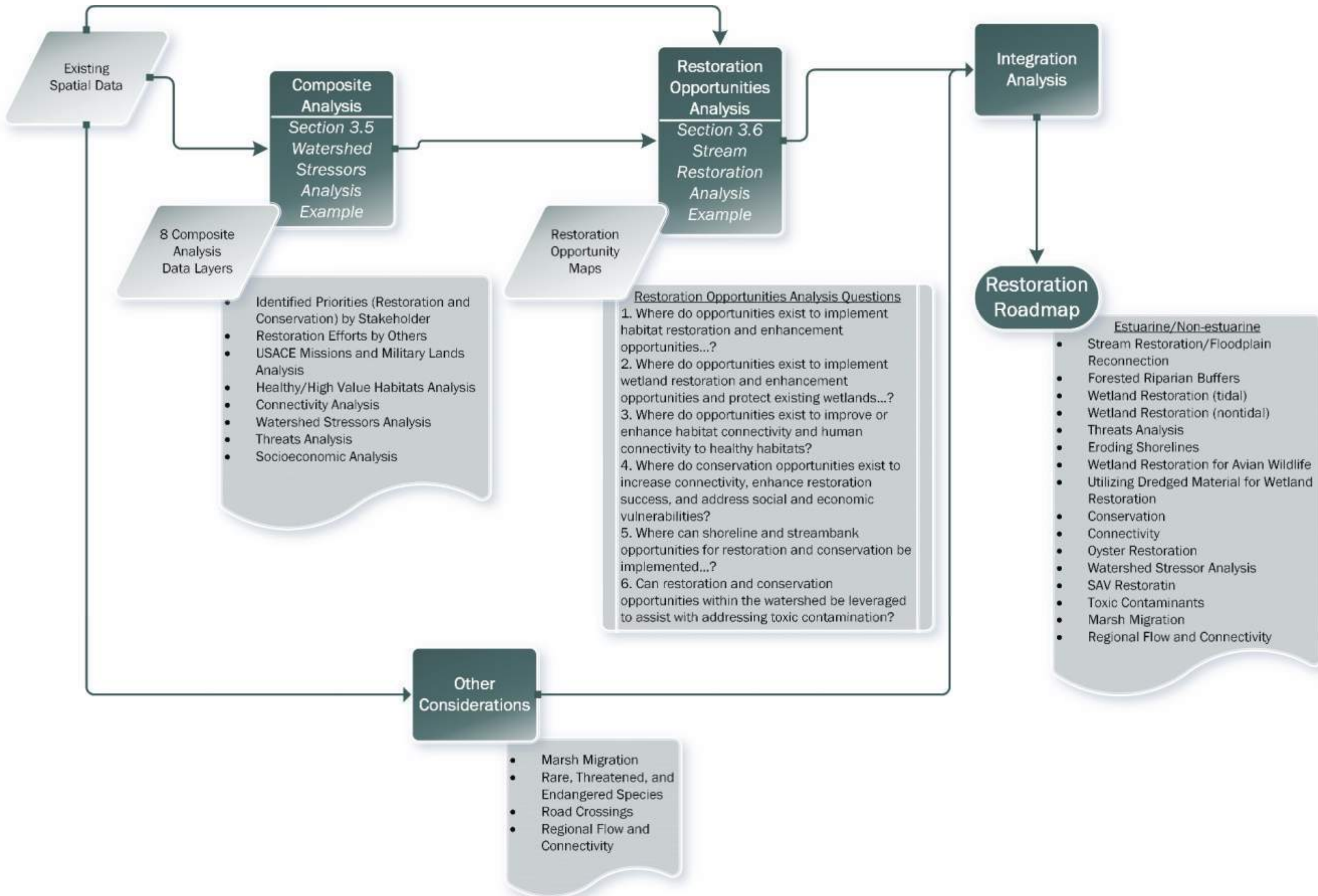


Figure 2. Formulate and refine strategies leading to the Restoration Roadmap

Composite Analysis

3.5 Composite Analyses

From the extensive geodatabase compiled for the CBCP, eight composite analyses were identified for use as foundational information syntheses of multiple data layers. Each combined a number of data layers focused on one topic. Because of time constraints, the project delivery team (PDT) made necessary decisions regarding the incorporation of data based on availability and quality, and screened layers for inclusion in each analysis accordingly. The composite analyses were combined and evaluated in different combinations to investigate a set of questions in the Restoration Opportunities Analysis. **Figure 3** shows the composite analyses concept; the composite analyses, the data layers used in each, and their output is listed in **Table 2**. The watershed stressors analysis is provided in this section as a detaled example of a composite analysis. Details on all composite analyses can be found in **Annex 2**.

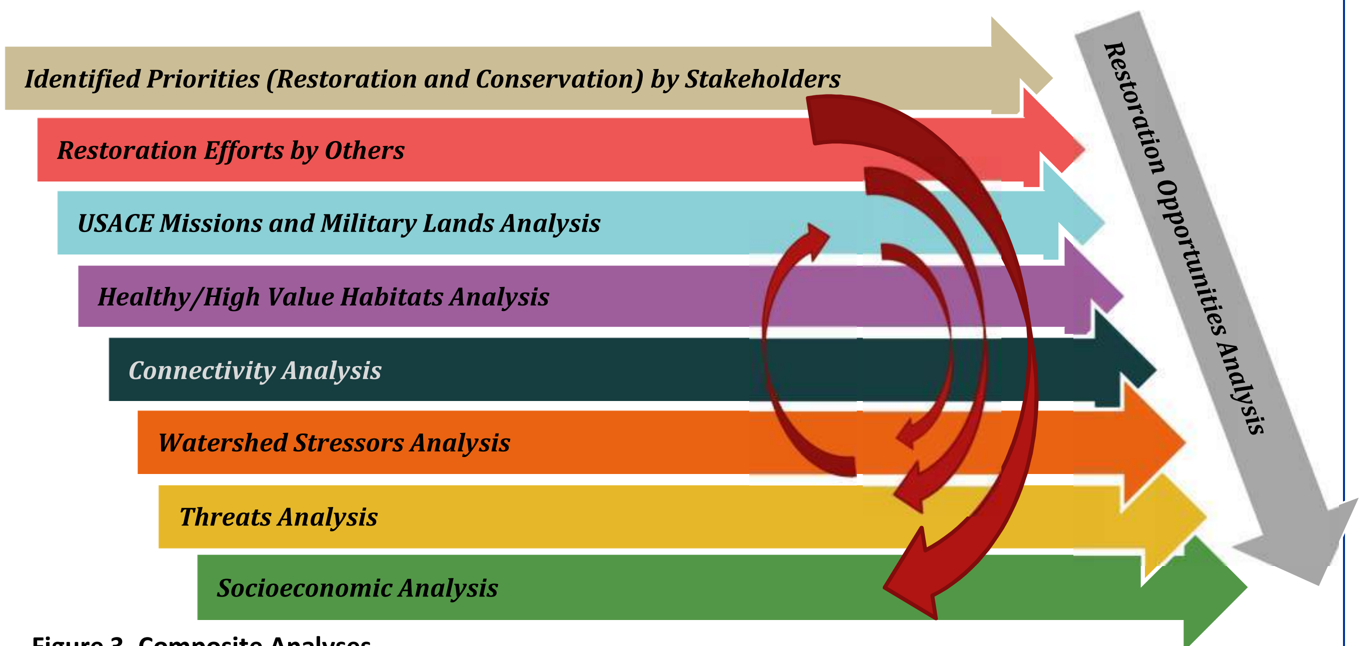


Figure 3. Composite Analyses

Table 2. Composite Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	Data Layers	Output	Code
Identified Priorities by Stakeholders	• *Focus Areas for USFWS* • *National Oceanic and Atmospheric Administration (NOAA) Habitat Focus Areas* • *NFWF Business Plan Focus Areas* • *Ducks Unlimited Focus/Project Areas*	Restoration priority areas identified by others Restoration and conservation priority areas identified by others	CA-1-RestPrio CA-1-CombPrios
Restoration Actions by Others	• *Systems Approach to Geomorphic Engineering (SAGE) implemented projects* • *NFWF Legacy Grants* • *Projects implemented on military lands* • *Projects that have received a USACE Nationwide Permit 27 (ecosystem restoration)* • *Stakeholder input to CBCP data calls* • *Existing Partnership Management Strategies (project layer developed by the cross-GIT)*	Restoration efforts by others	CA-2-RestEff
USACE Mission Analysis and Military Lands	• *Dams and reservoirs* • *Aquatic ecosystem restoration projects* • *Navigational channels and structures* • *Military lands* • *Levees* • *Coastal storm damage reduction projects* • *Dredged material placement sites*	USACE Projects USACE Study Authorities	CA-3-USACE-A CA-3-USACE-B
Healthy/High-value Habitats	• *State-identified healthy watersheds* • *Subwatersheds identified as brook trout catchments* • *CBP Black Duck Focus Areas* • *Audubon Important Bird Areas* • *Index of Ecological Integrity (IEI)* • *Nature's Network core and connector habitat*	Healthy/High-value Habitats Analysis	CA-4-HHVH
Connectivity Analysis	• *Nature's Network connector habitat*	Connector habitats in the Chesapeake Bay Watershed as identified by Nature's Network	CA-5-CON

Table 2 cont. Composite Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis		Data Layers	Output	Code
Watershed Stressors Analysis		• *Percent impervious cover* • *Percent forest cover* • *Percent of stream network within a subwatershed with forested riparian buffers* • *303(d) impaired waterways list* • *CBP Benthic Index of Biotic Integrity (B-IBI)* • *Nitrogen and phosphorus yield projections from SPARROW modeling*	Watershed Stressors Analysis scores	CP-6-WSA
Threats Analysis	Nontidal	• *Nontidal flooding* • *Future projected development* • *National Fish Habitat Assessment* • *Areas projected to have more frequent "normal" flooding* • *Future projected development* • *Sea level rise (SLR) curves* • *Resources at risk to coastal storms* • *Coastal vulnerability index (CVI)*	Evaluation of nontidal threats	CA-7-NTT
	Tidal		Evaluation of tidal threats	CA-7-TT
Socioeconomic Analysis		• *Locations of national, state, and local parks* • *Public access points* • *Underserved populations* • *National Inventory of Dams* (NID) • *Locations of reservoirs* • *Locations of water supply withdraws in the Susquehanna River Basin*	Socioeconomic Analysis without dams	CA-8-SOC-A
			Socioeconomic Analysis with dams	CA-8-SOC-B

3.5.1 Watershed Stressors Analysis Example

Overview: The Watershed Stressors Analysis (WSA) evaluates the presence of stressors to watershed health and function in each individual subwatershed based on six metrics: (1) percent impervious cover, (2) percent forest, (3) percent of stream network with forested riparian buffers, (4) streams miles listed as impaired on the 303(d) list, (5) CBP Benthic Index of Biotic Integrity, and (6) nitrogen (N) and phosphorus (P) yields as predicted by Spatially Referenced Regressions on Watershed (SPARROW) modeling. Subwatersheds are ranked by their resulting scores to identify the least degraded areas. The least degraded areas have higher scores.

Data layers: The following data were used in the Watershed Stressors Analysis.

- *Percent impervious cover* – Percent impervious cover for each subwatershed was determined from high resolution land cover data collected in 2016 by the Chesapeake Bay Conservancy. Percent impervious cover represents the amount of development within a watershed. As percent impervious cover increases in a watershed, the stream network becomes degraded. The impervious cover model (ICM) developed by the Center for

Watershed Protection (CWP) estimates that most stream quality indicators decline when impervious cover is greater than 10 percent (CWP 2003). Severe degradation is likely to occur once 25 percent imperviousness is reached (CWP 2003). Maryland Department of Natural Resources (MDDNR) General Guidelines for Impervious Cover incorporated these metrics. The scoring scheme used to rate percent impervious cover in the watershed screening is based on MDDNR's guidelines and the findings of the CWP (CWP 2003).

- *Percent forest cover* – Percent forest cover for each subwatershed was determined from high-resolution land cover data collected in 2016 by the Chesapeake Bay Conservancy. *The State of Chesapeake Forests* (The Conservation Fund 2006) identifies a relationship between stream health rating and percent tree cover within a watershed. The scoring scheme used to rate percent forest cover in the watershed screening is based on that relationship.

- *Percent of stream network within a subwatershed with forested riparian buffers* – Percent forested riparian buffer in each subwatershed was calculated by determining the percent of forested land within a 100 foot (ft) distance from each streambank. *The State of Chesapeake Forests* identifies a relationship between stream health rating and percent tree cover within a riparian area and sets a goal of increasing the percent of forested riparian areas to 70 percent. The scoring scheme used to rate percent forested riparian buffer in the watershed screening is based on that relationship.

- *303(d) impaired waterways list* – Under section 303(d) of the Clean Water Act (CWA), states are required to develop a list of impaired waters and report them to the U.S. Environmental Protection Agency (EPA). Impaired waters are those waters where water quality standards cannot be attained or maintained. The number of stream miles listed as impaired on the 303(d) list were calculated for each subwatershed. The scoring scheme for the impaired waterways data layer was determined using the Jenks method available in GIS.

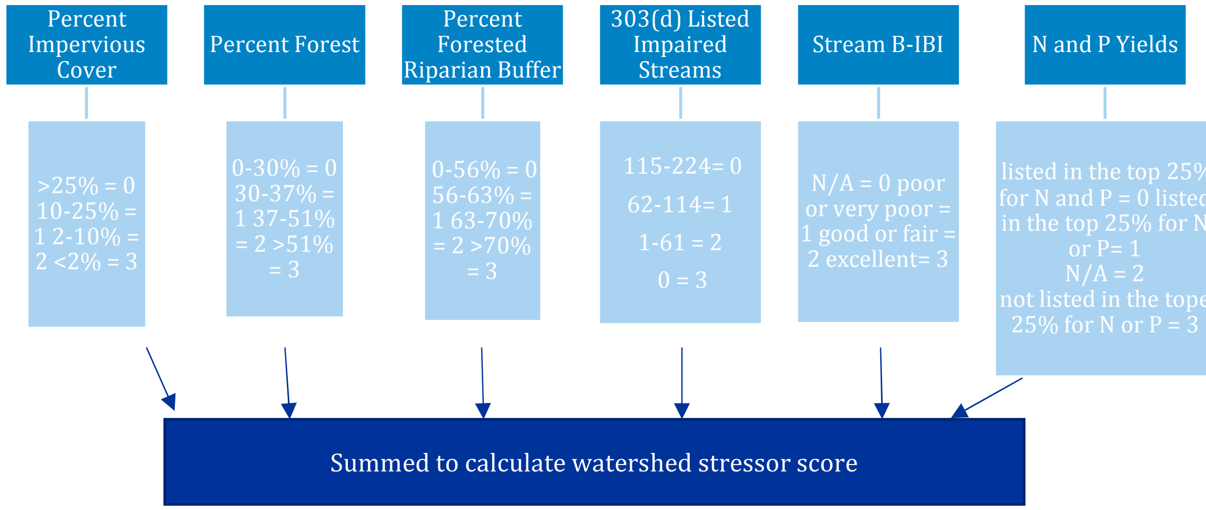
- *CBP Benthic Index of Biotic Integrity (B-IBI)* – Stream health is incorporated into the watershed screening by inclusion of the average Chesapeake Bay basin wide B-IBI. The B-IBI was developed from benthic macroinvertebrate data collected across the entire Chesapeake Bay Watershed and synthesized into a basin-wide evaluation by the CBP (CBP 2012). The average B-IBI was determined by subwatershed boundaries except in Pennsylvania and New York. In these two states, monitoring programs collected data from many "targeted" sampling sites (such as sites below an outfall of a pollutant source), as opposed to "random." These data were not included by CBP in the basin wide evaluation to avoid the presumed bias introduced by targeted site data (CBP 2012). CBP determined watershed B-IBI ratings in Pennsylvania and New York using the HUC 8 watershed boundaries, which are less certain because they are derived from fewer random/systematic sampling sites. Watershed stream health ratings were included in the watershed screening of this plan based on subwatershed boundaries. GIS was used to assign the subwatersheds in Pennsylvania and New York a rating from the CBP's HUC 8 watershed designations. The scoring scheme for the watershed screening of this plan was determined by assigning scores based on the health rating of the watershed.

- *Nitrogen and phosphorus yield projections from SPARROW modeling* – This dataset contains mean-annual incremental phosphorus (TP) fluxes and mean-annual incremental nitrogen (TN) fluxes predicted by the SPARROW models, CBTN_v4 and CBTP_v4, for individual stream and shoreline reaches in the Chesapeake Bay Watershed as defined by NHDPlus, a 1:100,000 scale representation of stream hydrography built upon the National Hydrography Dataset (NHD) (Horizon Systems 2010; Simley and Carswell 2010). Areas shown represent the top 25 percent of all Chesapeake Bay NHD catchments for phosphorus yields and nitrogen yields.

Conceptual diagram and computations: Individual data layers were assigned scores from 0 to 3 based on the criteria specified in **Table 3**. Scores were then totaled for all data layers into a final WSA score. The Jenks method was used to group the subwatersheds into categories based on the WSA score, and is depicted in **Figure 4**.

Table 3. Scoring framework for the Watershed Stressors Analysis

Parameter	Data Source	Metric	Scoring
Landuse (measures of landscape alterations from development)	Chesapeake Conservancy 2016	Percent impervious cover. Scoring based on MDNR General Guidelines for Impervious Surface Thresholds.	0 = >25% 1 = 10- 25% 2 = 2-10 % 3 = <2 %
	Chesapeake Conservancy 2016	Percent forest cover. Scoring based on goals set and relationships determined in USFS State of Chesapeake Forests (2006)	0 = 0-30% 1 =>30-37 2 =>37-51% 3 = >51
	EPA 2010 (Army Comp Plan)	Percent of stream network within subwatershed with forest (riparian buffer). Scoring based on goals set and relationships determined in USFS State of Chesapeake Forests (2006).	0 = 0-56% 1 = >56-63% 2 = >63-70% 3 = >70%
Stream health- water quality	303(d) Impaired waterways list (EPA)	Stream miles listed as impaired within subwatershed (scoring based on groups determined using Natural Breaks Method (Jenks) in GIS).	0 = 84.64 - 183.33 1 = 34.45 - 84.64 2 = 0.02 - 34.45 3 = 0
Stream health- biological integrity	Chesapeake Bay Program Benthic Index of Biotic Integrity 2000-2010 (watershed-wide B-IBI)	Subwatershed rating assigned by Chesapeake Bay Program based on B-IBI determined by stream monitoring.	0 = NA 1 = poor or very poor 2 = good or fair 3 = excellent
Nitrogen and Phosporus Impairments	SPARROW model output	Top 25 % of all Chesapeake Bay NHD catchments for nitrogen and phosphorus yields	0 = a subwatershed in the top 25% for N and P 1 = a subwatershed in the top 25% for N or P 3 = not a subwatershed in the top 25% for N or P


Percent Impervious Cover
Percent Forest
Percent Forested Riparian Buffer
303(d) Listed Impaired Streams
Stream B-IBI
N and P Yields
>25% = 0 10-25% = 1 2-10% = 2 <2% = 3
0-30% = 0 30-37% = 1 37-51% = 2 >51% = 3
0-56% = 0 56-63% = 1 63-70% = 2 >70% = 3
115-224= 0
62-114= 1
1-61 = 2
0 = 3
N/A = 0 poor or very poor = 1 good or fair = 2 excellent= 3
listed in the top 25% for N and P = 0 listed in the top 25% for N or P= 1
N/A = 2
not listed in the tope 25% for N or P = 3
Summed to calculate watershed stressor score

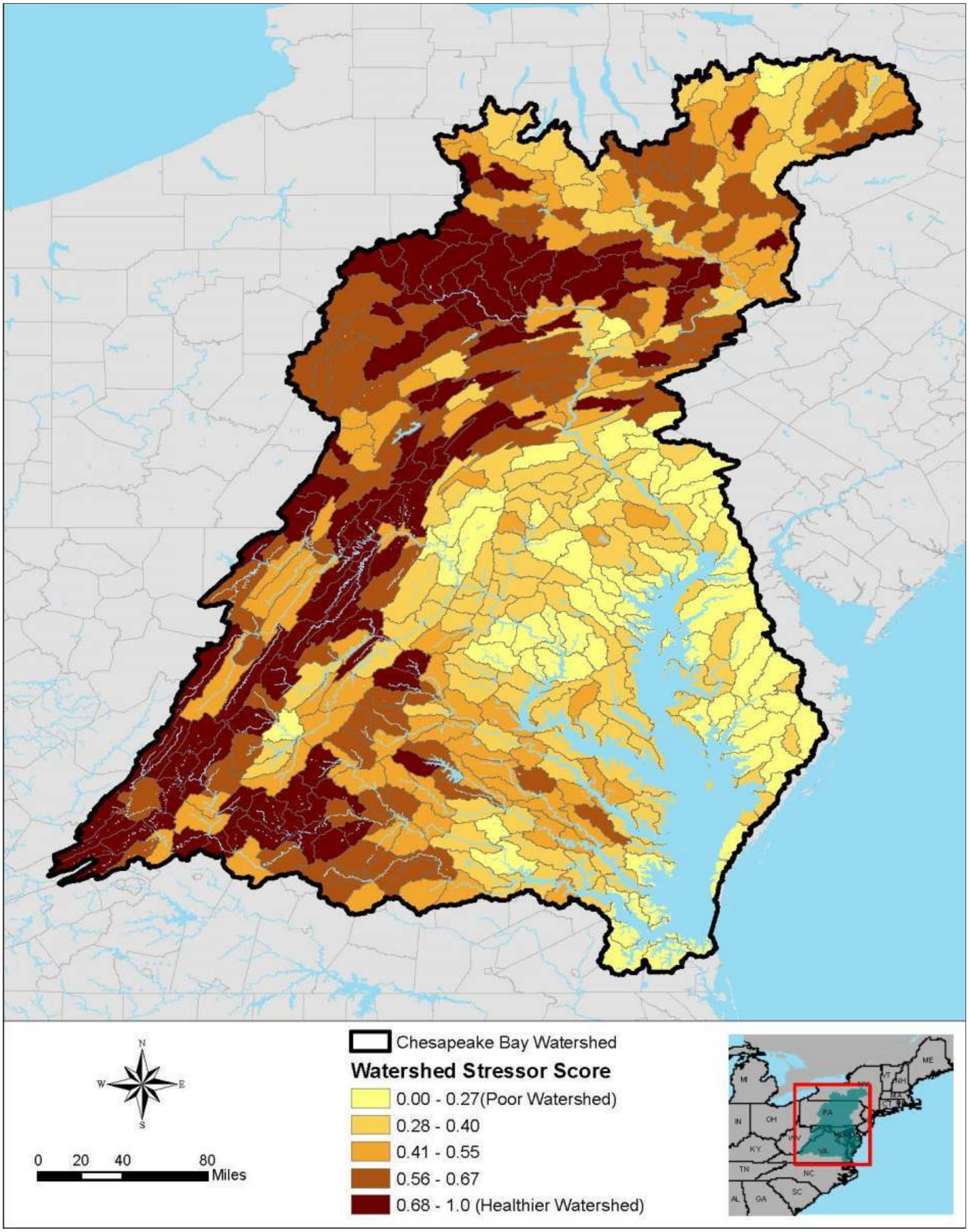


Figure 4. Watershed Stressors Analysis scores (CP-6-WSA)

Key points:

1. Watershed stressor scores generally follow patterns of development.
2. The least stressed regions of the watershed are generally in the western and northern subwatersheds, furthest from the mainstem of the Bay:
    - *Upper Susquehanna River Watershed in Pennsylvania*
    - *Upper Potomac River Watershed in West Virginia and western Virginia*
    - *Upper James River in Virginia*
3. Along the mainstem of the Bay, the least stressed subwatersheds are located in the Virginia portions in the York and James Rivers Watersheds.
4. The most heavily stressed subwatersheds are located:
    - *On the Eastern Shores of Maryland and Virginia and the Delmarva Peninsula in Delaware,*
    - *In the subwatersheds on the western shore of Maryland including the corridor from Baltimore, Maryland to the District of Columbia, and*
    - *The lower Susquehanna River Watershed in Pennsylvania.*
5. Subwatersheds in New York are moderately stressed in the Chemung River Watershed and other parts of the upper Susquehanna River Watershed.

Restoration Opportunities Analysis

3.6 Restoration Opportunities Analysis

The restoration opportunities analysis investigated a set of focused questions to identify spatially specific strategies and projects to assist with achieving 2014 Bay Agreement goals and outcomes and to optimize restoration and conservation efforts. These questions were developed and refined with stakeholder input. The results for each unique analysis is a set of subwatersheds, identified as *Opportunities*. Each geospatial evaluation identified the *Opportunities* as holding the greatest potential, need, or impairment, depending on the nature of the evaluation. Therefore, the *Opportunities* highlight those subwatersheds that provide the highest potential to support resiliency or address the specific 2014 Bay Agreement goal or outcome investigated by that evaluation. The initial results of this analysis were also refined with stakeholder input. The questions identified were:

1. Habitat Restoration: Where do opportunities exist to implement habitat restoration and enhancement opportunities (streams, freshwater fish, SAV, oysters, black duck, riparian buffer) to further the 2014 Bay Agreement goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, and community resilience benefits?

2. Wetlands Restoration: Where do opportunities exist to implement wetland restoration and enhancement opportunities and protect existing wetlands, maximize/optimize aquatic ecosystem restoration, flood risk management, beneficial use of dredged material, and community resilience benefits?
3. Connectivity: Where do opportunities exist to improve or enhance habitat connectivity and human connectivity to healthy habitats?
4. Conservation: Where do conservation opportunities exist to increase connectivity, enhance restoration success, and address social and economic vulnerabilities?
5. Shorelines and Streambanks: Where can shoreline and streambank opportunities for restoration and conservation be implemented to maximize/optimize aquatic ecosystem restoration and community resilience?
6. Toxic Contaminants: Can restoration and conservation opportunities within the watershed be leveraged to assist with addressing toxic contamination?

The following tables outline the analyses undertaken to investigate each respective question for restoration opportunities. The tables present the data layers used for each analysis and the output of those analyses. Results in bold represent direct inputs to the Restoration Roadmap. The Stream Restoration Analysis is provided as an example of the restoration analyses. The details of all analyses may be found in **Annex 2**.

3.6.1 Habitat Restoration

(1) Where do opportunities exist to implement habitat restoration and enhancement opportunities (e.g., riparian buffer, streams, freshwater fish, wetlands, SAV, oysters, black duck) to further the 2014 Bay Agreement goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, and community resilience benefits?

This series of questions is focused on identifying habitat restoration opportunities within the watershed and in the mainstem bay. It excludes wetlands, as they are the focus of Question #2. There are a number of components to this analysis.

Note: An analysis was attempted to investigate whether restoration for species with spatially targeted habitats within the 2014 Bay Agreement (black duck, eastern brook trout, fish passage blockages) could be co-located to benefit multiple species or goals. The following data were included: eastern brook trout (EBT) catchments, Black Duck Focus Areas, and fish passage prioritized blockages. The results of the analysis identified that there was little to no overlap of these resources; therefore, EBT is included here with the riparian and stream restoration considerations, and black duck is evaluated with wetlands.

Table 4. Habitat Restoration Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	Data Layers	Output	Code
Riparian Buffer Analysis	• Riparian buffer restoration opportunties • *Highest yielding N and P watersheds* • *Brook trout watersheds* • *National Fish Habitat Assessment* • *Trout Unlimited conservation strategies for EBT*	Acres of riparian buffer restoration *Opportunities* by subwatershed	1-HR-RFB-A
		Riparian buffer restoration *Opportunities* to benefit EBT habitat	1-HR-RFB-B1
		Riparian buffer restoration *Opportunities* to benefit resident fish habitat	1-HR-RFB-C
		Riparian buffer restoration *Opportunities* to address nitrogen and phosphorus loads	1-HR-RFB-D
		Compiled riparian buffer restoration *Opportunities*	**1-HR-RFB-E**
		Alignment of riparian buffer restoration *Opportunities* for EBT with Trout Unlimited conservation strategies	1-HR-RFB-B2

Table 4 cont. Habitat Restoration Analyses

Analysis	Data Layers	Output	Code
Stream Restoration Analysis	• *Brook trout watersheds* • *Extent of anadromous fish habitat* • *Watershed Stressors Analysis* • *National Fish Habitat Assessment* • *Trout Unlimited conservation strategies for EBT*	Stream restoration *Opportunities* to benefit EBT habitat	1-HR-SR-A
		Stream restoration *Opportunities* to benefit anadromous fish habitat	**1-HR-SR-B**
		Stream restoration *Opportunities* to benefit resident fish habitat	1-HR-SR-C
		Compiled stream restoration *Opportunities*	1-HR-SR-D
		Alignment of stream restoration *Opportunities* for EBT with Trout Unlimited conservation strategies and prioritized fish passage blockages	1-HR-SR-A2
Fish Passage Blockages Analysis	• *High prioritized fish passage blockages from CBP Fish Passage Workgroup* • *Stream Restoration Analysis results*	Fish passage prioritizations from the Chesapeake Bay fish passage prioritization tool	1-HR-FP-A
		High prioritized fish passage blockages (Tier 1 of three separate scenarios – EBT, diadromous fish, and resident fish scenarios) and watershed stressor scores	1-HR-FP-B
		High prioritized fish passage blockages for EBT (Tier 1 of CBP EBT Prioritization) tallied in opportunities for stream restoration to benefit EBT	1-HR-FP-C
		High prioritized fish passage blockages for anadromous fish (Tier 1 of CBP diadromous prioritization) tallied in opportunities for stream restoration to benefit anadromous fish	1-HR-FP-D
		High prioritized fish passage blockages for resident fish (Tier 1 of CBP resident fish prioritization) tallied in opportunities for stream restoration to benefit resident fish	1-HR-FP-E
		Stream restoration *Opportunities* compiled with associated prioritized fish passage blockages	1-HR-FP-F
Oyster Restoration Analysis	• *Oyster restoration data layer* • *Watershed stressors analysis*	**Oyster restoration watershed analysis**	**1-HR-OY-A**
SAV Restoration Analysis	• *Virginia Institute of Marine Sciences (VIMS) SAV Survey Data (1971–2015)* • *VIMS SAV Survey Data (2015)*	**SAV restoration *Opportunities***	**1-HR-SAV-C**

3.6.1.1 Stream Restoration Analysis (1-HR-SR) Example

Overview: To identify stream restoration opportunities to benefit:

a) EBT,

b) Anadromous fish, and

c) Resident fish.

Data layers:

- *Watershed Stressors Analysis* (description provided in Section 3.5.6, Watershed Stressors Analysis)
- *National Fish Habitat Assessment* – Moderate risk of current habitat degradation (description provided in Section 3.5.7, Threats Analysis)
- *Brook trout watersheds* – (description provided in Section 3.5.4, Healthy/high-value Habitats Analysis)
- *Extent of anadromous fish habitat* – Stream path accessible to anadromous fish from CBP (Fish Passage Prioritization Tool)
- *Trout Unlimited conservation strategies for EBT* (description provided in Section 3.6.1, Riparian Buffer Restoration Analysis)

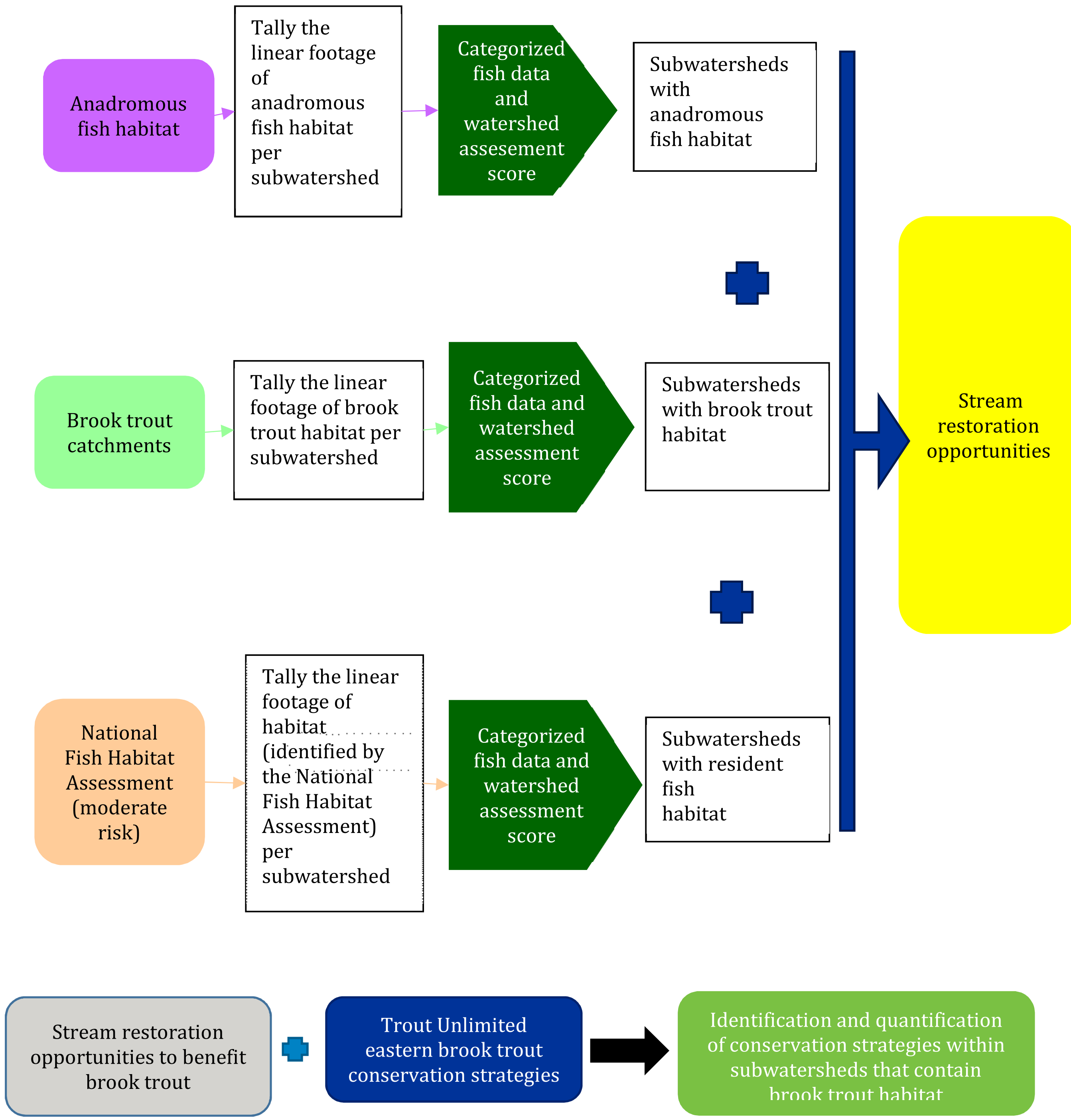
Conceptual diagram, computations, opportunity selection process: The Stream Restoration Analysis identified stream restoration opportunities that could benefit EBT, anadromous species, and resident fish species. The National Fish Habitat Assessment (moderate risk) was compiled with the Watershed Stressors Analysis to identify stream restoration opportunites that could benefit resident fish. The potential extent of EBT habitat was compiled with the Watershed Stressors Analysis to identify stream restoration opportunities that could benefit EBT. Subwatersheds that include anadromous fish habitat were compiled with the Watershed Stressors Analysis to identify subwatersheds where stream restoration could benefit anadromous fish.

The linear footage of streams containing anadromous fish habitat was quantified for each subwatershed. The linear footage of habitat (identified by the National Fish Habitat Assessment) at moderate risk was quantified for each subwatershed. Additionally, the linear footage of streams containing EBT habitat was quantified for each subwatershed. For each fish habitat dataset, the data layers were classified into five categories using the Jenks method in GIS based on the summed linear footage of habitat. The categorized dataset was then intersected with subwatersheds that received a watershed stressor score of >0.45 suggesting moderate to good conditions or a B-IBI of good or fair. These individual evaluations were then compiled together to produce one map that shows all of the subwatersheds targeted for stream restoration (stream restoration opportunities). The subwatersheds targeted in this map are color coded to reflect the fish that the opportunities could benefit.

Figures 5, 6, and 7 depict the tallied area of fish-specific data by subwatershed prior to application of the Watershed Stressors Analysis and identify those subwatershed that fall within the top two categories based on the Jenks method for each of the three objectives (a, b, and c), respectively.

Figure 8 compiles the subwatersheds with the results of the Watershed Stressors Analysis to consider the stress of a subwatershed for undertaking stream restoration. The 2014 Bay Agreement stream health outcome is focused on improving the health of degraded streams. As such, the stream restoration opportunities were further narrowed to identify those streams in the middle of the spectrum; that is, those with marginal health. Marginal health is defined by the CBCP as a Chessie-IBI of good or fair with a watershed assessment score >0.45. This provided a subset of 71 stream restoration opportunities within streams characterized as being in marginal health across the three objectives. **Table 5** provides a complete list of the stream restoration opportunities within streams characterized as being in marginal health (watershed assessment score >0.45 and an IBI of "good" or "fair").

Analyses were taken one step further for EBT opportunities. The conservation strategies developed by Trout Unlimited were considered within the context of the stream buffer opportunities identified by this analysis to benefit EBT (**Figure 9**). **Figure 9** was developed to portray the conservation strategies and the boundaries of the stream restoration opportunities for EBT. The conservation strategies were incorporated into the Restoration Roadmap to assist with prioritizing riparian buffer opportunities.


Anadromous fish habitat
Tally the linear footage of anadromous fish habitat per subwatershed
Categorized fish data and watershed assesement score
Subwatersheds with anadromous fish habitat
Brook trout catchments
Tally the linear footage of brook trout habitat per subwatershed
Categorized fish data and watershed assessment score
Subwatersheds with brook trout habitat
National Fish Habitat Assessment (moderate risk)
Tally the linear footage of habitat (identified by the National Fish Habitat Assessment) per subwatershed
Categorized fish data and watershed assessment score
Subwatersheds with resident fish habitat
Stream restoration opportunities
Stream restoration opportunities to benefit brook trout
Trout Unlimited eastern brook trout conservation strategies
Identification and quantification of conservation strategies within subwatersheds that contain brook trout habitat

Map products:

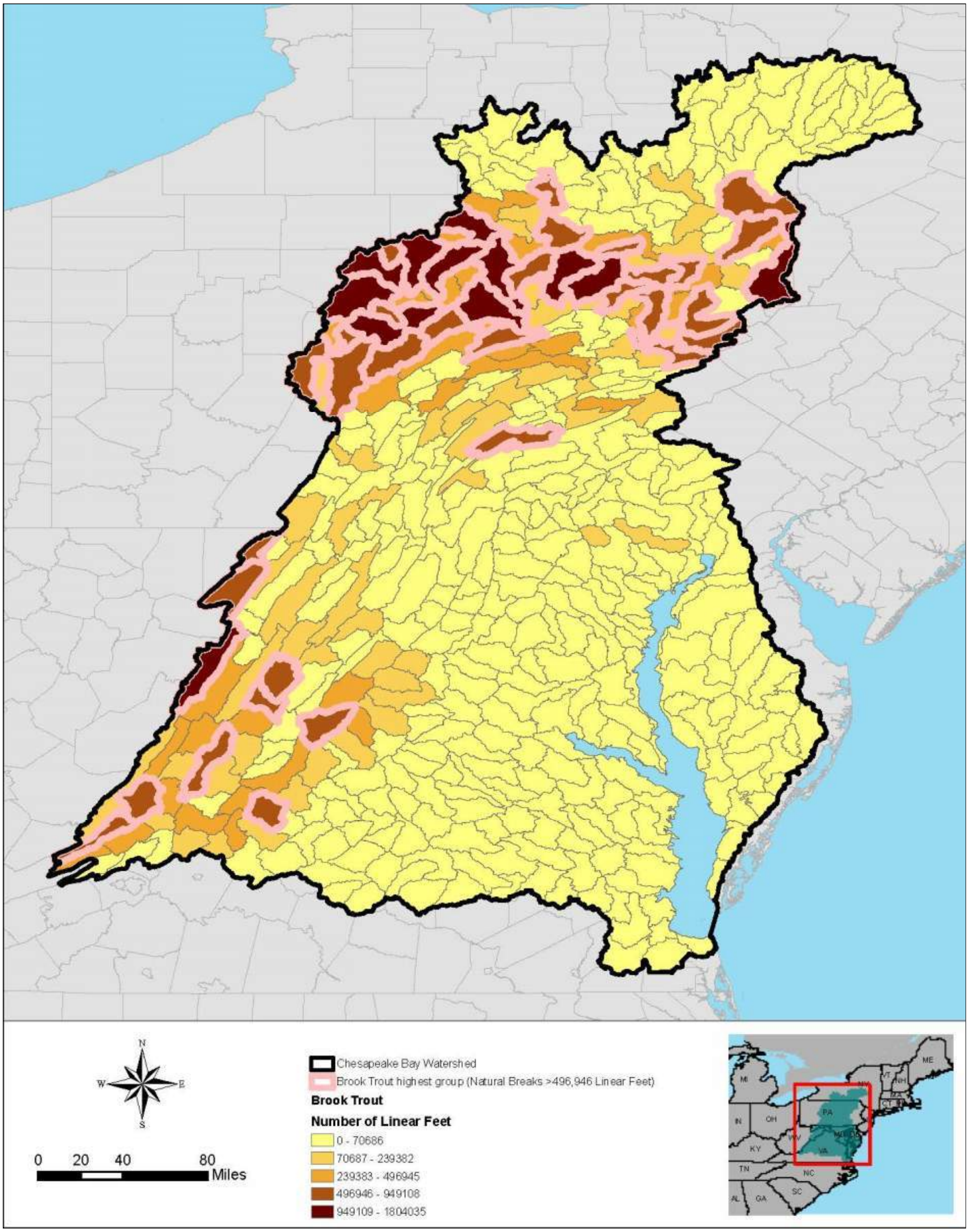


Figure 5. Stream restoration *Opportunities* to benefit EBT habitat (1-HR-SR-A)

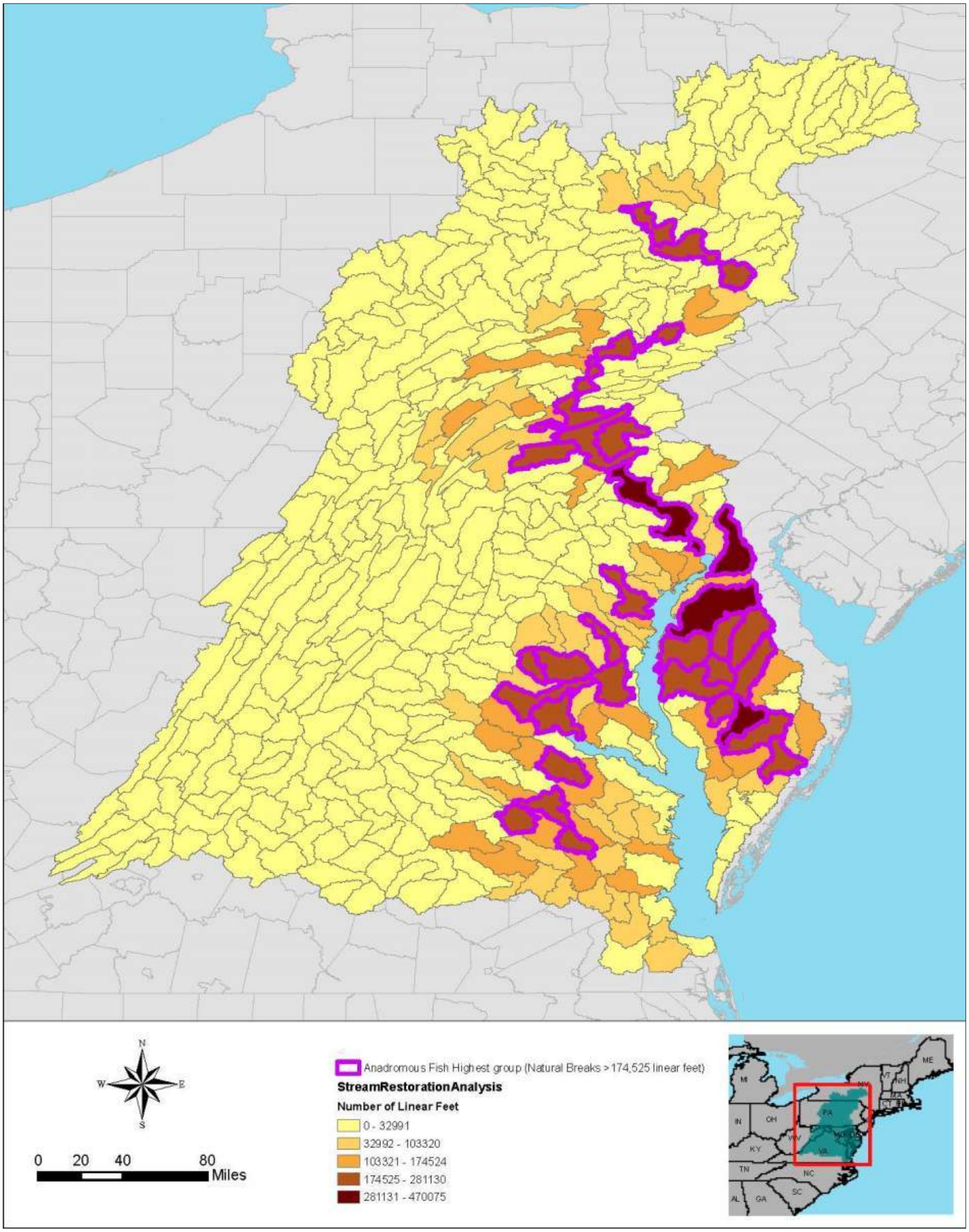


Figure 6. Stream restoration *Opportunities* to benefit anadromous fish habitat (1-HR-SR-B)

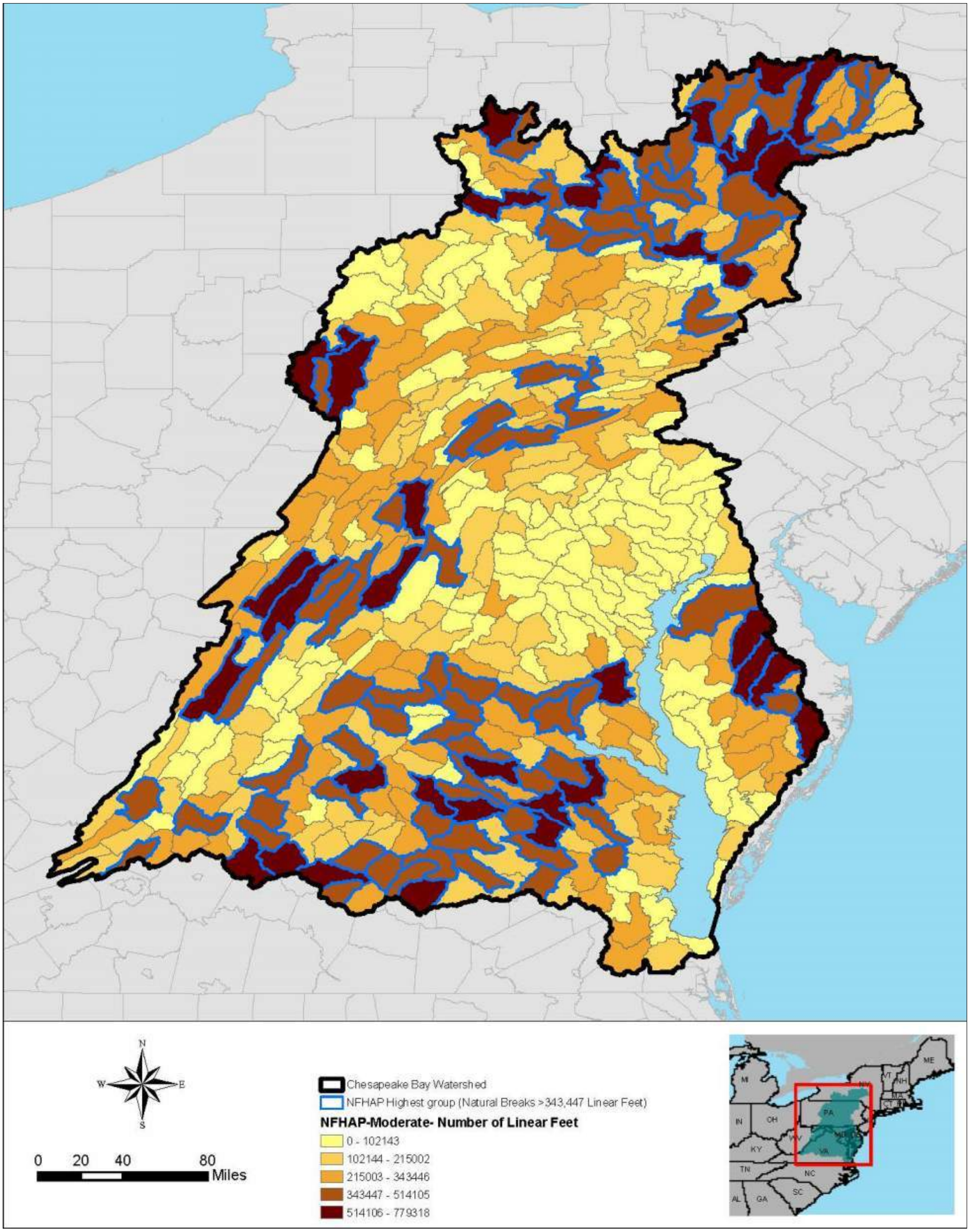


Figure 7. Stream restoration *Opportunities* to benefit resident fish habitat (1-HR-SR-C)

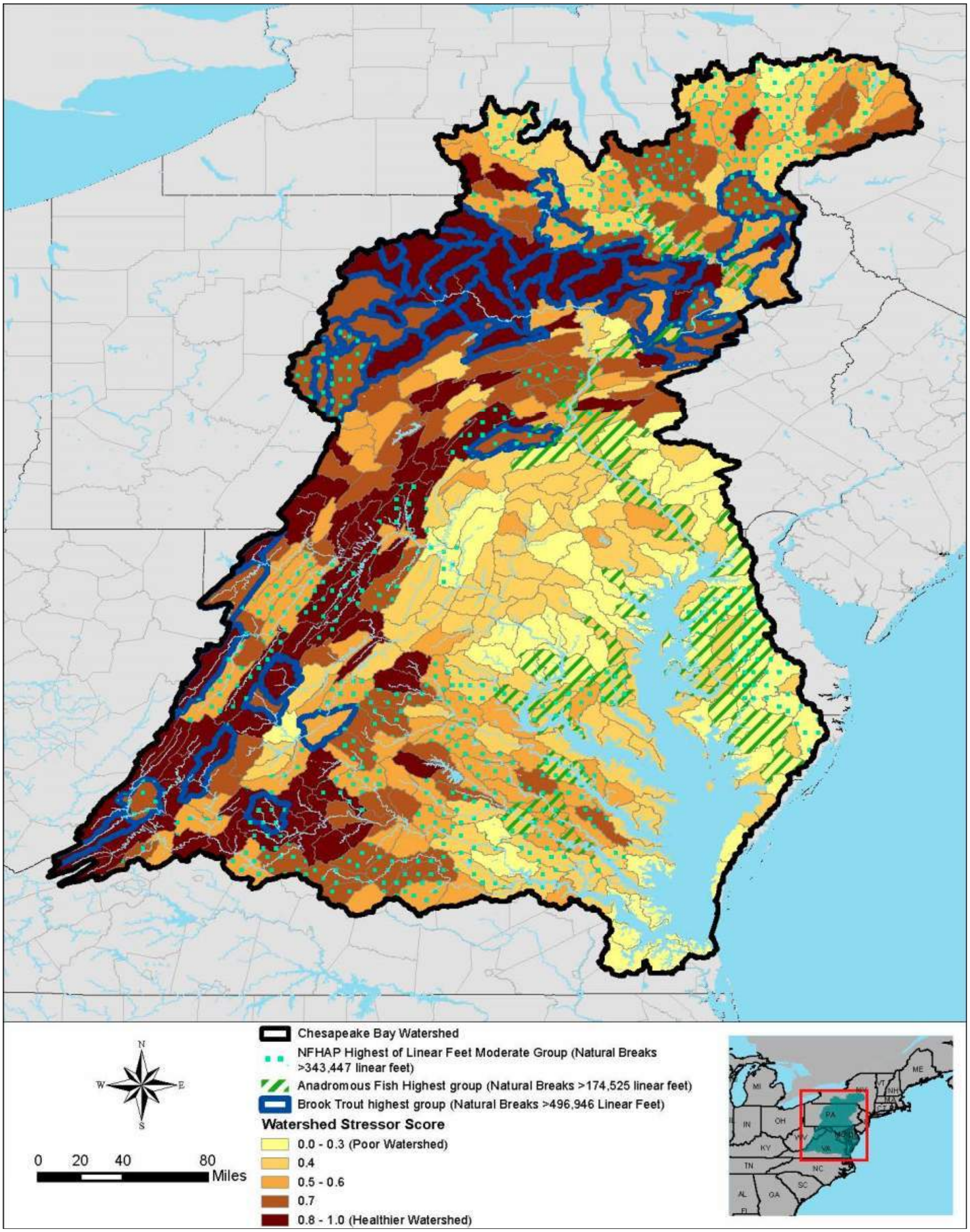


Figure 8. Compiled stream restoration *Opportunities* (1-HR-SR-D)

Table 5. Focused list of stream restoration opportunities for streams with marginal health.

atershed Nun	Subwatershed Name	STATES	Watershed Stressor Scores	Anadromous Fish (linear feet)	Brook Trout (Linear Feet)	National Fish Habitat Assesment - (Linear Feet)	IBI Scores
0208020104	Potts Creek	VA	0.83	0	515505	239334	GOOD
0208020201	Calfpasture River	VA	0.83	0	576241	81507	FAIR
0208020305	Upper Tye River	VA	0.78	0	676372	446989	FAIR
0208020306	Buffalo River	VA	0.78	0	107351	417872	FAIR
0207000307	Cacapon River	WV	0.78	0	239382	413286	FAIR
0207000302	Little Cacapon River	WV	0.78	0	6251	345150	FAIR
0205020602	Lycoming Creek	PA	0.78	0	1121430	269173	FAIR
0205020403	Fishing Creek	PA	0.78	0	828169	242094	FAIR
0205020204	First Fork Sinnemahoning Creek	PA	0.78	0	1653693	107261	GOOD
0205020402	Beech Creek	PA	0.78	0	773448	79373	FAIR
0205010609	Mehoopany Creek	PA	0.78	0	614422	72516	FAIR
0207000601	Shoemaker River-North Fork Shenandoah	VA	0.78	0	645626	58499	GOOD
0205020201	Sinnemahoning Portage Creek	PA	0.78	0	514463	25875	GOOD
0207000403	Licking Creek	MD,PA	0.72	0	0	608348	FAIR
0207000401	Tonoloway Creek	MD,PA	0.72	0	0	495136	GOOD
0208020312	Hardware River	VA	0.72	0	0	405693	FAIR
0207000306	North River	WV	0.72	0	22604	394574	FAIR
0207000105	South Fork South Branch Potomac River	VA,WV	0.72	0	213873	363160	GOOD
0205030409	Tuscarora Creek	PA	0.72	56772	79197	349682	FAIR
0205020105	Moshannon Creek	PA	0.72	0	717539	321381	FAIR
0207000101	North Fork South Branch Potomac River	VA,WV	0.72	0	1276369	271150	GOOD
0205020505	Little Pine Creek	PA	0.72	0	949108	161752	FAIR
0205020502	Upper Pine Creek	PA	0.72	0	1170368	122284	FAIR
0205020304	Lower West Branch Susquehanna River	PA	0.72	0	1336607	116706	FAIR
0205020608	Muncy Creek	PA	0.72	0	512567	114865	GOOD
0205020301	Kettle Creek	PA	0.72	0	1442818	97311	GOOD
0205020506	Lower Pine Creek	PA	0.72	0	1320049	60027	FAIR
0205020202	Driftwood Branch Sinnemahoning Creek	PA	0.72	0	1369107	58501	GOOD
0207000404	Back Creek	VA,WV	0.67	0	0	754506	FAIR
0208020702	Vaughans Creek-Appomattox River	VA	0.67	0	0	706597	FAIR
0205030501	Sherman Creek	PA	0.67	81766	617716	474366	FAIR
0208020502	Upper Willis River	VA	0.67	0	0	468710	FAIR
0208020113	Catawba Creek	VA	0.67	0	0	378108	GOOD
0208020105	Lower Jackson River	VA	0.67	0	801641	369675	GOOD
0205020603	Upper Loyalsock Creek	PA	0.67	0	754078	24665	FAIR
0207000505	Dry River	VA	0.67	0	539017	15955	GOOD
0208020304	Wreck Island Creek-James River	VA	0.61	0	0	639472	FAIR
0205010603	Towanda Creek	PA	0.61	0	256269	459863	FAIR
0205010305	Pipe Creek-Susquehanna River	NY	0.61	90396	115888	438116	FAIR
0208010607	Little River	VA	0.61	0	0	414641	FAIR
0208010304	Hazel River	VA	0.61	0	146226	407775	GOOD
0208010309	Robinson River	VA	0.61	0	78476	407340	FAIR
0205030103	Middle Creek	PA	0.61	0	195923	382805	FAIR
0208010504	Maracossic Creek	VA	0.61	74	0	374935	FAIR
0205010303	Catatonk Creek	NY	0.61	0	0	354667	FAIR
0208010202	Dragon Swamp	VA	0.61	68036	0	347050	FAIR
0208020704	Big Guinea Creek-Appomattox River	VA	0.61	0	0	345715	FAIR
0205010408	Cowanesque River	NY,PA	0.56	0	275480	762883	GOOD
0207000106	Lower South Branch Potomac River	WV	0.56	0	105638	761129	FAIR
0207000207	Patterson Creek	WV	0.56	0	57381	757969	FAIR
0207000103	Upper South Branch Potomac River	VA,WV	0.56	0	496945	624296	GOOD
0208010502	Matta River-Mattaponi River	VA	0.56	8350	0	604585	FAIR
0208010602	Middle South Anna River	VA	0.56	0	0	534376	FAIR
0205010409	Tioga River	NY,PA	0.56	0	819559	451328	GOOD
0208010501	Poni River	VA	0.56	0	0	440294	GOOD
0205010506	Lower Chemung River	NY,PA	0.56	101825	0	414211	FAIR
0205010307	Wappasening Creek-Susquehanna River	NY,PA	0.56	81483	0	409811	FAIR
0205010612	Tunkhannock Creek	PA	0.56	0	512948	401037	FAIR
0205010101	Canadarago Lake	NY	0.56	0	0	389504	FAIR
0207000507	South River	VA	0.56	0	465145	373001	FAIR
0208020205	Lower Maury River	VA	0.56	0	294257	370187	GOOD
0205010707	Fishing Creek	PA	0.56	0	756932	203426	FAIR
0205010614	Lower Susquehanna River	PA	0.50	281130	119119	659645	FAIR
0208010505	Chapel Creek-Mattaponi River	VA	0.50	181453	0	582115	FAIR
0208010610	Middle Pamunkey River	VA	0.50	123161	0	533388	FAIR
0207001104	Zekiah Swamp Run	MD	0.50	45910	0	447857	FAIR
0208010306	Marsh Run-Rappahannock River	VA	0.50	84568	0	414181	GOOD
0208010608	Northeast Creek-North Anna River	VA	0.50	61803	0	413411	FAIR
0208010311	Mine Run-Rapidan River	VA	0.50	0	0	367038	GOOD
0205030110	Susquehanna River	PA	0.50	216066	90875	362818	FAIR
0208010611	Lower Pamunkey River	VA	0.50	190304	0	157702	FAIR

US Army Corps of Engineers

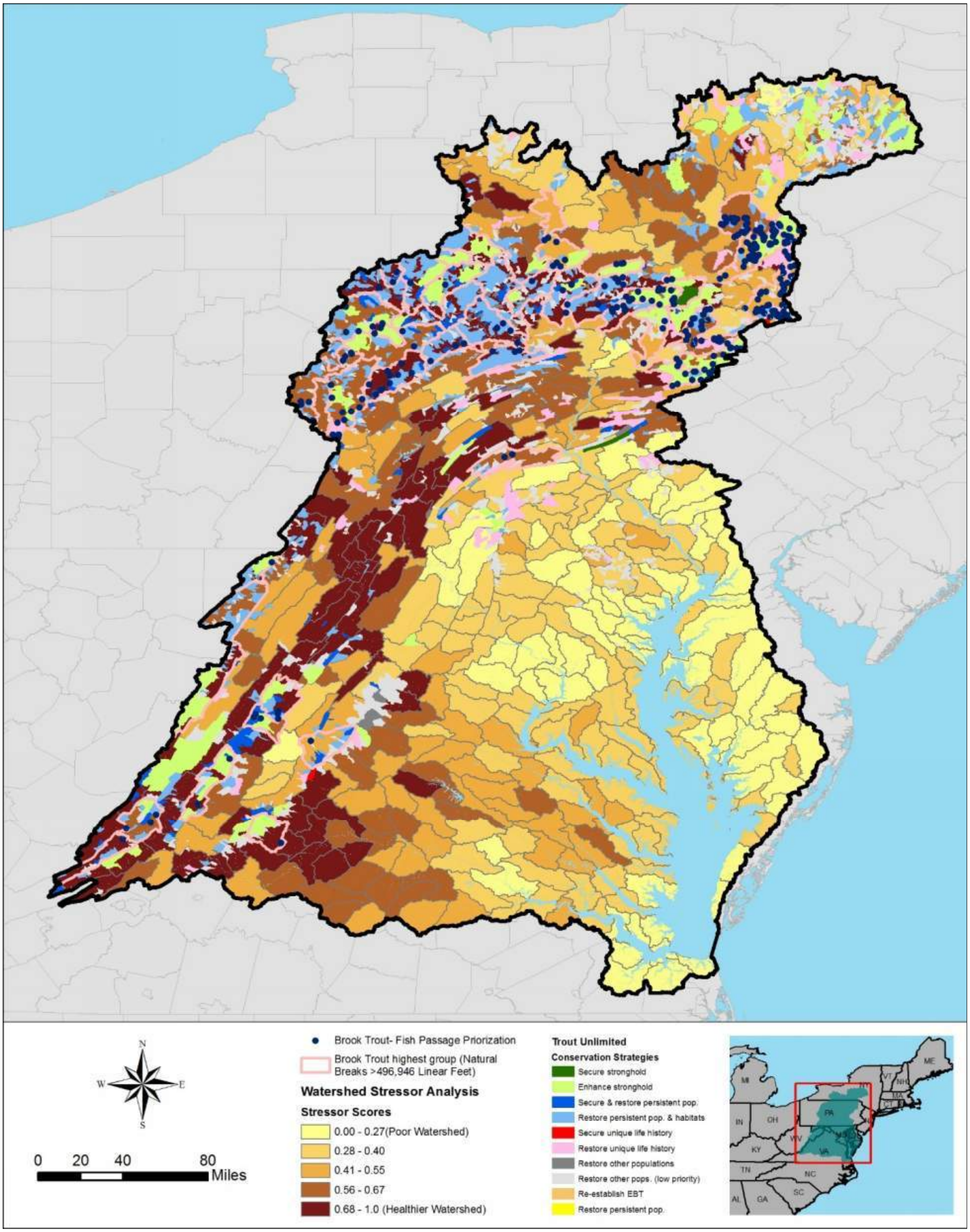


Figure 9. Alignment of stream restoration *Opportunities* for EBT with Trout Unlimited conservation strategies and prioritized fish passage blockages (see next section for explanation of blockages) (1-HR-SR-A2)

The CBCP Master Results Database identifies stream restoration opportunities for each of the three objectives, IBI scores, and watershed assessment scores.

Key points:

1. The analysis identified that watershed assessment scores were highest (least stressed subwatershed) in:
   a) Subwatersheds with opportunities to benefit EBT habitat in the upper Susquehanna River and the West Branch Susquehanna River in Pennsylvania and in the western portions of the watershed in Virginia and West Virginia.
   b) Subwatersheds with opportunities to benefit resident fish in the Potomac River of western Maryland, Pennsylvania, and West Virginia; upper James River in Virginia; the Upper Susquehanna, western subwatershed in the West Branch Susquehanna, and the central subwatershed in the Lower Susquehanna in Pennsylvania, and throughout the Upper Susquehanna in New York.
2. Subwatersheds exhibit higher stress levels in subwatersheds with opportunities to benefit habitat for anadromous fish along the mainstem of Maryland's Chesapeake Bay and the lower Susquehanna River in Pennsylvania.
3. Subwatersheds on Maryland's Eastern Shore that have opportunities for stream restoration to benefit resident and anadromous fish also are stressed.
4. Subwatersheds in Virginia in the lower Rappahannock, York, and James Rivers for resident and anadromous fish have moderate stress levels.
5. USACE would be most suited to pursue stream restoration for habitat improvements in those subwatersheds with low stressors such as those in New York, in the northern and western Pennsylvania portions of the watershed, western Maryland, West Virginia, and the western half of Virginia in the bay watershed.
6. There are stream restoration opportunities in stressed subwatersheds that could target watershed stressors and greatly benefit the health of those watersheds.
7. There are Trout Unlimited EBT conservation strategies identified for catchments within identified stream restoration opportunities. This information has potential for siting projects on a smaller scale with follow-up investigations.

3.6.2 Wetlands Restoration

(2) Where do opportunities exist to implement wetland restoration opportunities and protect existing wetlands to further Chesapeake Bay Agreement 2014 Goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, beneficial use of dredged material, and community resilience benefits?

This series of questions is focused on identifying wetland restoration opportunities within the watershed and in tidal regions where wetlands could be restored to benefit wildlife, incorporate beneficial use of dredged material, and where wetlands and restoration opportunities are at risk to future threats.

Table 6. Wetland Restoration Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	*Data Layers*	Output	Code
Identify Wetland Restoraton and Enhancement Opportunities	• *High resolution land cover data* • *USGS Digital Elevation Model* • *CBP hydric soils layers*	**Nontidal wetlands restoration *Opportunities*: Total acres by subwatershed**	**2-WR-A**
		Tidal wetlands restoration *Opportunities*: Total acres by subwatershed	**2-WR-B**
		Nontidal wetlands enhancement *Opportunities*: Total acres by subwatershed	2-WR-D
		Tidal wetlands enhancement *Opportunities*: Total acres by subwatershed	2-WR-E
Identify those wetland restoration opportunities that can benefit avian wildlife	• *Tidal and nontidal wetlands restoration opportunities* • *Nesting locations for wading birds and water birds* • *CBP Black Duck Focus Areas* • *Audubon Important Bird Areas*	**Tidal wetland restoration *Opportunities* to benefit avian wildlife analysis**	**2-WR-AV-A**
		Nontidal wetland restoration *Opportunities* that benefit avian wildlife within subwatersheds	2-WR-AV-B
		Wetland restoration *Opportunities* (tidal and nontidal combined) targeting Black Duck Focus Areas within subwatersheds	2-WR-AV-C
Identify those wetland restoration opportunities that can benefit imperiled species	• *Tidal and nontidal wetlands restoration and enhancement compilation* • *Nature's Network imperiled species dataset*	Overlap of imperiled species habitat and tidal wetland restoration *Opportunities*	2-WR-IMP-A
		Overlap of imperiled species habitat and tidal wetland enhancement *Opportunities*	2-WR-IMP-B
		Overlap of imperiled species habitat and nontidal wetland restoration *Opportunities*	2-WR-IMP-C
		Overlap of imperiled species habitat and nontidal wetland enhancement *Opportunities*	2-WR-IMP-D

Table 6 cont. Wetland Restoration Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	Data Layers	Output	Code
Identify where potential wetland restoration projects exist that provide an opportunity to beneficially use dredged material	• *USACE navigation projects* • *Tidal and nontidal wetlands restoration and enhancement opportunities*	***Opportunities* for using dredged material to restore and enhance tidal wetlands**	**2-WR-NAV-A**
		***Opportunities* for utilizing dredged material to restore and enhance nontidal wetlands**	**2-WR-NAV-B**
Threats analysis of wetlands	• *Threats Analysis* • *Wetlands restoration and enhancement compilation*	Wetland restoration *Opportunities* at risk to nontidal threats	2-WR-TH-A
		Wetland enhancement *Opportunities* at risk to nontidal threats	2-WR-TH-B
		Wetland restoration *Opportunities* at risk to tidal threats	2-WR-TH-C
		Wetland enhancement *Opportunities* at risk to tidal threats	2-WR-TH-D

3.6.3 Connectivity

(3) Where do opportunities exist to improve habitat connectivity and human connectivity to healthy habitats?

This series of questions is focused on identifying opportunities within the watershed to improve habitat connectivity by considering fish passage blockages, existing healthy habitat locations, and their relation to proposed restoration opportunities, as well as risks to those resource from future threats.

Table 7. Connectivity Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	*Data Layers*	Output	Code
Where are current healthy habitats at risk to future threats	• *Healthy/High-value Habitats Analysis* • *Threats Analysis*	**Healthy/high-value habitat at risk to nontidal threats**	**3-CNT-HHVH-A**
		Healthy/high-value habitat at risk to tidal threats	**3-CNT-HHVH-B**
Improve and maintain human connections to the natural environment	• *Socioeconomic analysis* • *Habitat restoration compilation* • *Wetlands restoration and enhancement compilation* • *Threats analysis*	Wetland restoration opportunities co-located with socioeconomic resources	3-CNT-SOC-A
		Wetland and habitat restoration opportunities co-located with socioeconomic resources	3-CNT-SOC-B
		Wetland enhancement opportunities co-located with socioeconomic resources	3-CNT-SOC-C
		Wetland enhancement and habitat restoration opportunities co-located with socioeconomic resources	3-CNT-SOC-D
		Socioeconomic resources facing nontidal threats	3-CNT-SOC-E
		Socioeconomic resources facing tidal threats	3-CNT-SOC-F

3.6.4 Conservation

(4) Where do conservation opportunities exist to increase connectivity, enhance restoration success, and address social and economic vulnerabilities?

This series of questions is focused on identifying areas adjacent to healthy habitats that are currently not preserved. Other socioeconomic benefits such as proximity to source water protection areas, etc. will be considered to provide added societal benefits.

Table 8. Conservation Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	*Data Layers*	Output	Code
Conservation opportunities	• *Healthy/high-value habitats analysis* • *Protected lands layer from CBP* • *Habitat restoration compilation* • *Wetlands restoration and enhancement*	**Conservation *Opportunities* by subwatershed**	**4-CSV-A**
		Conservation and combined wetland restoration (tidal and nontidal) opportunities comparison to habitat restoration opportunities	4-CSV-B
		Conservation and combined wetland enhancement opportunities comparison to habitat restoration opportunities	4-CSV-C
		Conservation and tidal wetland restoration opportunities comparison to habitat restoration opportunities	4-CSV-D
		Conservation and tidal wetland enhancement opportunities comparison to habitat restoration opportunities subwatersheds	4-CSV-E
		Conservation and nontidal wetland restoration opportunities comparison to habitat restoration opportunities	4-CSV-F
		Conservation and nontidal wetland enhancement opportunities comparison to habitat restoration opportunities	4-CSV-G
Consider opportunities to provide added societal benefits	• *Conservation opportunities* • *Socioeconomic analysis*	**Analysis of conservation opportunities and socioeconomic resources**	**4-CSV-SOC-A**
Threat reduction potential	• *Conservation opportunities* • *Threats analysis*	**Conservation opportunities at risk to nontidal threats**	**4-CSV-TH-A**
		Conservation opportunities at risk to tidal threats	4-CSV-TH-B

3.6.5 Shorelines and Streambanks

(5) Where can shoreline opportunities for restoration and conservation be implemented to maximize/optimize aquatic ecosystem restoration and community resilience?

Note: Initially, the intention was to incorporate streambank erosion along with shoreline evaluations. However, no comprehensive dataset focused on eroding streambanks was identified.

Table 9. Shorelines and Streambanks Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	*Data Layers*	Output	Code
Identify opportunities where shoreline erosion projects could be undertaken to protect habitat	• *Eroding shoreline* • *Habitat restoration compilation* • *Wetlands restoration and enhancement* • *Conservation opportunities compilation*	**Acreage affected by shoreline erosion by subwatershed**	**5-SS-ERO-A**
		***Opportunities* for considering shoreline erosion with wetland restoration: Acreage of combined wetland restoration opportunities affected by shoreline erosion by subwatershed**	**5-SS-ERO-B**
		***Opportunities* for considering shoreline erosion with tidal wetland restoration: Acreage of tidal wetland restoration opportunities affected by shoreline erosion by subwatershed**	**5-SS-ERO-C**
		Opportunities for considering shoreline erosion with nontidal wetland restoration: Acreage of nontidal wetland restoration opportunities affected by shoreline erosion by subwatershed	5-SS-ERO-D
		Opportunities for considering shoreline erosion with wetland enhancement: Acreage of combined wetland enhancement opportunities affected by shoreline erosion by subwatershed	5-SS-ERO-E
		Opportunities for considering shoreline erosion with tidal wetland enhancement: Acreage of tidal wetland enhancement opportunities affected by shoreline erosion by subwatershed	5-SS-ERO-F
		Opportunities for considering shoreline erosion with nontidal wetland enhancement: Acreage of nontidal wetland enhancement opportunities affected by shoreline erosion by subwatershed	5-SS-ERO-G
		Opportunities for considering shoreline erosion with conservation: Acreage of conservation opportunities affected by shoreline erosion by subwatershed	5-SS-ERO-H
Identify if any areas targeted for stream restoration could incorporate features to reduce future risks	• *Stream restoration opportunities* • *Threat analysis*	Stream restoration opportunities at risk to future nontidal threats	5-SS-SR

3.6.6 Toxic Contaminants

(6) Can restoration and conservation opportunities within the watershed be leveraged to assist with addressing toxic contamination?

Table 10. Toxic Contaminants Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	*Data Layers*	Output	Code
Are there opportunities to address toxic contaminants?	• *NPL (Superfund Sites)* • *Abandoned mines and Abandoned Mine Land Problem Areas (PA)*	**Locations of superfund sites and abandoned mine land problem areas and reclamation projects**	**6-TOX-A**
		Military lands in conjunction with 'final' listings of NPL sites	6-TOX-B

3.7 Other Considerations

Other Considerations

3.7.1 Eastern Brook Trout

Analyses were taken one step further for EBT opportunities. The conservation portfolio developed by Trout Unlimited was considered within the context of the opportunities this analysis identified for stream restoration opportunities to benefit EBT. The acreage of each conservation strategy was tallied within each subwatershed. A map was developed to portray the conservation strategies and the boundaries of the stream restoration opportunities for EBT. The conservation strategies were incorporated into the Strategic Roadmap to assist with prioritizing between stream restoration opportunities.

Additionally, the CBCP evaluated the conservation portfolio to align recommendations based on how each strategy was defined (Fessenmeyer et al. 2017).

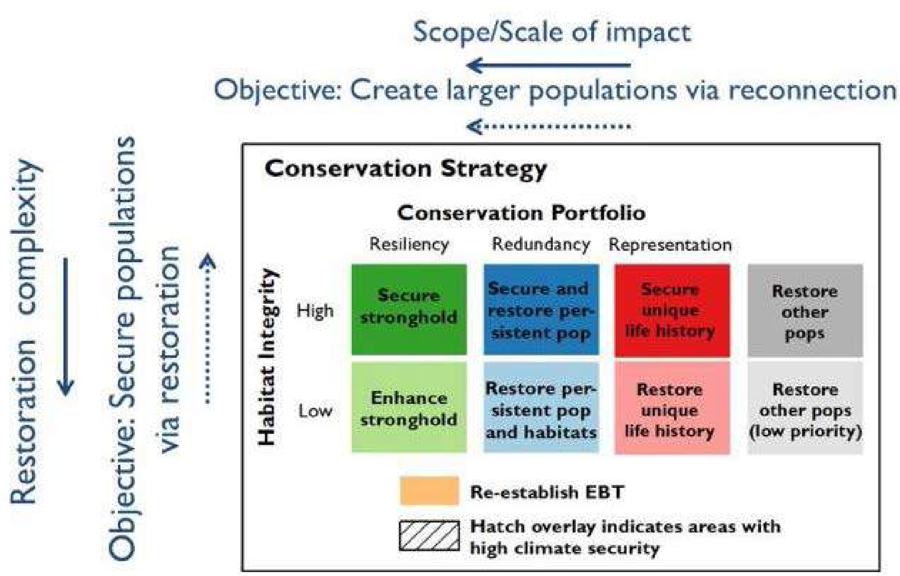


Figure 10. Eastern brook trout conservation portfolio (reproduced from Fessenmeyer et al. 2017)

The conservation portfolio assigned existing EBT patches to one of the following strategies identified in **Figure 10** and defined below. The aim of the conservation strategy is to address stressors and habitat needs in patches to increase habitat integrity and achieve resilience (move patches along the grid shown in **Figure 85** up and to the left). Towards that effort, the restoration opportunities that the CBCP identified in EBT patches (stream restoration, riparian buffer restoration, fish passage blockage removal, and management of watershed stressors) were evaluated in the context of the conservation portfolio strategies. Proposed actions to benefit EBT are presented in the following discussion for each of the conservation portfolio strategies focused on EBT restoration.

Secure stronghold strategy: Limited restoration action likely required to secure these populations. Conservation, protection to prevent new stressors, mitigation of future threats.

- CBCP Proposed Action – Identify conservation opportunities in opportunities with these patches.

Enhance stronghold strategy: Restoration focused on addressing existing stressors within these patches.

- CBCP Proposed Actions – Identify stressors using watershed stressors analysis and recommend measures to address stressors. Select WSA = 0.45–0.7, determine what the impairments are and recommend measures to improve conditions. If WSA ≥0.8, but IBI is fair, poor, or very poor, suggest stream (habitat) restoration.

Secure unique life history: Assigned to patches which do not meet portfolio redundancy and resiliency criteria, but which may contain unique life histories

- Comp Plan Proposed Action – conservation

Secure and restore persistent populations strategy: Restoration through non-native trout eradication or connectivity enhancements, limited habitat restoration efforts, remove fish blockages to connect larger blocks of habitat

- CBCP Recommendation – Primary actions are focused on increasing connectivity by removal of fish passage blockages. Identify if there are fish passage blockage removal opportunities by incorporating the number of EBT prioritized blockages. Select opportunities subwatersheds where “secure and restore persistent pops and habitat” (dark and light blue patches), overlay EBT prioritized fish passage blockages. Recommend consideration of habitat restoration if WSA > 8.0 and possible restoration if between 0.45–0.7. Also, recommend consideration of non-native trout eradication.

Restore persistent populations and habitats strategy: restoration through non-native trout eradication; likely with concurrent habitat restoration work (*Sequencing/dependency), remove fish blockages to connect larger blocks of habitat

- Comp Plan Proposed Action – Identify stream restoration for EBT opportunities with ‘unstressed’ conditions by selecting those with WSA = 0.8-1.0. Recommend these subwatersheds for stream (habitat) restoration and non-native trout eradication. Identify if there are fish passage blockage removal opportunities by incorporating the number of prioritized blockages. Determine if there are riparian buffer opportunities based on whether the subwatershed was a riparian buffer opportunity for EBT.

Restore unique life history: Provide opportunity for population and habitat restoration work to shift patches into redundant category

Comp Plan Proposed Action – stream restoration

Actionable measures were identified for opportunities using the conservation portfolio strategies and the watershed stressors analysis. Individual subwatersheds often contain patches that are classified into different strategies by the EBT conservation portfolio. Proposed actions incorporate the recommendations and strategies outlined in the Partnerhsip's management strategy for EBT and stream restoration, riparian buffer restoration, and fish passage blockage removal opportunity analyses undertaken as part of this CBCP.

3.7.2 Marsh Migration

As sea levels rise, the ability of a marsh to migrate inland will be an important factor determining the future location of tidal wetlands. NOAA (2015) developed a model based on previous work by The Nature Conservancy that evaluates the potential for tidal wetlands to migrate inland. A cost distance approach was taken that considers elevation and land use adjacent to existing wetlands to estimate the inland migration potential. The results of NOAA's modeling were incorporated with CBCP analyses as described below. The intent was to identify where wetland restoration opportunities should consider inland migration corridors.

Table 11. Marsh Migration Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	Data Layers	Output	Code
Marsh Migration	• *Existing wetlands layer* • *Migration/cost corridor data* • *Tidal wetland restoration opportunity* • *Threats to existing tidal wetlands opportunity*	Marsh migration modeling by NOAA (2015) and existing wetlands	7-MM-A
		Total acres by subwatershed projected to have a low cost for marsh migration	7-MM-B
		Overlap of threatened, existing wetlands, and low-cost migration corridors	7-MM-C
		Extent of opportunities to undertake wetlands restoration within migration corridors	**7-MM-D**

3.7.3 Rare, Threatened and Endangered Species

USFWS identified the presence of rare, threatened, and endangered (RTE) or T&E species and species of concern by subwatershed. To identify restoration and conservation opportunities that could be undertaken to enhance the habitat for these species, an assessment was made to identify whether these species were aquatic species. If an aquatic species, it was determined which were associated with streams or wetlands.

Table 12. Rare, Threatened, and Endangered Species Analyses.

Analysis	Data Layers	Output	Code
Rare, Threatened, and Endangered Species	• *Presence of rare, threatened, and endangered species (USFWS)* • *Species of concern (USFWS)* • *Wetland restoratoin opportunities* • *Stream restoration opportunities*	Spatial distribution of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed	7-RTE-A
		Spatial distribution and number of aquatic species by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed	7-RTE-B
		Spatial distribution and number of species associated with stream environments by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed	7-RTE-C
		Spatial distribution and number of wetland species by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed	7-RTE-D
		Opportunities focused on wetland restoration to benefit T&E and critical species	7-RTE-E
		Opportunities focused on stream restoration to benefit T&E and critical species	7-RTE-F
		Comparison of conservation opportunity locations to benefit federally listed rare, threatened, and endangered species and critical species (identified by USFWS) within the Chesapeake Bay Watershed	7-RTE-G

3.7.4 Road Crossings

A number of human activities can disrupt the continuity of river and stream ecosystems. The most familiar human-caused barriers are road crossings and dams, which impact the stream ecosystems in similar ways. Using the Chesapeake Fish Passage Prioritization Tool, the Chesapeake Bay Fish Passage Workgroup (FPWG) was successful in prioritizing nearly 5,000 dams in the Chesapeake Bay Watershed for their potential removal that for the benefit of anadromous fish. In general, high priority dams targeted for future removal have anadromous fish present downstream of the dam and open more high-quality habitat than lower priority dam removals (**Figure 97**). Future priority dam removal projects tend to be clustered closer to the Chesapeake Bay than in headwater areas since the target species include anadromous fish such as river herring and American shad. Prioritization has been completed for EBT and resident fish passage and has been used to determine the highest priority dams for removal in headwater and higher gradient streams.

Table 13. Road Crossings Analyses.

Analysis	Data Layers	Output	Code
Road Crossings	• *Chesapeake Fish Passage Prioritization Tool* • *North Atlantic Aquatic Connectivity Collaborative (NAACC)*	Surveyed stream crossing in the Chesapeake Bay Watershed	7-RC-A

3.7.5 Regional Flow and Connectivity

Nature's Network developed data that characterizes the ability to flora and fauna to move across the landscape. This regional flow data ranges from constrained flow to high diffuse flow. The purpose of this analysis is to discern where there are important areas of regional flow, as determined by the Nature Conservancy (2016), which could benefit from tidal and/or nontidal wetland restoration. By aligning areas for potential wetland restoration with regional flow, opportunities to improve connectivity and ease of passage are identified. To investigate this concept, the CBCP overlaid the combined wetland restoration opportunities with this regional flow data. The acreage that is identified by Nature's Network as being a regional flow corridor of any degree was summed within each subwatershed. The total acreage of restoration opportunity was classified into 5 groups utilizing the Jenks method in ArcGIS. The top 2 groups of watersheds based on acreage of opportunity are identified as opportunities.

Table 14. Regional Flow and Connectivity Analyses. Output in bold indicates that this is a direct input to the Restoration Roadmap.

Analysis	Data Layers	Output	Code
Regional Flow and Connectivity	• *Combined wetland restoration opportunities* • *Regional flow data (TNC)*	**Regional flow and wetland restoration opportunities analysis**	**7-RG-B**

3.7.6 The Sediment Shadow and Considerations for Resilience in Wetlands Restoration

In its effort to build resiliency in the Chesapeake Bay Watershed restoration efforts, USACE worked with NOAA and other CBP partners to consider the latest research available on sediment transport in the Chesapeake Bay as related to the ability of wetlands to maintain elevation in the face of relative sea level change (e.g., sea level rise and subsidence) as erosion. The following section describes the results of the the discussion and provides information based on personal communication and discussion with CBP and Greg Noe, research ecologist (USGS) to educate the application of sediment additions to wetland restoration, and where those additions may be best directed and needed.

Tidal rivers around the world can trap large quantities of sediment between the head-of-tide and mouth of the estuary, depositing sediment in both channel and wetlands, leading to meaningful reductions in sediment loading to estuaries (Meade 1982, Downing-Kunz and Schoellhamer 2015, Ralston 2017). This phenomenon of substantial trapping of sediment by tidal rivers has been called the 'sediment shadow' (Ensign et al. 2015), where contemporary sediment availability in tidal freshwater rivers is often minimal compared to upstream nontidal reaches and downstream oligohaline reaches. Sediment loads from watersheds can be trapped at large rates by nontidal floodplain deposition and river channel storage downstream of watershed nontidal loading gages (Noe and Hupp 2009), as well as by tidal freshwater forested wetlands (TFFW) located downstream of the head-of-tide (Ensign et al. 2015, 2016). As a result, much of the sediment load has been reduced to low levels in lower tidal freshwater rivers downstream of these sedimentation hotspots. Further downstream past the tidal freshwater zone and into oligohaline river reaches, sediment availability increases substantially associated with estuarine sources of sediment including the estuarine turbidity maximum. These patterns have been observed for either channel suspended sediment concentrations (SSC) of floodplain wetland sedimentation rates along many rivers along the U.S. Atlantic Coast, including in the Chesapeake Bay (Ensign et al. 2015, 2016, Hupp et al. 2015, Noe et al. 2016).

In the Chesapeake, sampling of suspended sediment in river channels along longitudinal riverine gradients has revealed minimal SSC in TFFW reaches, somewhat greater SSC in upstream nontidal reaches, and much greater SSC in downstream oligohaline reaches. Suspended sediment concentrations over month-long measurement periods was much greater in the river channel at an oligohaline (median = 21 and 31 mg L-1) compared to TFFW (3 and 2 mg L-1) or nontidal reach (8 and 7 mg L-1) of both the Choptank and Pocomoke rivers, respectively (Ensign et al. 2014). Along the Mattaponi River, mean SSC increased from 7, 7, 12, 16, to 20 mg L-1, and along the Pamunkey River increased from 14, 13, 25, to 32 mg L-1, along gradients from microtidal river, upper TFFW, lower TFFW, salt-stressed TFFW, to oligohaline river (Hupp, unpublished data). In comparison, the long-term mean SSC concentration at the closest nontidal reaches are 10 and 23 mg L-1 in the Mattaponi and Pamunkey rivers, respectively (USGS, https://cbrim.er.usgs.gov/index.html, gages 01674500 and 01673000). Suspended sediment concentrations also steeply decrease downstream along the tidal freshwater James River during high flow events (Bukaveckas and Isenberg 2013).

Longitudinal patterns of sedimentation in Chesapeake tidal river wetlands generally match the river channel SSC patterns. Along both the Choptank and Pocomoke rivers, short-term wetland sediment accretion rates increased from nontidal (mean = 8 mm yr-1) to lower TFFW (12 mm yr-1) to oligohaline (19 mm yr-1; Ensign et al. 2014). However, TFFW situated just downstream from the head-of-tide (32 mm yr-1) had very high (Choptank) or somewhat higher (Pocomoke) accretion rates associated with Tropical Storm Lee that caused the largest flood of record on the Choptank but a smaller flood on the Pocomoke River (Ensign et al. 2014). Long-term sedimentation rates were similar along the same river gradients (Ensign et al. 2015). Tidal freshwater marshes along the Mattaponi River had increasing short-term sedimentation and accretion rates towards downriver locations near the oligohaline boundary and estuary turbidity maximum (Darke and Megonigal 2003). Short-term wetland sediment accretion increased monotonically downstream along the Mattaponi and Pamunkey rivers, averaging from 4, 7, 10, 12, to 14 mm yr-1 from nontidal (microtidal channel), upper TFFW, lower TFFW, salt-stressed TFFW, to oligohaline floodplain wetlands (Noe, unpublished data). In contrast, short-term sediment accretion along the Nanticoke River on the eastern shore of Maryland decreased slightly from tidal freshwater marsh to downstream mesohaline marsh (Beckett et al. 2016). Long-term tidal marsh and subtidal sedimentation rates along the Patuxent River were similar between the upper estuary (tidal fresh and oligohaline) and lower estuary (mesohaline), with the mass of sediment trapped annually in the upper estuary similar to the watershed sediment load (Boynton et al. 2008).

In summary, tidal channels and wetlands along lower tidal rivers often experience minimal sediment availability compared to upstream (nontidal or tidal freshwater near the head-of-tide) and downstream (oligohaline or mesohaline) reaches. Watershed sediment loads are largely removed by sedimentation in wetlands and channels upstream, and estuarine sediment loads are not transported upstream from the saline estuary into lower tidal freshwater reaches. This phenomenon appears to be widespread among Chesapeake tidal rivers, suggesting that contemporary watershed derived sediment loads (and sediment-associated nutrient and contaminant loads) mostly do not get transported through tidal rivers to downstream, saline portions of the estuary, most of the time.

Because the resilience of tidal wetlands to SLR is a function of suspended sediment concentration (Kirwan et al. 2016), the rates of sediment supply to TFFW can predict the impact of SLR on ecosystem resilience. Low sediment availability limits wetland elevation growth in TFFW and could accelerate their conversion (Stagg et al. 2016). In the Chesapeake, a tidal freshwater marsh along the Nanticoke River was gaining elevation at a rate similar to relative SLR, whereas oligohaline marshes were decreasing in elevation, and mesohaline marsh was gaining elevation at a slower rate than relative SLR, despite all of the sites having substantial sedimentation rates that suggested high rates of soil subsidence (Beckett et al. 2016). Tidal freshwater marsh along the Patuxent River had varying rates of elevation change, either no change or increasing elevation gain rates that were greater than relative SLR (Delgado et al. 2013). Preliminary data from the TFFW along the Mattaponi and Pamunkey rivers indicate rates of elevation change are less than relative SLR along the upper tidal freshwater reaches of these Chesapeake rivers (Noe, unpublished data). Tidal freshwater wetlands in the Chesapeake are likely (but not always) experiencing sediment deficits relative to their need to gain elevation in response to relative SLR. In particular, TFFW along lower tidal freshwater rivers where 'sediment shadows' are common likely are experiencing sediment deficits. The addition of sediment direcly to TFFW could augment their sediment supply sufficiently to enable their elevations to grow upward relative to SLR, and as a result increase their ecosystem resilience, while maintaining the goals of low sediment delivery to downstream portions of the Chesapeake Bay. Targeting wetlands for restoration through sediment addition would be best informed by measurements of channel sediment concentrations and tidal wetland sediment accretion and elevation change (identifying hotspots of sediment deficits). However, more research is needed to evaluate the impacts of sediment addition on TFFW ecosystem health and elevation change in response to sediment additions.

3.8 Integration of *Opportunities* Analysis into the *Restoration Roadmap*

A result of all the analyses conducted as a part of the CBCP was the creation of *Opportunities* for the unique geospatial analyses that identify subwatersheds with high potential to address different goals and outcomes covered in the 2014 Bay Agreement. Each analysis into each specific question identified a set of opportunities in areas throughout the watershed that could most benefit from action.

The analyses that have been selected to be used in the opportunity summary map are listed in **Table 15** by estuarine and nonestuarine area. The ID following the name of the analyses denotes the associated map(s). Fish passage is not included in the full opportunity analysis because data was not available for New York or West Virginia. However, fish passage (1-HR-FP-D) is incorporated into the opportunity analyses presented in the State Appendices for Pennsylvania, Maryland, Virginia, Washington, DC, and Delaware.

Table 15. List of Analyses Used to Determine Overall Opportunity Maps for Estuarine and Nonestuarine Areas of the Chesapeake Bay Watershed.

Estuarine	Nonestuarine
Stream Restoration (1-HR-SR-B)	Stream Restoration (1-HR-SR-B)
Riparian Buffers (1-HR-RFB-E)	Riparian Buffers (1-HR-RFB-E)
Tidal Wetland Restoration Opportunities (2-WR-B)	Nontidal Wetland Restoration Opportunities (2-WR-A)
Nontidal Wetland Restoration Opportunities (2-WR-A)	Future Threats – Nontidal (CA-7-NTT)
Future Threats – Tidal and nontidal (CA-7-TT; CA-7-NTT)	Wetland Restoration to Benefit Avian Wildlife (2-WR-AV-A)
Eroding Shorelines (5-SS-ERO-A; 5-SS-ERO-B; 5-SS-ERO-C)[1]	Conservation (4-CSV-A; 4-CSV-SOC-A; 4-CSV-TH-A)
Wetland Restoration to Benefit Avian Wildlife (2-WR-AV-A)	Policy – Healthy/High-Value Habitats at Risk to Future Threats – nontidal wetlands (3-CNT-HHVH-B)
Wetland Restoration Utilizng Dredged Material– tidal and nontidal wetlands (2-WR-AV-NAV)	Water Quality (CP-6-WSA)[2]
Conservation (4-CSV-A; 4-CSV-SOC-A; 4-CSV-TH-A)	Toxic Contaminants (6-TOX-A)
Policy – Healthy/High-Value Habitats at Risk to Future Threats – Tidal and nontidal wetlands (3-CNT-HHVH-A; 3-CNT-HHVH-B)	Connectivity – Regional Flow (No Map ID)
Oyster Restoration	
SAV Restoration (1-HR-OY)	
Water Quality (CP-6-WSA)[2]	
Toxic Contaminants (6-TOX-A)	
Marsh Migration (7-MM-D)	
Connectivity – Regional Flow (No Map ID)	

[1] General eroding shorelines map opportunities was selected, but within these opportunities, wetland restoration opportunities and wetland enhancement should be considered as important areas, but may not be the areas at greatest risk to shoreline erosion.

[2] The bottom two groups, i.e., the most stressed watersheds would benefit the most from WQBMPs

The *Opportunities* for each of the above analyses were selected via the processes documented previously in this appendix. Because there are a number of analyses that occur only in estuarine or tidal areas (oyster restoration, SAV, etc.), these data were separated and scored only in those subwatersheds where 2014 Bay Agreement goals and outcomes have the potential to occur, eliminating bias towards tidal/estuarine areas at the mouth of the watershed when compared to the basin states further from the mainstem of the Chesapeake Bay.

The method of determining which subwatersheds belonged in the estuarine grouping versus the nonestuarine grouping was determined in the Threats Analysis (Maps: CA-7-TT; CA-7-NTT). The factor creating the distinction between the estuarine and nonestuarine grouping is based on the USACE Sea Level Rise “high” prediction for 2100. If a subwatershed is within the area that could be impacted by the ‘high’ SLR prediction, it was included in the estuarine grouping. If the SLR prediction did not have an effect on a subwatershed, it was included in the nonestuarine grouping.

For each analysis, subwatersheds that had *Opportunities* identified were given the score of 1, while those with no *Opportunities* idenfitied were given a score of 0. Then, the Opportunities in each subwatershed were summed, resulting in the identification of subwatersheds with greatest overall *Opportunity*. For example, if there was a subwatershed identified as a *Opportunity* in four different analyses, it received the score of 4. The maximum potential score for *Opportunities* in estuarine areas is 16, while the maximum potential score for nonestuarine areas is 10. No subwatershed in either the estuarine or nonestuarine analysis had subwatershed *Opportunities* for every category, so the actual maximum score received for the estuarine analysis is 11, while the nonestuarine is 7. The results for both analyses are displayed on one map, but are differentiated by color (**Figure 11**).

The table that accompanies the Restoration Roadmap figure is available online at http://www.nab.usace.army.mil/Missions/Civil-Works/Chesapeake-Bay-Comprehensive-Plan/ Included in the table is information derived from each opportunity analysis, including:

a) Geospatial location at the subwatershed scale, which was selected through composite analyses and restoration opportunity analysis

b) Assigned management measures

c) Cost range

d) Environmental benefits

e) Ecosystem good and services

f) Implementation plan that identifies what agency oversees implementation, any barriers, and future threats

g) Sequencing and dependencies

h) Significance that the bay agreement goals or other agency plans or priorities this strategy would meet

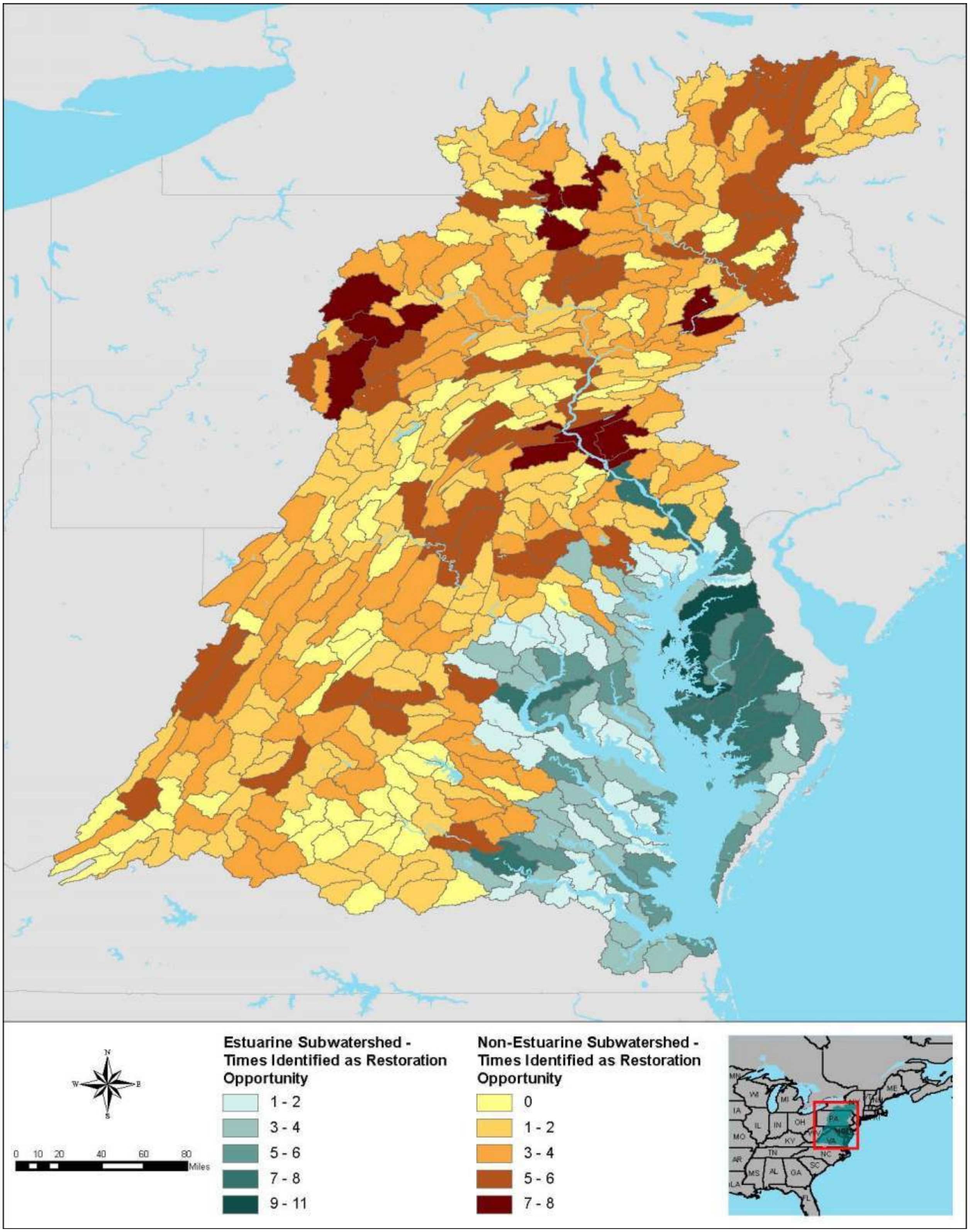


Figure 11. Restoration Roadmap: *Opportunities* integration map for both estuarine and nonestuarine analyses

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Section 4

Benefits and Concept Unit Cost Estimates

Ecological benefits of aquatic habitat restoration were considered for the CBCP. Ecosystem goods and services (EGS) produce outputs or services that have value or provide benefits to people. Valuing these benefits, both current and future, from the natural environment explains its contribution to well-being and dependency of society on its ecological base. To be considered in this report, a clear economic linkage had to be demonstrated by each habitat type. The information is summarized from the CBP website (www.Chesapeakebay.net) and from USACE "Lower Susquehanna River Watershed Assessment, MD and PA" (2015) and "Chesapeake Bay Shoreline Erosion in Maryland: A Management Guide" (2011).

1. **Assumption 1:** Efforts to restore aquatic habitats focus largely on habitats showing a trend of loss that would not otherwise be restored by natural processes in a timely manner.

2. **Assumption 2:** After establishment of restored aquatic habitats , which can take months to years depending on the habitat type and ambient environmental conditions, these habitats can provide ecological benefits comparable to those of natural habitats.

3. **Assumption 3:** Habitat restoration is an important natural resource management tool, and compliments regulations designed to protect existing resources and conditions, which would otherwise not restore lost habitats.

National and regional priorities inform selection among competing USACE restoration projects as incorporated in budgetary priority criteria emphasizing scarcity, connectivity, special status species, hydrologic character, geomorphic condition, plan recognition, and self-sustainability. To position a project to compete for limited funding, project restoration objectives should align with these criteria. Benefits should be measured in units appropriate to project restoration objectives. USACE has a formalized system to measure benefits of ecosystem restoration projects, and metrics used to measure benefits must be approved by USACE.

4.1 USACE Benefits Metrics

The goal of USACE Civil Works ecosystem restoration activities is to "restore significant ecosystem function, structure, and dynamic processes that have been lost or degraded and to partially or fully reestablish the attributes of a naturalistic, functioning and self-sustaining system." A library of approved benefits metrics is available at the USACE ecosystem restoration gateway website (https://cw-environment.erdc.dren.mil/restoration.cfm). The qualities of a "good" metric are relevance, ambiguity, comprehensiveness, directness, operability, and understandability. Modeling is used for analyzing environmental systems. There are several general and specific community or ecosystem-level models potentially applicable for all restoration projects, although these would require adjustment or calibration to be suitable to the Chesapeake Bay Watershed in many cases (**Table 16**). Additionally, the ecosystem restoration model library identifies numerous individual species models potentially applicable to restoration projects in the bay watershed (**Table 17**). (Note that the number of models by animal type presented below derived by tallying those presented at the website link (**Table 18**)).

Table 16. USACE Aquatic Restoration Habitat Type and Ecosystem Benefits Defined.

Habitat Type	Ecosystem Benefits
Bay Islands	Remote bay islands provide habitat conducive to nesting water birds, wading birds, and waterfowl because of limited access by predators. Bay islands otherwise provide habitats typical of the mainland. Bay islands are diminishing because of natural erosion.
SAV	SAV in the rivers and Bay provide fish and wildlife with food and habitat, add oxygen to water, absorb nutrient pollution, trap sediment, and reduce erosion. Underwater grasses need sunlight to grow. Impaired water clarity from eutrophication is the principal stressor to Bay SAV.
Shoreline	Beaches provide nesting habitat for horseshoe crab and several species of birds. Shallow water provides habitat for SAV and serves as a nursery area for fish. Mudflats are an important foraging habitat for birds. Shoreline armoring causes the loss of natural shoreline habitat in the Bay. Natural eroding shorelines provide sediment that creates and maintains shoreline shallow water habitat and beaches.
Streams/Rivers	Freshwater waterways, the landscape's natural infrastructure, concentrate and transport water and associated constituents across the landscape. Streams/rivers provide habitat for fish and wildlife, and can provide water quality improvement along their length. Degraded water quality from pollution, altered flows, degraded/altered physical habitat, and loss of riparian buffers are principal stressors to rivers and streams.
Impoundments	Impoundments are manmade ponds and lakes built to provide habitat that is otherwise largely lacking naturally in much of the bay watershed. These manmade systems provide habitat for aquatic life typical of ponds and lakes. Impoundments trap sediment, can treat nutrient pollutants, and often serve as unintentional water quality improvement features for receiving rivers. Lakes and ponds formed by impoundments are vulnerable to impacts of nutrient loading which can cause eutrophic conditions. Sediment conveyed in the delivering river or stream carries in sediment which gradually fills impoundments.
Wetlands, Tidal and Nontidal	Wetlands trap polluted runoff, improve water quality, and can buffer adjacent landscapes from storms and flooding. Wetlands also provide habitat to hundreds of fish, birds, mammals, and invertebrates. Historically, draining and filling for agriculture and development caused massive wetland losses. Today, accelerating sea level rise threatens tidal wetlands.
Riparian Buffers (Bay and River)	Forest buffers prevent pollution from entering waterways, stabilize stream banks, provide food and habitat to wildlife, and keep streams cool during hot weather. Forest buffers provide woody debris that supports the food web.
Oysters	Oysters make up one of the region's most valuable commercial fisheries. Oysters filter-feed and clean Bay waters. Oyster beds provide habitat to aquatic life that orients to structure. Oyster rock is the only natural hard structure within the Bay. Over-harvesting, disease, impaired water quality, and habitat loss have led to a severe drop in oyster populations.
Fish Passage	Several fish species move between freshwater rivers and the salt waters of the Bay and ocean during their life history. Dams, culverts, and other structures block these migratory fish from reaching their spawning grounds and reduce the amount of habitat available to local fish. Historic and current overfishing (including as bycatch) greatly reduced populations of these species. Historically, these species likely were important in transporting nutrients upstream from the Bay to rivers. Removing blockages or installing lifts, ladders, or passageways can reopen river habitat and allow fish like herring or American shad to swim farther upstream.

Table 17. Models and analyses available to determine benefits for EGS.

Habitat Equivalency Analysis
Habitat Evaluation Procedures
Hydrogeomorphic Assessment of Wetlands
Index of Biotic Integrity
Multi Criteria Decision Analysis
Qualitative Habitat Evaluation Index

Table 18. Restoration type and species models potentially suitable for bay watershed.

Restoration Type	Mollusk	Fish	Amphibian	Reptile	Bird	Mammal
Coastal Wetland					8	1
Dam Removal		3				
Environmental Dredging		2			2	
Estuary	3	11	1	1	10	
Fish Passage		5				
Floodplain			1	1	2	
Fresh Wetland		7	1	1	19	8
Invasive Species						
Lake		24	2	2	13	2
Large River		25	1	2	10	3
Large Watershed/Major Restoration		6	1		4	1
S-M Watershed			2		2	1
Stream		23		1	8	2

Source: USACE 2017a

This list includes few models with metrics immediately suited to the ecological community (ecosystem) focus of USACE's ecosystem restoration mission in the Chesapeake Bay Watershed. In particular, it would be appropriate for USACE to identify and approve models suitable for a variety of tidal and nontidal wetlands that are typically restored in the Chesapeake Bay Watershed.

4.2 Concept Unit Cost Estimates

Currently, there are no cost estimates determined as to how much funding would be required to achieve the 2014 Bay Agreement goals and outcomes. In an effort to support the restoration effort toward implementation of restoration actions, the CBCP presents concept cost estimates for aggregated management measures.

Due to the fact that the Chesapeake Bay watershed is so large, there is a wide range of variability in the temporal, spatial, and type of restoration actions that could potentially be implemented. The geospatial analysis was conducted on a large, bay-wide scale, and cost development was driven by the scope of the geospatial analysis. Therefore, the cost estimates should be considered order of magnitude costs for planning and/or budgeting purposes.

The results of the geospatial analysis result in opportunities, along with a compilation of candidate restoration projects where that data is available and incorporated into the CBCP. Within the opportunities (or any subwatershed within the Chesapeake Bay), there could be implementation of many restoration management measures. To account for the broad scale of analysis and inherent risks and uncertainty attributed to project implementation, approximately 30% contingency was added to cost ranges. Undefined length/acreage of potential projects allows for USACE and other action agencies to define project costs based on specific management measures they wish to implement, rather than predefined restoration actions. As restoration projects are defined and management measures are selected, more precise costs would be developed during site-specific analyses leading to implemenation.

The concept cost estimates that were developed as part of the CBCP were based on research on past USACE projects, as well as outreach to stakeholders regarding management measures not typically implemented by the USACE. Costs are provided as a range and were escalated to fiscal year 2017. **Table 19** present the cost ranges for construction costs only. During the development of costs for site-specific projects, it would be necessary to incorporate costs incurred for planning, engineering, design, permitting, real estate, and construction management.

Table 19. Concept Unit Cost Estimates for Aggregated Restoration Management Measures.

Category	Restoration Management Measure	Construction Cost Range
Tidal	Oyster Reef	$147-$205k/ac
	Submerged Aquatic Vegetation	$41.0k-$314k/ac
	Tidal Wetland	$1.30k-$722k/ac
	Riparian Buffer	$0.800k-$133k/ac
	Living Shoreline	$0.150k-$1.30k/ac
Non-Tidal	Fish Passage	$0.190k-$200k/lf
	Stream Restoration	$0.600k-$1.60k/lf
	Non-Tidal Wetland Restoration	$16.0k-$178k/ac
	Riparian Buffer	$0.800k-$133k/ac
	Conservation	$0.390-$13.0k/ac

The following bullets describe and define cost categories included in the overall concept cost estimates that were considered for each restoration management measures:

- *Mineral substrate:* Excavating and/or placing dredged material or earth (non-shell) mineral materials to establish desired substrate. Dredged material would be assumed to be the predominant substrate source for tidal projects.
- *Shell substrate:* Addition of shell material or other material that will promote shell organism growth, as well as placement of shell-forming organisms.
- *Channels:* Establish water channel and direct flows by excavation and/or placement of fill or structures.
- *Vegetation:* Planting/seeding submerged aquatic, wetlands, or upland vegetation. Also, eradication/management of invasive exotic upland or wetland vegetation.
- *Fish:* Introduce or eradicate (invasive species) of fish or other aquatic organisms
- *Stabilization structures:* Construct or modify groins, breakwaters, and bank stabilization works to control erosion/deposition. This would also include vegetation as a component of a living shoreline project.
- *Control structures:* Construct or modify weirs, dams, and pipes to control water levels and maintain target water quality and salinity conditions.

The following bullets display cost documentation corresponding to each restoration management measure (including an additional 30 percent contingency unless otherwise indicated to account for unknown costs due to lack of design and as typical for screending level concept cost estimates):

- *Oyster beds:* Unit costs include mobilization and demobilization. Unit costs include the construction of 1-foot planting height of each substrate type. Costs were referenced from a USACE, Baltimore District 2014 oyster reef restoration construction contract.

- *Submerged Aquatic Vegetation:* Reef balls and sand are considered as mineral substrate. Costs were referenced from the USACE, Norfolk District Lynnhaven Feasibility Study Report and from the North Atlantic Coast Comprehensive Study (NACCS) (USACE, 2015). Contingency was applied to each cost to cover unknown due to lack of design and due to different use/application. The study suggested 27.8 percent contingency for SAV construction cost. At screening level of estimate, 30 percent contingency was used to be conservative and to be consistent with contingency for other measures.

- *Tidal wetland:* Unit costs are based on 2017 USACE, Baltimore District Atlantic Coast of Maryland Beach Renourishment, NACCS, and Poplar Island 2017 wetland planting contracts.

- *Riparian buffer:* Unit costs for mineral substrate measure were borrowed from Tidal Wetland unit costs, assuming similar type of construction has similar costs. For Vegetation Measure, the minimum cost is based on the Chesapeake Assessment Scenario Tool (CAST) available online at https://cast.chesapeakebay.net. For maximum Vegetation Measure cost, it was based on Chesapeake Bay Riparian Handbook of USDA Forest Service Stewardship Incentive Program (page 284 of pdf). The NACCS parametric cost was used for stabilization structure feature.

- *Living shoreline:* The low range cost estimates was obtained from the VIMS Center for Costal Resources Management, which present a range of costs for living shorelines projects with sand fill with stone structures typically $150-$500 per linear foot (VIMS, 2018). Source NACCS Study at price level of third quarter FY2014. The unit cost was escalated to third quarter FY2017. The CAST Tool for “Urban and Non-Urban Shoreline Erosion Control for Non-Vegetated” are also added for comparison. The minimum and maximum CAST Tool costs are selected between costs in several States. It was assumed that the CAST unit cost is also current (2017 price).

- *Fish passage:* Unit costs are based on the Technical Alternatives Analysis to Provide Fish Passage at Embrey Dam Report dated 1998 (escalated to third quarter FY2017) and the Dam Removal Cost from the Database Developed by American Rivers (Chesapeake States only).

- *Stream Restoration:* Unit costs were based on the USACE, Baltimore District Anacostia Watershed, Prince George’s County Ecosystem Restoration Study, and the USACE, Baltimore District Small Aquatic Ecosystem Restoration Western Branch Patuxent River Contract from June 2010. Contingency from the Anacostia Watershed, Prince George’s County Ecosystem Restoration feasibility study was applied according to each site. The contingency varies from 31 percent to 37 percent based on the abbreviated risk analysis of the study. CAST Tool costs for stream restoration were added. The minimum cost was identified from non-urban areas and the maximum cost is from urban areas. It was assumed that the CAST unit cost is also current (2017 price). The minimum and maximum CAST tool costs are selected between costs in several states.

- *Non-tidal wetland:* Unit costs were assumed the same as tidal riparian buffer unit costs, assuming similar type of construction has similar costs. For control structures, cost is borrowed from the USACE, Baltimore District Small Aquatic Ecosystem Restoration Western Branch Patuxent River Contract from June 2010, which was escalated to third quarter FY2017 using civil works escalation index for feature code 06. The CAST tool cost for control structure was added to non-tidal wetlands. The cost is the same for all states in the Chesapeake Bay area. There is no indication from the CAST tool website which management measure the water control structure was used for. It seems that it is more appropriate for the cost to be with the non-tidal wetland measure than any other. CAST Tool cost is also added for vegetation. The CAST Tool does not make the distinction between tidal and non-tidal wetlands. There are several CAST Tool costs for the wetlands that may be suitable for this measure, but the cost for "Wetland Restoration – Floodplain" was used. The CAST Tool Wetland Enhancement cost is also added, and the cost appears suitable for the vegetation enhancement measure. The minimum and maximum CAST Tool costs are selected between costs in several states. It was assumed that the CAST unit cost is also current (2017 price).

- *Riverine riparian buffer:* Except for vegetation, unit costs were assumed the same as tidal riparian buffer unit costs, assuming similar type of construction. Unit costs for vegetation are based on unit costs from Chesapeake Bay Riparian Handbook of USDA Forest Service Stewardship Incentive Program dated June 1998 and Maryland climate Action Plan Greenhouse Gas and Carbon Mitigation Working Group Policy Option Documents. Unit costs for vegetation are also based on the Cast Tool. The "Forest Buffer-Streamside with Exclusion Fencing" CAST Tool cost is appropriate for riverine riparian buffer measure. The minimum and maximum CAST Tool costs are selected between costs in several states. It was assumed that the CAST unit cost is also current (2017 price).

- *Conservation:* Unit costs are based on personal communications with Chesapeake Bay Program staff. Price quoted in July 2017, so no need for escalation of cost. It is assumed conservation unit costs associated with real estate will vary considerably across the watershed. Additional data to consider unit costs were based off of conservation easements for Department of Defense facilities through the Readiness and Environmental Protection Integration (REPI) Program. Based on data available through 2012, 14,015 acres of land were acquired adjacent to DOD installations for a total cost of $62,237,000, for the average cost of $4,400 per acre (USDA, 2013).

Section 5

Ecosystem Goods and Services

5.1 Introduction

EGS are socially valued aspects or outcomes of ecosystems that depend on self-regulating or managed ecosystem structures or processes. For the CBCP, capturing EGS in qualitative ways demonstrates a more accurate representative of the ecosystem and informs decision-making. This section provides an overview of how EGS were determined in the watershed, defines terminology and assumptions, discusses potential markets, and incentives considered.

5.1.1 Authority for employing EGS as an evaluation tool in the document

In Section 729 of the Water Resources Development Act (WRDA) of 1986, as amended, USACE has authority to undertake watershed planning studies with multiple objectives and to accommodate flexibility and collaboration into the planning process for examining needs and opportunities and developing recommendations. EGS were established for the "Study of Water Resources Needs of River Basins and Regions," and EGS can be applied to watershed planning and studies like this planning document.

EGS can be found in USACE planning guidance relative to aquatic ecosystem restoration project planning. This guidance describes EGS as the "Conceptual basis for evaluating nonmonetized NER (National Ecosystem Restoration) benefits is society's value toward the increase in Ecosystem Services." References addressing the use of EGS can be found in USACE 2012 Environmental Operating Principles, which provide direction to ensure the USACE workforce recognize its role in responsibility for, stewardship use, and restoration of natural resources across the nation. Contributing to NER is identified in USACE guidance as an objective for USACE ecosystem restoration planning. Contributions to NER outputs are expressed in nonmonetary units, and increase in the net quantity and/or quality of desired ecosystem resources.

5.1.2 EGS Assumptions

The following assumptions were defined in the development of this EGS narrative:

1. **Assumption 1:** Goods are items that are tangible, and services are activities provided by other people. Goods and services are endpoints along a gradient. For purposes of this document they will be lumped together. Use of goods and services provides benefits that can be valued in economic and monetary terms.

2. **Assumption 2:** Businesses consume goods and services as they are producing other goods and services.

3. **Assumption 3:** EGS can be used sustainably within the natural limits set by environmental carrying capacity. Human use of EGS within these limits does not irreversibly impair the integrity and proper functioning of the ecosystems providing/supporting EGS.

4. **Assumption 4:** Sustainable aquaculture, silviculture, and agriculture systems can provide EGS. Abiotic resources such as minerals and fossil fuels are not considered EGS because they are not renewable.

5. **Assumption 5:** Wind energy and solar energy are not considered EGS because they cannot be attributed to specific ecosystem types.

6. **Assumption 6:** Relevant EGS vary by scale of region of interest and what residents in a region value.

7. **Assumption 7:** EGS analysis typically considers the physical scale at which the ecosystem functions underpinning the EGS that present and the geographic scale necessary to generate EGS of human value.

8. **Assumption 8:** This document concentrates on activities within the waters and lands of the Chesapeake Bay watershed, the focus of bay protection policies and restoration efforts. TMDL regulations are used to focus benefit considerations.

5.1.3 Primary Categories of EGS

Ecosystem functions were grouped into broad conceptual categories based on ecological processes and structures generating EGS (**Table 20**)**.** The source of this classification and the corresponding definitions are below. A literature search revealed overlapping EGS categories.

Table 20. Primary Categories of EGS (source: De Groot et al., 2002).

Ecosystem Function	Associated EGS
Production	Production of carbohydrate structures that provide food, raw materials, and energy
Regulation	Biogeochemical processes maintaining life support systems, providing clean air, water, and soil
Information	Reflection, spiritual enrichment, cognitive development, recreation, and aesthetics
Habitat	Refuge and reproduction space for plants and animals

5.1.4 Defining Restoration Activities Increasing EGS Supply

EGS of interest in this document are those produced by various agencies, organizations, companies, and citizen groups undertaking environmental restoration measures in the broad sense, as well as environmental BMPs implemented by various entities to fulfill TMDL requirements and meet other environmental requirements. Voluntary activities are also of interest and are given some consideration.

For the purposes of this document, USACE restoration project types (restoration or enhancement) in the Chesapeake Bay Watershed were divided into two simplified categories based on hydrology (tidal versus nontidal), then generic habitat type in terms of common usage (**Table 21**).

Table 21. Categorization of USACE restoration type.

USACE RESTORATION TYPES			
TIDAL HABITATS	Oyster Beds	NONTIDAL HABITATS	Fish Passage
	SAV		River/Stream
	Beach Dune		Reservoir Impoundment
	Tidal Wetland		Nontidal Wetland
	Bayside Riparian Buffer		Riverine Riparian Buffer
	Bay Islands		

Water pollution controls are often categorized as either gray or green infrastructure. Gray infrastructure refers to common urban and suburban wastewater and stormwater controls comprising predominantly built environment materials. Green infrastructure includes BMPs for the treatment of nonpoint-source runoff that incorporate vegetation and soils, such as installation of buffer strips at stream edges and restoration of wetlands. Alternative mixes of green and gray infrastructure can be used to achieve water quality improvement targets under the Chesapeake Bay TMDL. Green infrastructure has the potential to improve water quality while providing other EGS (**Table 22**). Financial valuation of these additional EGS not adequately captured in existing markets could potentially offset the cost of achieving the TMDL targets.

The Chesapeake Bay Assessment Scenario Tool (CAST) is a standard that was followed to inventory numerous types of green and gray infrastructure BMPs accredited to provide water quality improvements to meet the bay TMDL requirements. This document used a simplified categorization of the CAST BMPs prepared by Chesapeake Bay Scientific and Technical Advisory Committee (STAC 2017), but screened out gray infrastructure BMPs. These gray infrastructure BMPs were screened out: Alternative Water System (Off Stream Watering Without Fencing) (Agriculture Sector), Dirt/Gravel Roads (Forestry/Urban Sector), Permeable Pavement (Urban Sector), and Filtering Practices (Urban Sector). Gray infrastructure BMPs, for purposes of this document, are not considered to constitute ecosystems or to contribute EGS (although they do provide critical water quality and quantity treatment functions). Gray infrastructure can contribute EGS disbenefits if it displaces habitat. (USEPA 2012).

Each one of the following green infrastructure BMPs was evaluated according to its category of ecosystem service.

Table 22. Categories of Green BMPs for EGS.

Green infrastructure BMPs as providers of EGS	
Agriculture	Agriculture Forest Buffers
	Grass Buffers
	Agriculture Stream Restoration
	Wetland Restoration and Streamside Wetland Restoration
	Agriculture Shoreline Management
Forestry	Forest Conservation
	Forest Harvesting Practices
Urban	Urban Forest Buffers
	Urban Stream Restoration
	Urban Growth Reduction
	Urban Shoreline Management
	Abandoned Mine Reclamation
	Bioretention
	Urban Tree Planting
	Impervious Surface Reduction
	Wet Ponds
	Grass Buffers

Restoration of toxic contaminant sites also are considered gray infrastructure for purposes of this report. Remediation and restoration of toxic contamination seeks to isolate or encapsulate, not derive EGS from their habitat value. There are restoration and compensatory projects in urban areas at where toxic pollutants exist (e.g., Anacostia River, Elizabeth River, and Baltimore Harbor). However, in these settings restoration practitioners focus on minimizing interaction of toxic restorations sites to fish, wildlife, humans, and the environment. The production of EGS is not the primary purpose of the project.

5.1.5 Definitions of EGS Terminology and Categorization

Table 23 provides relevant EGS terminology and categories.

Table 23. EGS terminology and categorization.

Ecosystem Service	Definition (all except carbon sequestration based on de Groot and others (2002) except modified for clarity and brevity.)	Primary ES Category (de Groot and others [2002])
Food	Wild plants and animals that can be harvested for food. (Category includes small-scale subsistence farming and aquaculture which lack external inputs and still maintain other ecosystem functions.)	Production
Raw Material	Renewable wood, fiber, and biochemical compounds which provide materials for construction, textiles, animal feed, as well as energy sources (such as fuel wood and animal power).	Production
Disturbance prevention/Hazard Mitigation	Ability of ecosystems to ameliorate natural hazards and disruptive events, and provide safety for human life and constructions, including storm wave and flood protection.	Regulation
Soil Retention	Vegetation cover and roots retaining/protecting soil, preventing excess erosion and down-gradient sedimentation/deposition	Regulation
Water Regulation	Natural system maintenance of surface flows, and consequent natural irrigation and drainage, buffering of extreme discharges, channel flow regulation, and provision of water medium for transportation.	Regulation

Table 23 cont. EGS terminology and categorization.

Ecosystem Service	Definition (all except carbon sequestration based on de Groot and others (2002) except modified for clarity and brevity.)	Primary ES Category (de Groot and others [2002])
Water Supply	Filtering, retention, and storage of water in streams, lakes, aquifers which provides water for consumptive use by households, agriculture, industry.	Regulation
Carbon Sequestration/Climate Regulation	Reduction, avoidance, or sequestration of greenhouse gases (including noncarbon compounds for purposes of this document) by storage of carbon in vegetation, soils, and sediment.	Regulation
Property value support (via aesthetics)	Landscape features which provide enjoyable scenery.	Information
Recreation	Variety of natural features with recreational uses, and includes use of and travel to such natural ecosystems for outdoor sports and ecotourism.	Information

5.1.6 EGS Category Selection, Assumptions, Categorization

Three value domains are identified for EGS: (1) ecological, (2) sociocultural, and (3) economic (De Groot et al. 2010). Because ecological values and associated EGS (including habitat provision and ecosystem sustainability) are already considered in USACE benefits metrics for ecosystem restoration projects, there is no need to consider these EGS in this document.

Water quality improvement EGS are inherent to green infrastructure BMPs undertaken to meet Chesapeake Bay TMDL requirements. Accordingly, water quality improvement EGS were screened out from consideration in this document to focus on other EGS not adequately considered. Existing market links (discussed further in subsequent section) were also used to screen EGS for inclusion in this report. Those EGS with clear monetary values were favored.

EGS retained in this document are typically considered secondary benefits for USACE ecosystem projects, but are not quantified for use in agency-required cost effectiveness analyses. The magnitude of EGS produced would vary as a function of site conditions, project magnitude, and other variables. USACE's Engineer Research and Development Center (ERDC) (2015) provides performance metrics potentially suitable for many of the EGS that would be produced by the habitat restoration projects. Consideration of magnitude of EGS provided by various green infrastructure BMPs and shellfish aquaculture is an evolving topic under consideration by the CBP. Chesapeake Bay Trust (2017) provides a scoring system to consider EGS outputs (additional goals) BMPs would produce in addition to water quality improvements. De Groot and others (2010) provide a variety of performance indicators for EGS that could also be utilized.

EGS such as soil retention and human health are omitted in this evaluation as a separate category, since the evaluation has been captured in other EGS categories. The Cultural/Spiritual Support and Educational Support are combined in some EGS treatments; combining these would generally be appropriate for this document. EGS outputs would differ among CBP BMPs in Cultural/Spiritual/Educational Support in that nonhabitat BMPs would presumably not provide cultural/spiritual support while BMPs including habitat restoration measures would presumably provide cultural/spiritual support. All could provide educational support, but presumably magnitude of this would vary as a function of ease of access by educators (generally, proximity to educational institutions would presumably be a major factor determining utility).

Conserved lands are not addressed in this section as "increasing EGS." These lands can include restoration work to increase EGS or protect/maintain lands in their existing condition. This results in no net change in EGS produced.

5.1.7 EGS Produced by Habitat Restoration and Green Infrastructure BMPs

A determination of EGS produced by USACE ecosystem restoration projects was determined by a review of literature and best professional judgment (**Table 24**). ERDC (2015) provides a list of EGS produced by various coastal habitats that USACE could restore and was utilized as a basis for determining EGS produced. For nontidal habitats that USACE could restore, EGS were determined based on habitat type of interest's nearest analogue from ERDC (2015), as well as from review of USEPA (2012), Chesapeake Bay Trust (2017), and other documents. USEPA (2012) provided a consideration of EGS produced by riparian buffers, wetlands, and forests. Chesapeake Bay Trust (2017) provides "additional goals" other than water quality improvement that could be produced by environmental BMPs undertaken to meet the bay TMDL. Although not identified as EGS, the additional goals are essentially equivalent. Green infrastructure BMPs are assumed to produce the same EGS as their equivalent natural habitat type (**Table 25**).

Table 24. USACE Habitats Restored and Resultant EGS Produced.

Tally	Hydrology Category	Habitat Type to Restore or Enhance	Food provisioning (6)	Raw goods and material		Hazard mitigation (reduced risks to property infrastructure, human safety)	Soil retention	Water supply and regulation		Property value support (via aesthetics)	Recreation		Climate regulation (carbon sequestration)
1	Tidal	Oyster beds	Y	N		Y (4)	N	N		N	N		N
2		Submerged aquatic vegetation	N	N		N (5)	Y	N		N	N		N
3		Beach/dune	N	N		Y	Y	N		Y	Y		N
4		Tidal wetland	N	N		Y	Y	N		N	N		N
5		Bayside riparian buffer (1)	N	Y		Y	Y	N		N	N		N
6		Bay Islands	N	N		Y	Y	N		N	N		N
1	Nontidal	Fish passage	N	N		N	N	N		N	N		N
2		River/stream	N	N		N	Y	N		N	N		N
3		Reservoir/impoundment	N	N		Y	Y	Y		Y	Y		N
4		Nontidal wetland	N	N		Y	Y	N		N	N		N
5		Riverine riparian buffer (1)	N	Y		Y	Y	N		N	N		N

(0) EGS from Ches. Bay STAC March 2017, except deleted “Ecosystem sustainability,” “Human health,” and “Cultural, Spiritual and Educational support”. Added “Soil retention.”
(1) Upland. Wetland riparian areas included under “tidal wetland” or “nontidal wetland”
(2) Additional category “cultural/spiritual/educational” would be Y for all habitat types so not included as column.
(3) Direct. Indirect not or minimally considered.
(4) Shallow water reefs as historically occurred from Potomac River southward could provide property/structure protection.
(5) Large bed would provide some wave protection in growing season.
(6) Listed as “Commercial harvestable fish and wildlife production” in ERDC (2105)

Table 25. EGS Produced by Green Infrastructure BMPs.

(Blank chart from STAC Workshop filename "ChesBaySTAC,274_3.24.17_ Reduced BMP Matrix.pdf," except that columns "Ecosystem sustainability" and "Cultural, Spiritual and Educational support" deleted, soil retention added.

All BMPs contribute to watershed ecosystem sustainability by better managing nutrients and or sediment and would produce positive EGS.

All BMPs provide educational support potential, although those near schools would have substantially greater utility. Those locations are unknown at this time.

Conversely, it is assumed that minimal cultural and spiritual support is provided by any BMP (although BMPs with vegetation of great stature or providing vistas could perhaps provide this service).

Although many BMPs constitute ecosystems, they are often simplistic and periodically disturbed by humans and so differ from unmanaged natural ecosystems.)

(chart cells filled in by CS 5/9/2017)

Tally	Sector	BMP Group	Food Provision	Raw Material		Hazard Mitigation	Soil Retention	Water Supply and Regulation		Aesthetics	Recreation Supply		Climate Regulation, carbon sequestration	
1	Agriculture	Ag Forest Buffer	N	N		Y	Y	N		Y	N		Y	
2		Grass Buffers	N	N		Y	Y	N		Y	N		Y	
3		Ag Stream Restoration	N	N		Y	Y	N		Y	N		N	
4		Wetland Restoration and Streamside Wetland Restoration	N	N		N	Y	N		Y	N		Y	
5		Ag Shoreline Management (incl. Non-Vegetated and Vegetated)	N	N		Y	Y	N		Y	N		N	
6		Stream Access Control with Fencing	N	N		Y	Y	N		N	N		N	
7		Alternative Crops and Alternative Crop/Switchgrass (RI)	Y	N		N	Y	N		N	N		Y	
8	Forestry	Forest Conservation	N	N		N	Y	Y		Y	N		Y	
9		Forest Harvesting Practices	N	Y		N	Y	Y		N	N		Y	
10	Urban	Urban Forest Buffers	N	N		N	Y	N		Y	N		Y	
11		Urban Stream Restoration	N	N		N	Y	N		N	N		N	
12		Urban Growth Reduction	N	N		N	N	Y		Y	N		Y	
13		Urban Shoreline Management	N	N		Y	Y	N		N	N		N	
14		Abandoned Mine Reclamation	N	N		Y	Y	N		Y	N		N	
15		Bioretention	N	N		N	N	N		N	N		Y	
16		Urban Tree Planting	N	N		N	N	N		Y	N		Y	
17		Impervious Surface Reduction	N	N		N	N	N		Y	N		N	
18		Wet Ponds	N	N		N	Y	N		Y	N		N	
19		Grass Buffers	N	N		N	Y	N		Y	N		Y	
20		Runoff Reduction	N	N		Y	Y	N		N	N		N	
21		Infiltration Practices	N	N		N	Y	N		N	N		N	
22		Erosion and Sediment	N	N		N	Y	N		N	N		N	

5.1.8 Demand Drivers and Valuation Techniques for EGS

Four broad categories were used for valuation, as defined by the US Forest Service: (1) government incentives, (2) private markets, (3) environmental regulation, and (4) Green Goodwill. Federal programs such as the Conservation Reserve Program or Wetland Restoration Program provide financial incentives for implementing habitat restoration and green infrastructure BMPs (USEPA 2012). Environmental markets are an innovative policy approach to increasing funding for environmental conservation and are often viewed as a complement to traditional conservation programs (USDA n.d.). EGS market places are founded on the principal that specific environmental impacts can be offset or compensated. Multiple types of EGS credits can be incorporated into a single market place (stacking credits) (Van Maasakkers 2016). Implementing market-based conservation can be complex. From landowner outreach to payment for credits, dedicated personnel in multiple agencies and organizations are needed to complete the entire process (Pinchot Institute 2017).

Three markets for EGS have emerged under the Clean Water Act (CWA) and Endangered Species Act (ESA). Water quality trading and wetland banking are two market-like mechanisms used under the CWA. Species habitat banking, also known as conservation banking, has developed under the ESA. An additional market for carbon sequestration credits is evolving (Van Maasakkers 2016; USDA n.d.) (**Table 26**).

The Chesapeake Bay Bank (**Table 26**) has created a market allowing multiple types of EGS credits to be traded. The Bay Bank constitutes a marketplace that allows landowners to realize financial benefits for provision of EGS. An independent system verifies that EGS are credible and measurable (Van Maasakkers 2016).

Table 26. Chesapeake Bay Bank; Statutes and Regulatory Agencies (Van Maasakkers, 2016).

Credit Type	Regulatory Driver	Agency
Carbon dioxide	Regional Greenhouse Gas Initiative	Energy and environmental agencies in participating states
Bog turtle habitat; Trout habitat; Forest	Endangered Species Act Sections 7 and 10; MD Forest Conservation Act	Local jurisdictions (counties/municipalities)
Water quality – N and P	Clean Water Act, Section 303(d)	USEPA
Wetlands	Clean Water Act, Section 404	USACE

Water quality trading schemes constitute pollution markets. These allow point-source dischargers to buy credits from each other and from nonpoint sources in order to meet CWA requirements. Nutrient trading credits could be sought by both the public and private sectors. By reducing emissions more greatly than required, they can become credit sellers. A central element of water quality trading is setting water quality criteria for each water body, accomplished by the TMDLs. For trading to work the TMDL needs to be clear, precise, and consistently enforced through the permitting process. Based on the TMDL for a water body, specific limits for each entity discharging into the water body need to be set (USEPA 2015; Van Maasakkers 2016).

Various water quality trading programs are available at the state level in Pennsylvania, West Virginia, Virginia, and Washington, DC. A trading program is under development in Delaware. No water quality trading exists in New York that affects Chesapeake Bay (USEPA 2015; Environmental Trading Network, 2017). For agricultural sources, several states in the

Chesapeake Bay Watershed have developed trading programs to support more cost-effective nutrient reductions and to provide a potential additional incentive to generate nutrient reductions beyond their allocation, or baseline, to sell. In addition to trading programs, more traditional agricultural cost-share and payment programs are being used to make progress towards reduction goals. The incentives offered by these public sector programs can be used to bring farms into compliance with baseline requirements for trading. Research indicates that nutrient trading can act as an incentive for some agricultural entities to adopt nutrient controls and meet their load allocations (i.e., trading baseline) under the TMDL, these incentives would only support a portion of the required agricultural load reductions and remaining effort would still be needed for encouraging the agricultural sector to meet its TMDL goals. (USEPA 2015).

Wetland mitigation banking is founded on the idea that damage to a wetland can be compensated for by establishment of a new wetland, restoration of a previous one, or enhancement to an existing one. The responsible agency for wetland mitigation banking is USACE with oversight by EPA. Wetland banks provide ecological and monetary value in the form of credits by improving the functions and values provided by impaired or degraded natural systems. Wetlands credits relate to requirements these agencies set forth. Wetland banking has become an established practice with numerous of these being commercial for-profit organizations such that the credits from the banks can be sold to entities needing to compensate for wetlands impacts (Van Maasakkers 2016). Wetland mitigation banks are operating in Pennsylvania and Maryland (The Nature Conservancy and Ducks Unlimited 2015).

Other markets, such as Rare Species Habitat Banking Species, allow for development of sensitive areas for ESA species and compensation can be sought by restoring, enhancing, or conserving land elsewhere (Van Maasakkers 2016).

In carbon markets, the New York state program is the only active carbon compliance market in the Chesapeake Bay Watershed as of 2017 and includes sequestration of carbon due to afforestation. This program provides for increased EGS supply (from forests) only in New York in the bay watershed. Other Public Sector Market activities (not for profit activities) are conducted in a sustainable manner, for compliance purposes that can provide EGS. In many cases, regulations are needed to ensure that the activities are sustainable, so detrimental environmental and social impacts do not result.

Green Goodwill is another broad category of EGS markets and their valuation. Various environmental organizations such as The Nature Conservancy (TNC) and Ducks Unlimited (DU), and land trusts seek to maintain and restore natural habitats for the inherent value of the ecosystems themselves. These natural lands provide numerous EGS (e.g., watershed lands maintained to provide municipal water). In these situations, a water company or municipality maintains a source water watershed in a natural condition to provide potable water requiring minimal treatment. The Conservation Fund (2006) "State of Chesapeake Forests" provides inventory of such lands in the bay watershed.

Other Private Sector (for profit markets) not for compliance purposes include Market Hunting (deer), the regulated commercial market for wild-harvested venison. Ecological benefits would be avoiding deforestation, promoting natural reforestation, and increasing success of active reforestation efforts by plantings. This could occur on any land type supporting high deer population densities (MD Botanical Heritage Workgroup 2014). The native plant and seed industry/environmental horticulture industry is another private market that results in the production and sale of local native plants and seeds.

5.1.9 Valuation Assumptions and Techniques (Direct and Indirect Pricing)

Both direct and indirect values were defined and considered for EGS. **Table 27** presents a simplified overview of whether the monetary value of these EGS involve direct or indirect market pricing. Direct values utilized are actions such as harvesting food, timber, or other resources from the ecosystem, as well as using an ecosystem as a place for recreation. Indirect values (such as for an ecosystem providing erosion protection or carbon regulation).

Table 27. EGS and monetary valuation technique.

EGS	Direct Market Pricing	Indirect Market Pricing
Food provisioning	Y	Y
Raw goods and material	Y	Y
Hazard mitigation (reduced risks to property and infrastructure, human safety)	N	Y
Soil retention	N	Y
Water supply and regulation	Y	Y
Property value support (via aesthetics)	N	Y
Recreation	Y	Y
Climate regulation (carbon sequestration)	N	Y

Economic use values driving demand include direct values (harvesting food, timber, or other resources from the ecosystem; using an ecosystem as a place for recreation) and indirect values (an ecosystem providing erosion protection or carbon regulation) (De Groot et al. 2010).

There is particular interest in the potential for combining incentive systems with markets or payment systems for multiple EGS to incentivize water quality improvement projects that would provide multiple EGS (as opposed to just water quality improvement or restored habitats). Combined systems would allow BMP projects to generate revenue from multiple separate EGS. This type of stacking/bundling of EGS for payments would allow the owners of a restored wetland to sell credits not only for pollutant-load reductions but also for bonus EGS, such as GHG reductions, wetland habitat, and water storage for flood mitigation. The desirability of allowing EGS payments to be stacked in this way is a source of debate; however, if separate payments are not earned for the same EGS, then no double counting would occur (USEPA 2012). In shellfish aquaculture, profit rates are low enough to be of concern, and investigations have been underway by NOAA, Maryland Sea Grant, and others to determine whether companies engaging in aquaculture should be eligible to sell nutrient trading credits to increase their profits.

5.1.10 EGS Market Categories, Motives, and Changes in EGS

Table 28 provides a summary of motives for EGS.

Table 28. Motives and Changes in EGS.

Market Category	Market Sector / Land Ownership	Motive	Change in EGS		
Voluntary	Private	Profit (such as to sell for future environmental credits**)	0		
	Private*	Not for profit (other motive)	+		
	Public	Not for profit (other motive)	+		
Compliance	Private	Incentivized/Required by government regulation	0		
	Public	Incentivized/Required by government regulation	0		

*USACE real estate policies would require cost-sharing nonprofit or government entity sponsor to own land with-project.
**Future environmental credits for compliance markets.

5.1.11 Conclusion

EGS valuation efforts have changed the terms of discussion on natural resource management. Nature conservation management strategies do not necessarily pose a trade-off between the environment and development. Investments in EGS constitute a win-win situation, which generates substantial ecological, social, and economic benefits (de Groot et al. 2010). For rural areas, environmental markets have the potential to become a new economic driver of substantial importance (USDA n.d., 2017).

To use a market approach to incentivize Chesapeake Bay Watershed restoration it is incumbent upon society to ensure that EGS markets are strong enough to generate substantial restoration effort. Based on the magnitude of remaining water quality improvements needed to meet TMDL requirements, demand drivers need to be increased. A fundamental challenge to increasing EGS outputs is that markets for these are traditionally limited absent government incentive. Regulations create markets that would not otherwise exist for many EGS. Creating markets for EGS is an area of recent intense interest. Efforts to increase output of EGS need to be carefully thought through though to avoid inducing unintended negative consequences.

Establishment of the bay TMDL is an unprecedented effort by society. It was undertaken because bay water quality improvements sought for decades through voluntary and state-focused efforts could not be realized and a watershed approach was needed.

Compensatory mitigation and compliance work are competing for sites that could otherwise be used for USACE ecosystem restoration projects. Because of this and USACE's unique capabilities to take on large and complex tasks, USACE should focus on projects too large in scale or complicated for other entities to undertake, such as degraded habitats caused by previous large-scale engineering efforts including by USACE and USDA-NRCS and its predecessors (such as massive length of channelized streams and wetlands on the Eastern Shore of Maryland) and channelization and piping of streams in urban areas. Urban and other settings where landowners are seeking other principal benefits (such as improved safety, public access) rather than habitat restoration would be included. Derelict urban shorelines where living shorelines could be retrofitted would be an example of such opportunities for public access. Urban restoration comes at a high price per acre. Additional opportunities likely suited for USACE include cases where partnering agency or organization would not be seeking CWA credits. Green Goodwill organizations such as TNC, DU, and land trusts fit this category. Public sector partners could include the military as part of stewardship efforts and states, counties, and municipal governments. Additional USACE agency efforts to establish and approve benefits metrics suitable for bay watershed restoration efforts needed.

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Section 6

Considerations for Implementation

This section presents information on project sequencing, project dependencies, and implementation barriers to project success. This information can assist in identifying the appropriate federal, state, and nonprofit funding sources and partnerships, at the right time, to implement conservation and restoration projects identified in the CBCP. The sequencing of projects, along with appropriate funding timetables serves to secure environmental benefits to the nation through the development and implementation of watershed based plans. In addition to this section being a guide for USACE, it is also a resource for state and local governments, regional agencies, and NGOs.

6.1 Project Sequencing and Dependencies

There are a number of sequencing considerations when proceeding to project implementation. Sequencing refers to considerations of steps or actions that precede project implementation. To achieve the intended outcomes there are some efforts that need to precede others. In general, water quality impairments and other stressors should be addressed prior to or in conjunction with USACE undertaking aquatic habitat restoration. The opportunities identified for stream health are marginally healthy subwatersheds with recognized watershed stressors. Consideration should be given to local stressors to determine if and how to address them prior to habitat restoration. It is anticipated that water quality impairments will be addressed by local sponsors or other partners. Stream restoration in opportunities with low stressors could be undertaken immediately for resident fish and EBT. However, there are no stream restoration opportunities for anadromous fish in low stress subwatersheds.

Various restoration practices to improve and expand brook trout habitat have been identified for implementation. In streams where non-native trout are present, non-native trout should be eradicated prior to restoring fish passage or removing a fish blockage where the removal of the blockage will connect to allopatric (EBT only) patches. This will prevent non-native trout from inhabiting current allopatric patches. In patches designated as "enhance stronghold," stressors should be addressed prior to undertaking habitat restoration. Also, when undertaking connectivity projects in patches in the "restore persistent populations and habitats," habitat restoration should be undertaken to provide a supporting habitat prior to or in conjunction with fish passage blockage removal.

Various wetland restoration practices have been identified for implementation to restore and enhance wetlands. In sites dominated by invasive species, control and repeated treatment along with wetland restoration and enhancement efforts may be needed to ensure long-term success of wetland restoration and enhancement sites. In sites contaminated with hazardous and/or toxic materials, restoration may be of lower priority than other sites and remediation undertaken by local partnersh and stakeholders may be necessary prior to conducting wetland enhancement and restoration opportunities.

Oyster restoration must be preceded by the development of a tributary plan that comprehensively looks at restoration opportunities within the river or river reach being restored. The presence of SAV is part of the consideration, as well as eroding shorelines. Typically, in the Chesapeake Bay, potential oyster restoration sites are too far from the shoreline to provide shoreline protection, but in more southern parts of the bay, there may be opportunities to leverage oyster reefs to provide shoreline stabilization. Alternatively, eroding shorelines may be the source of sediment to oyster and SAV restoration areas. In that light, those resources should be evaluated to understand potential negative impacts to restored oyster reefs in the adjacent waters.

Various restoration practices have been identified to improve and expand upon existing SAV beds. Successful restoration of SAV habitat in the bay is dependent on its improved water clarity conditions. In areas where SAV was historically present but is currently absent, water quality monitoring may need to be conducted to determine the factor(s) contributing to decreased SAV in the area; this monitoring should be compared to conditions in subwatersheds where SAV have rebounded or been restored. Implementation of water quality BMPs in the contributing watershed and tributaries to should occur if proposed SAV restoration areas do not meet water clarity standards for underwater grasses. If water clarity measurements become conducive to SAV restoration, small-scale, test plots should be planted in proposed restoration sites to determine feasibility for success of large-scale SAV plantings. If there is a nearby seed-base, SAV should return on its own if water clarity and conditions are favorable for underwater grasses. SAV restoration has been one of the primary areas of interest by the bay community. Further coordination with the CBP's SAV Workgroup would be appropriate for technical expertise and other restoration lessons learned that could be shared.

6.2 Barriers

Each of the Partnership's management strategies identifies barriers to achieving their specific goal or outcome. There are several factors, across the board, that influence the success of each of the 2014 Bay Agreement outcomes, and the outcomes of similar studies. These factors include: (1) funding availability, (2) the capacity of organizations to tackle issues within their jurisdiction, and (3) coordination between local, state, and federal governments, as well as NGOs to plan and implement projects. The discussion below presents a subset of the barriers identified in the Partnership's management strategies. Those presented below were selected because they reflect the current health of the watershed, reflect funding and partnering challenges, or identify a gap the CBCP has taken steps to address.

Common barriers associated with the current health of the watershed and the 2014 Bay Agreement outcomes in which the barrier is identified are:

1. Water quality – Poor water quality is recognized as a limiting factor for a number of outcomes: oysters, SAV, fish habitat (tidal, sub-tidal, nearshore, intertidal, nontidal cold and upstream waters, and nontidal warm waters), forage fish, stream health, EBT
2. Habitat loss, degradation, and fragmentation – Oysters, black duck, forage fish, fish habitat, stream health, EBT

3. Climate impacts and the lack of understanding of the extent of change that will occur – Fish habitat, oysters, forage fish, SAV, water quality

4. Shoreline disturbance and development – Black duck, forage fish, SAV

5. Landownership and willingness to participate – Wetlands, fish passage

6. Land use and watershed development/urbanization – Forage fish, fish habitat, stream health, EBT, SAV, and healthy watersheds

Barriers outside of the condition of the natural environment are also recognized. However, additional issues related to funding exist. For example, it is recognized that there are challenges in finding a nonfederal match to federal funds for costly projects. The Partnership, as noted in the riparian forest buffer outcome, identified that federal funds often go unused and sometimes it is due to lack of matching funds. To meet water quality outcomes, there is a challenge in understanding and addressing financial capacity needs to implement watershed implementation plans and two-year milestones. The lack of adequate and stable funding is a significant factor in meeting public access goals.

The CPB also found that from a policy standpoint, existing laws and policies do not adequately address many identified stressors (stream health outcome). Technical assistance for local communities is often insufficient and the application process for assistance can be complicated (forest buffer outcome). Lack of support from local and state governments and conflicting funding priorities can often be a challenge (contaminants and healthy watersheds outcomes). Additionally, the level of existing knowledge and implementation capacity among local officials varies widely.

Benefits of an ecosystem restoration or conservation project are often difficult to quantify, as are the impacts and trade-offs of natural resource decisions. Several 2014 Bay Agreement outcomes identified that understanding and communication of the benefits and need of projects to the public and local officials is a barrier that limits the ability to implement projects or reach goals (e.g., fish passage and healthy watersheds outcomes). Community support for restoration efforts will be key to achieving goals.

Barriers associated with federal initiatives include limitations in federal program flexibity that is desired by states and landowners to meet various outcomes. Also identified as a barrier to meeting goals is commonly a lack of interagency coordination and staff training at all levels of government. Further, federal engagement with local governments and groups throughout the watershed is needed and necessary to implement locally acceptable projects.

This Comprehensive Plan helps focus restoration efforts that improve the health of the natural environment and conserve existing valuable habitats by beginning to address some of these identified barriers. For example, the 2014 Bay Agreement riparian forest buffers coutcome identified challenges in siting riparian forest buffers where they would do the most good. The ripairian forest buffer analysis presented in the CBCP can be applied to address this challenge. With respect to conservation, a lack of permanent protection is a challenge, specifically for oysters and riparian forest buffers. Pairing conservation efforts and riparian buffer projects in subwatersheds that were identified as opportunities could assist in addressing this challenge. The healthy, high-value habitat analysis can assist with challenges of understanding where healthy waters and watersheds exist. Additionally, the 2014 Bay Agreement heathy watersheds outcome identified a barrier with understanding which healthy watersheds are most vulnerable to degradation. The CBCP analyses can be applied to assist in furtherin understanding and making decisions about where to invest limited resources. Finally the CBCP provides input to assist with making land use decisions. The investigations that considered human connections to the watershed may be applicable to address barriers related to connecting young people, urban populations, and underrepresented groups to the Bay and restoration efforts.

Section 7

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Annex 1

Comprehensive listing of measures identified for the Chesapeake Bay Watershed

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
CONSERVE AND PROTECT HABITATS	*Conserve existing and restored and enhanced black duck breeding, migratory, and wintering habitat.*	
	Conserve native fish habitats essential for migration, spawning, foraging, and overwintering.	
	Conserve existing reefs and restored reefs by designating them as reef sanctuary sites.	
	Develop incentives and tools for landowners to implement binding land conservation mechanisms that protect land from future development.	
	Provide technical assistance to landowners to facilitate creation of binding land conservation mechanisms that protect land from future development.	
	Monitor land use changes to track the rate and quantity of conversion of wetland, farm, and forest lands to developed lands and the amount of impervious surface.	
	Implement land conservation practices to protect healthy watersheds.	
	Conserve lands of cultural, indigenous, and community value through binding land preservation mechanisms that protect land from future development.	
	Provide outreach to the citizens, leadership, and other stakeholders to disseminate land use conversion findings and to communicate conservation tools and incentive programs to the public.	
	Outreach conservation initiatives and opportunities to underrepresented communities, urban populations and communities that rely on natural resources for sustenance and recreation.	
	Create public-private partnerships to determine land conservation strategies for landscapes benefitting the economy, environment, and our quality of life.	
	Conserve riparian forest buffer habitat through binding land preservation mechanisms that protect them from future development.	
	Establish landowner incentives for establishment of riparian forest buffers.	
	Provide technical assistance to landowners to encourage restoration and enhancement of riparian forest buffers and provide maintenance assistance.	
	Increase protection of riparian forest buffers in local land use regulations.	
	Conserve SAV beds through designation of protected, sanctuary sites.	
	Generate policy for more stringent regulatory protection of SAV beds.	
	Conserve tree canopies in urban and suburban landscapes.	
	Enact more protective policies for tree canopies at the local level in urban and suburban landscapes.	
	Conserve tidal wetlands through binding land preservation mechanisms that protect them from future development.	
	Conserve nontidal wetlands through binding land preservation mechanisms to protect them from future development.	

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
ENHANCE AND RESTORE HABITATS	***Black Duck Habitat***	
	Restore black duck breeding, migratory, and wintering habitat in wetlands through creation of habitats in areas that historically supported black duck populations.	✓
	Restore black duck breeding, migratory, and wintering habitat through creation of habitats in riparian areas that historically supported black duck populations.	✓*
	Enhance the function and value of existing, degraded black duck breeding, migratory, and wintering wetland habitat.	✓
	Enhance the function and value of existing, degraded black duck breeding, migratory, and wintering riparian buffer habitat.	✓*
	Reconnect fragmented black duck breeding, migratory, and/or wintering wetland habitats.	✓
	Reconnect fragmented black duck breeding, migratory, and/or wintering riparian buffer habitats.	✓*
	Conduct monitoring and adaptive management of black duck wetland restoration and enhancement sites.	✓
	Conduct monitoring and adaptive management of black duck riparian buffer restoration and enhancement sites.	✓*
	Conduct initial removal and/or treatment of exotic and invasive species that have the potential to impact black duck populations and their habitat in wetland areas	✓
	Conduct initial removal and/or treatment of exotic and invasive species that have the potential to impact black duck populations and their habitat in riparian buffer areas	✓*
	Adaptively manage exotic and invasive species that have the potential to impact black duck populations and their habitat through prevention, eradication, and control in wetland areas.	✓
	Adaptively manage exotic and invasive species that have the potential to impact black duck populations and their habitat through prevention, eradication, and control in riparian buffer areas	✓*
	Brook Trout Habitat	
	Restore streams through creation of habitats that historically supported brook trout populations.	✓
	Enhance the function and value of existing, degraded streams that support brook trout populations.	✓
	Reconnect fragmented streams and associated riparian buffers that support brook trout populations.	✓
	Reintroduce brook trout into stream habitats that historically supported brook trout populations.	
	Conduct monitoring and adaptive management of brook trout restoration and enhancement sites.	✓
	Conduct initial removal and/or treatment of exotic and invasive species that have the potential to impact brook trout populations and their habitat.	✓*
	Adaptively manage exotic and invasive species that have the potential to impact brook trout populations and their habitat through prevention, eradication, and control.	✓*
	Fish and Benthic Habitat	
	Conduct monitoring and adaptive management of fish habitat and restoration sites.	✓

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
ENHANCE AND RESTORE HABITATS	*Restore fish spawning, nursery, foraging, and overwintering fish habitats through creation of habitat that historically supported native fish populations.*	✓
	Enhance the function and value of existing, degraded fish spawning, nursery, foraging, and overwintering native fish habitats.	✓
	Restore native, oyster reef habitats through construction of new habitat in areas that historically supported oyster reefs.	✓
	Enhance the function and value of existing, degraded native oyster reef habitats.	✓
	Enhance the function and value of existing, degraded native freshwater mollusk habitat.	✓
	Restore native freshwater mollusk habitat through creation of habitat in areas that once supported freshwater mollusk populations.	✓
	Conduct adaptive management and monitoring at mussel restoration and enhancement sites.	✓
	Conduct monitoring and adaptive management at oyster reef restoration and enhancement sites.	✓
	Reestablish the plankton/zooplankton monitoring program to understand trophic dynamics influencing fish forage dynamics.	
	Riparian Buffer	
	Restore riparian forest buffer habitat through creation of habitat in areas that historically supported riparian forest buffers.	✓*
	Enhance the function and value of existing, degraded riparian forest buffer habitat.	✓*
	Reconnected fragmented riparian forest corridors.	✓*
	Adaptively manage and monitor riparian buffer restoration and enhancement sites.	
	Conduct initial removal or treatment of exotic and invasive species that have the potential to impact riparian forest buffers.	✓*
	Adaptively manage exotic and invasive species that have the potential to impact riparian forest buffers through prevention, eradication, and control.	✓*
	Shoreline/Streambanks	
	Stabilize existing, eroding shorelines/streambanks with living shorelines.	✓
	Restore shorelines/streambanks through creation of habitats at eroding shorelines/streambanks that historically supported shoreline/streambank habitats.	✓
	Enhance the function and value of existing, degraded habitats at eroding shorelines/streambanks.	✓
	Restore beach and dune habitats through creation of habitats that historically supported beach and dune habitats.	✓
	Enhance the function and value of existing, degraded beach and dune habitat.	✓
	Restore beach and dune habitats through creation of habitats from dredged material from navigation channels in areas that historically supported beach and dune habitats.	✓
	Enhance the function and value of existing, degraded beach and dune habitats using dredged material from navigation channels.	✓
	Conduct initial removal and/or treatment of exotic and invasive species that have the potential to impact shorelines/streambanks.	✓
	Adaptively manage exotic and invasive species that have the potential to impact shorelines/streambanks through prevention, eradication, and control.	✓*

US Army Corps of Engineers

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
ENHANCE AND RESTORE HABITATS	*Monitor and adaptively manage shoreline/streambank restoration and enhancement sites to assess implementation progress.*	✓
	Restore streams through creation of stream habitats in areas that historically supported stream habitats.	✓
	Enhance existing, degraded stream habitats.	✓
	Remove legacy sediments.	✓
	Reconnect fragmented streams.	✓
	Reconnect fragmented floodplains that were historically connected.	✓
	Monitor and adaptively manage stream restoration and enhancement sites to assess implementation progress.	✓
	Submerged Aquatic Vegetation	
	Restore submerged aquatic vegetation (SAV) beds through creation of new habitat by harvesting and planting seeds or by transplanting SAV from healthy beds to restoration sites.	✓
	Enhance the function and value of existing, degraded SAV beds.	✓
	Reconnect fragmented SAV beds in areas that historically contained SAV.	✓
	Conduct SAV monitoring and adaptive management at enhancement and restoration sites.	✓
	Conduct initial removal and/or treatment of exotic and invasive species that have the potential to impact SAV.	✓
	Adaptively manage exotic and invasive species that have the potential to impact SAV through prevention, eradication, and control.	✓
	Tree Canopies	
	Restore tree canopies through creation of habitat in urban and suburban landscapes.	✓*
	Enhance the function and value of existing tree canopies in urban and suburban landscapes.	✓*
	Implement incentive programs to support tree canopy plantings and tree canopy plantings in other areas.	
	Conduct initial removal or treatment of exotic and invasive species that have the potential to impact tree canopies.	✓*
	Adaptively manage exotic and invasive species that have the potential to impact tree canopies through prevention, eradication, and control.	✓*
	Wetlands	
	Restore tidal wetlands through creation of habitats that historically supported tidal wetlands.	✓
	Enhance the function and value of existing, degraded tidal wetlands.	✓
	Restore nontidal wetlands through creation of habitats that historically supported nontidal wetlands.	✓
	Enhance the function and value of existing, degraded nontidal wetlands.	✓
	Restore the function and value of existing, degraded tidal wetlands using dredged material from navigation channels.	✓
	Enhance the function and value of existing, degraded tidal wetlands using dredged material from navigation channels.	✓
	Restore the function and value of existing, degraded nontidal wetlands using dredged material from navigation channels.	✓
	Enhance the function and value of existing, degraded nontidal wetlands using dredged material from navigation channels.	✓
	Restore remote bay islands through creation of habitat in areas that historically contained bay islands.	✓
	Reconnect fragmented nontidal wetlands.	✓
	Reconnect fragmented tidal wetlands.	✓

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
ENHANCE AND RESTORE HABITATS	*Restore remote bay islands through creation of habitat using dredged material from navigation channels in areas that historically contained bay islands.*	✓
	Enhance the function and value of existing, degraded remote bay islands.	✓
	Enhance the function and value of existing, degraded remote bay island using dredged material from navigation channels in areas that historically contained bay islands.	✓
	Conduct monitoring and adaptive management of tidal and nontidal wetland restoration and enhancement sites.	✓
	Conduct initial removal or treatment of exotic and invasive species that have the potential to impact tidal and nontidal wetland habitat.	✓
	Adaptively manage exotic and invasive species that have the potential to impact tidal and nontidal wetland habitat through prevention, eradication, and control.	✓*
	Conduct monitoring and use of data-driven, holistic modeling to understand climate change effects and its impacts to the Chesapeake Bay ecosystem.	
INCREASE EDUCATIONAL OPPORTUNITIES AND STEWARDSHIP	*Outreach to nonprofits, the public, and local leadership to engage them in environmental restoration and enhancement planning efforts and educator training programs.*	✓*
	Promote stewardship with local communities and schools by engaging them to participate in restoration projects.	✓*
	Promote stewardship with local communities and schools through citizen monitoring programs.	
	Inform nonprofits, the public, and local leadership of Chesapeake Bay monitoring programs and the status of restoration, enhancement, and conservation implementation in the watershed.	
	Conduct outreach to recruit and engage socially vulnerable communities to participate in restoration and enhancement projects and citizen monitoring efforts.	
	Conduct community-partnership building in socially vulnerable communities to understand perceptions and preferred strategies for environmental restoration, enhancement, and conservation.	
	Implement STEM programs at schools that align with the Standards of Learning and Curriculum Framework to promote an understanding of watershed issues and restoration strategies.	
	Schools participate in "sustainable school" certification program and “Blue Ribbon School” certification programs that includes best management practices (BMPs) for schools in the watershed.	
RESTORE AND PROTECT FISH AND WILDLIFE POPULATIONS	*Remove/modify impediments to fish passage.*	✓
	Adaptively manage existing and future projects to allow for fish passage.	✓
	Conduct dredge surveys and comprehensive stock assessments to track the status and trends of blue crab populations and response to restoration and enhancement projects.	
	Implement integrated water management at impounded water bodies such as dams and reservoirs to meet water related needs and maximize environmental benefits to the maximum, practical extent.	✓
	Protect managed fisheries by increasing monitoring and enforcement of legal harvesting.	
	Protect oyster reefs by increasing monitoring and enforcement of poaching operations.	

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
RESTORE AND PROTECT FISH AND WILDLIFE POPULATIONS	*Reintroduce native mollusks (nonreef, fresh and brackish species) into areas with suitable habitat that historically supported native mollusk populations.*	
	Policy - Increase mechanisms to allow for regulatory protection of oyster restoration reefs through designation of sanctuary areas.	
CREATE POLICY	*Attain new authorizations for or modification of existing authorizations to permit USACE involvement in new mission areas.*	
INCREASE PUBLIC ACCESS AND RECREATION OPPORTUNITIES	*Increase public access points for recreation in the watershed.*	✓*
REMEDIATE AND CONTROL TOXIC CONTAMINANTS	*Conduct monitoring to identify toxic contamination source sites and assess remediation progress at existing contaminant sites.*	
	Compile education materials regarding existing procedures and BMPs for prevention of release of toxic contaminants.	
	Coordinate a voluntary action program to encourage the phase out of polychlorinated biphenyl (PCB) containing materials and encourage use of non-PCB technologies.	
	Remediate toxic contamination sites to prevent and reduce impacts of contamination sites to the watershed.	
IMPROVE WATER QUALITY	*Incorporate green infrastructure into retrofits of existing infrastructure and when constructing new infrastructure.*	✓*
	Implement alternative crops as a BMP to reduce to reduce nonpoint source pollution in the watershed.	
	Implement conservation tillage as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement land retirement as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement stream fencing as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement tree planting as a BMP to reduce nonpoint source pollution in the watershed.	✓*
	Implement forest conservation as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement urban growth reduction as a BMP to reduce nonpoint source pollution in the watershed.	
	Reduce impervious surfaces as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement dirt and gravel road erosion and sediment control as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement street sweeping as a BMP to reduce nonpoint source pollution to the watershed.	
	Implement urban nutrient management as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement septic denitrification and pumping as a BMP to reduce source pollution in the watershed.	
	Implement bioretention as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement urban stormwater management as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement erosion and sediment control BMPs to reduce nonpoint source pollution in the watershed.	
	Implement pasture management BMPs to reduce nonpoint source pollution in the watershed.	

MEASURE CATEGORY	MEASURE	POTENTIAL IMPLEMENTATION BY USACE
IMPROVE WATER QUALITY	*Implement Animal Feeding Operations/Concentrated Animal Feeding Operations land management BMPs to reduce point source pollution in the watershed.*	
	Utilize cover crops as a BMP to reduce nonpoint source pollution in the watershed.	
	Implement trash management BMPs to reduce nonpoint source pollution in the watershed.	
	Provide technical assistance to farmers and landowners for implementation of BMPs that will improve water quality.	
	Provide incentives for farmers and landowners for implementation of BMPs that will improve nonpoint source pollution in the watershed.	
	Policy – Increase mechanisms to allow for more stringent regulatory protection discharge on nonpoint source pollutants in the watershed.	
	Monitor status and long-term trends in water quality to determine compliance with state and federal water quality standards and Total Maximum Daily Load (TMDL) implementation status.	
	Reclaim and remediate land and water bodies affected by abandoned mine lands.	
	Increase protection of healthy watersheds through implementation of local ordinances.	
	Monitor and adaptively manage BMPs and remediation efforts to assess health and implementation progress of BMPs and remediation efforts of watersheds.	

*Measure can only be undertaken by USACE on USACE-owned property

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Annex 2

Detail of Composite Analyses, Restoration Opportunities Analyses, and Other Considerations

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US Army Corps of Engineers

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1.0 Composite Analyses

From the extensive geodatabase compiled for the CBCP, 8 composite analyses were identified for use as foundational information syntheses of multiple data layers. Each combined a number of data layers focused on one topic. Because of time constraints, the project delivery team (PDT) made necessary decisions regarding the incorporation of data based on availability and quality, and screened layers for inclusion in each analysis accordingly. The composite analyses were combined and evaluated in different combinations to investigate a set of questions in the Restoration Opportunities Analysis. **Figure 1** shows the composite analyses concept, while each composite analysis is detailed in the following sections.

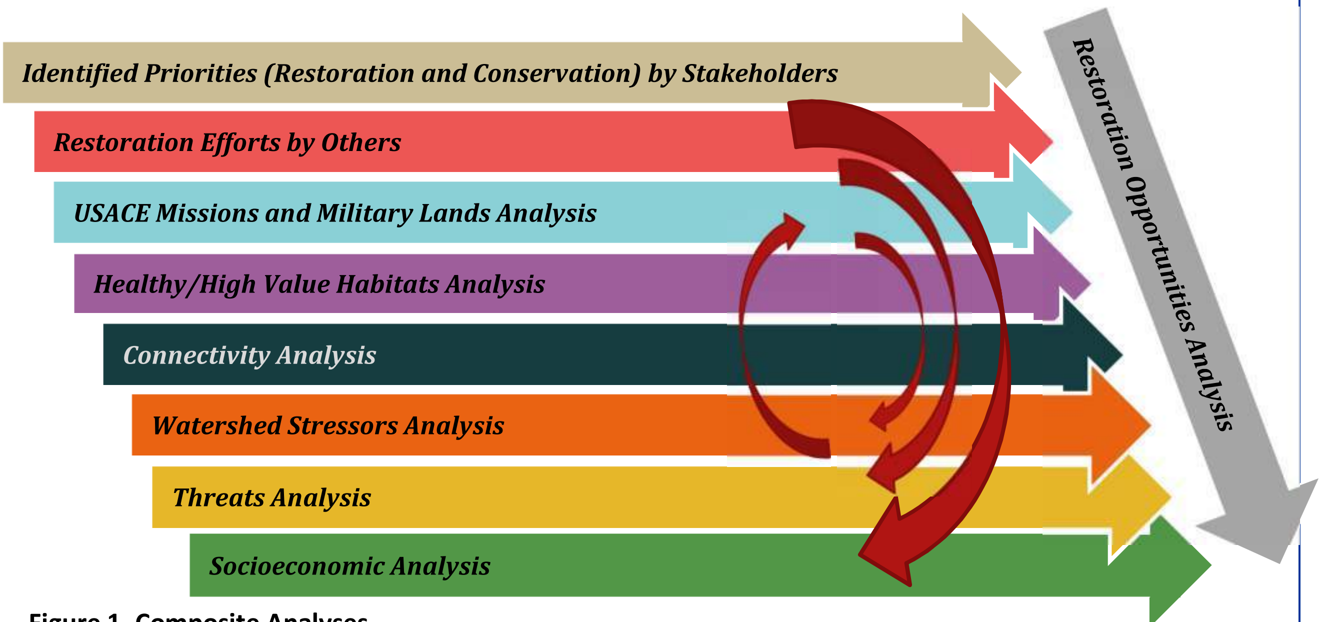


Figure 1. Composite Analyses

1.1 Identified Priorities by Stakeholders

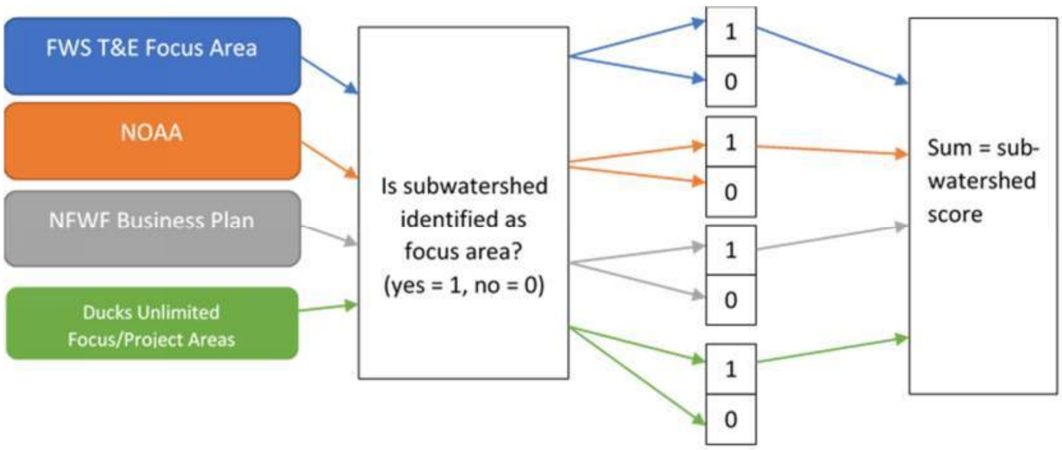
Overview: This compilation shows the regions in the watershed identified as focus or priority areas by agencies and groups working to restore the Chesapeake Bay. Focus areas for restoration were differentiated from those identified for conservation. **Figure 2** shows the priorities for restoration and **Figure 3** identifies those for conservation. **Figure 4** depicts the compiled priorities for restoration and conservation.

1a. Restoration data layers: The following layers were overlaid in GIS to develop the restoration focus area composite:

- Federal agency prioritized areas:
  - *Focus Areas forUSFWS* – Chesapeake Bay Field Office – Threatened and Endangered Species (T&E)
  - *National Oceanic and Atmospheric Administration (NOAA) Habitat Focus Areas*
  - *NFWF Business Plan Focus Areas* – Focuses on the recovery of four keystone species (oysters, crabs, river herring, and eastern brook trout (EBT))

- *Ducks Unlimited Focus/Project Areas*

Conceptual diagram and computations: A subwatershed was scored as a '1' if the subwatershed was part of an agency's identified restoration focus area, and a '0' if it was not a focus area. The scores for each subwatershed were then summed to provide the total score. The final scores were categorized using the Jenks Natural Breaks classification method (Jenks method) and are depicted in five groups.



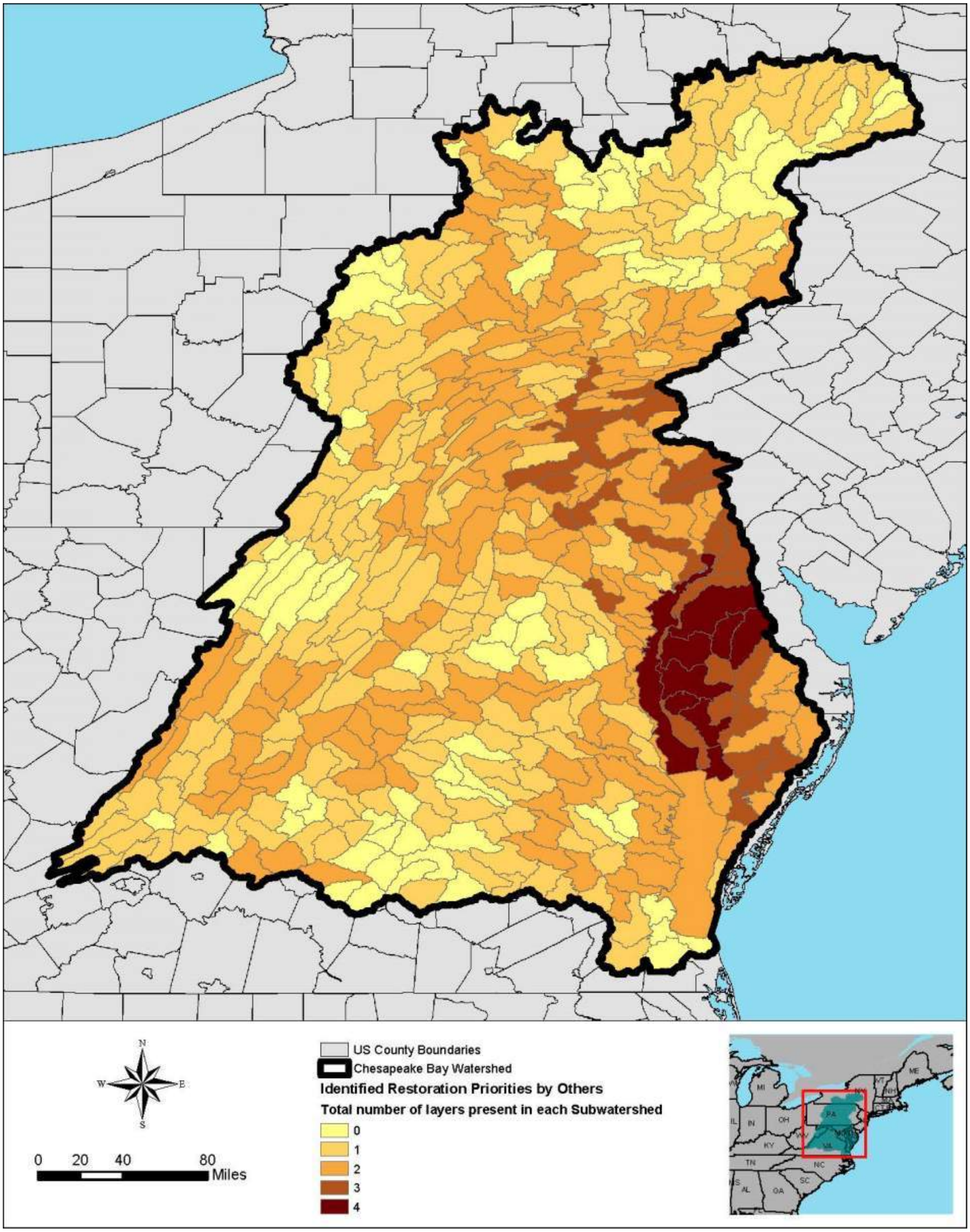


Figure 2. Restoration priority areas identified by others (CA-1-RestPrio)

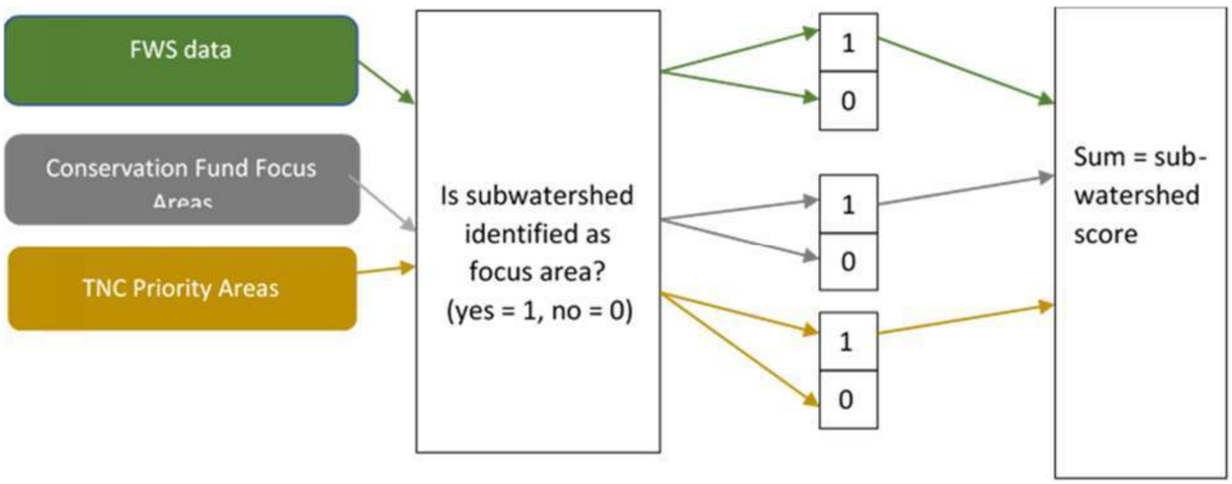
Key points:

1. Restoration efforts by groups reported are largely focused in the Maryland mainstem, Eastern Shore of Maryland, and Lower Susquehanna River Watersheds.

1b. Conservation data layers: The following layers were overlaid in GIS to develop the conservation focus area composite:

- *Conservation Fund Focus Areas*
- *The Nature Conservancy (TNC) Priority Areas* – Areas identified and prioritized using ecoregional assessments for conservation
- *USFWS* – Other species data included birds, fish, and invertebrates

Conceptual diagram and computations: A subwatershed was scored as a '1' if the subwatershed was part of an agency's identified conservation focus area, and a '0' if it was not a focus area. The scores for each subwatershed were then summed to provide the total score.



Key points:

1. Conservation efforts by groups reporting have been focused in:
    a) Maryland Eastern Shore
    b) Potomac River Watershed around the District of Columbia
    c) Lower Susquehanna River corridor in Pennsylvania
    d) Chemung and Upper Susquehanna River Watersheds in New York
    e) West Virginia portions of the upper Potomac River Watershed
    f) Subwatersheds in the Pamunky, Mattaponi, and lower James River Watersheds in Virginia

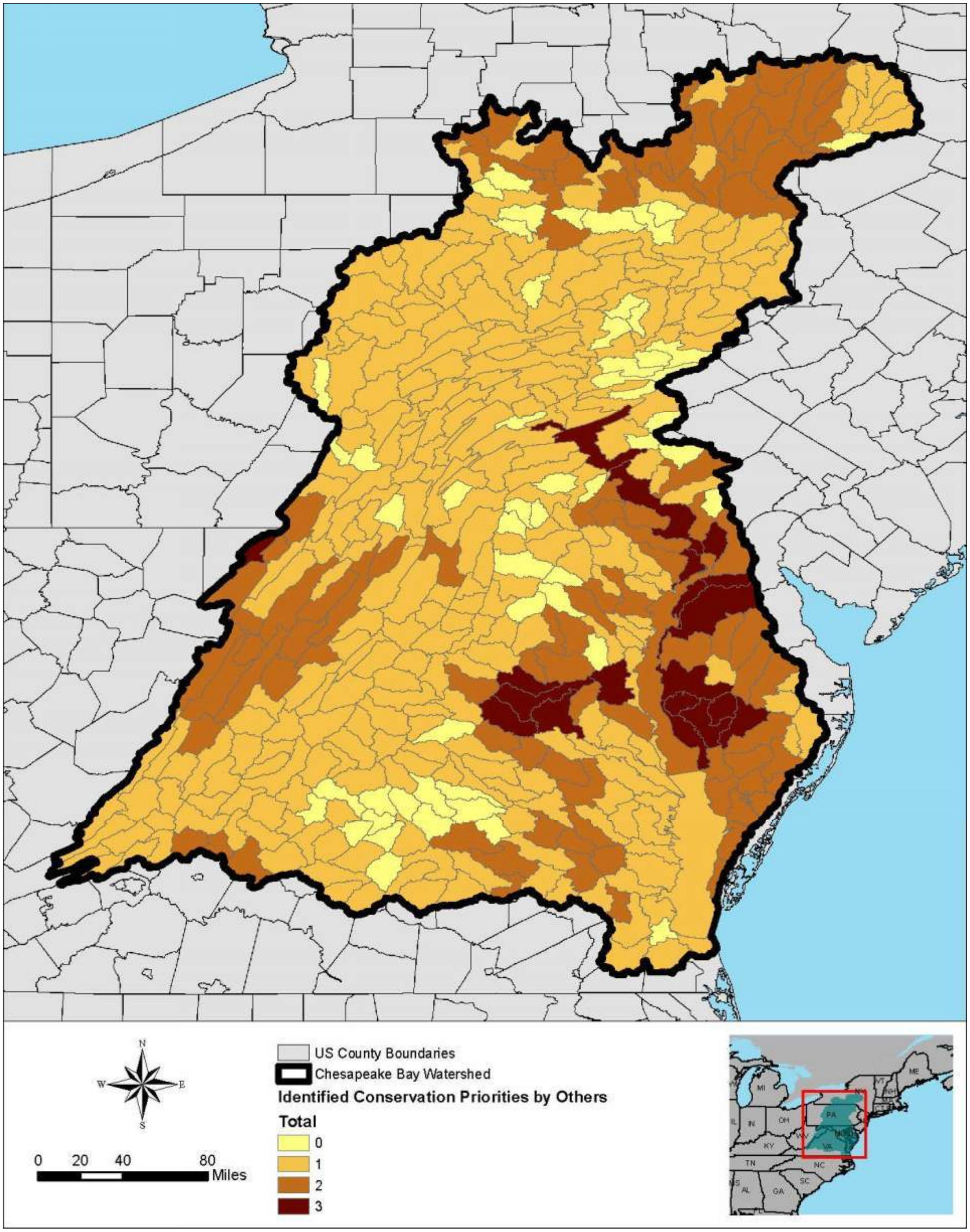


Figure 3. Conservation priority areas identified by others (CA-1-ConsPrio)

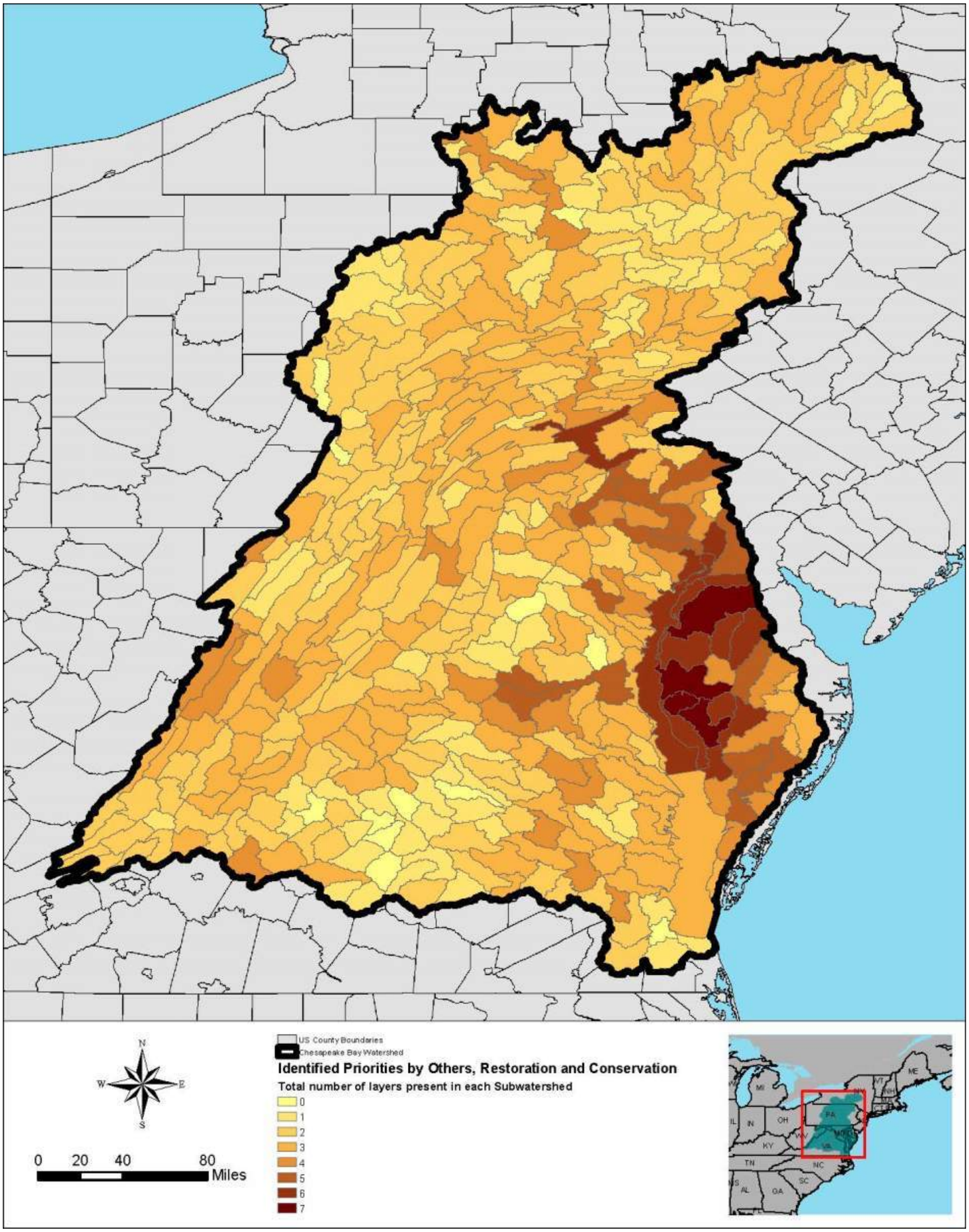


Figure 4. Restoration and conservation priority areas identified by others (CA-1-CombPrios)

Key points:

1. Combined restoration and conservation priorities by groups reporting have been focused in:

a) The Maryland mainstem and the Eastern Shore of Maryland

b) Potomac River Watershed around the District of Columbia

c) Lower Susquehanna River corridor in Pennsylvania

1.2. Restoration Actions by Others

Overview: This compilation summarizes the information available to show where restoration actions have been implemented within the watershed (**Figure 5**).

Data layers: The following layers were overlaid in GIS to develop the 'Restoration action by others' composite:

- *Systems Approach to Geomorphic Engineering (SAGE) implemented projects*
- *NFWF Legacy Grants*
- *Projects implemented on military lands*
- *Projects that have received a USACE Nationwide Permit 27 (ecosystem restoration)*
- *Stakeholder input to CBCP data calls*
- *Existing Partnership Management Strategies (project layer developed by the cross-GIT)*

Conceptual model and computations: Data are depicted as points representing the location of each project.

Key points:

1. Significant efforts have been invested in Chesapeake Bay restoration. In the past, the Chesapeake Bay TMDL has been a particular focus to reduce nitrogen, phosphorus, and sediment in the watershed. With the exception of efforts implemented on military lands, information identifying where projects have been implemented toward TMDL reduction was unavailable. This is a concern and significant data gap in understanding what type of strategies have been used spatially across the watershed. The availability of such information would have enabled an analysis of whether specific strategies are being over- or under-used and in which locations, and would have enabled a determination of where gaps exist in implementing restoration efforts.

2. Restoration efforts reported span the Chesapeake Bay Watershed.

3. Concentrated restoration efforts were reported in the corridor between the District of Columbia and Baltimore, Maryland; the western shore of the bay north of Baltimore; the middle Eastern Shore of Maryland; the Norfolk, Virginia area and the lower James River (Virginia).

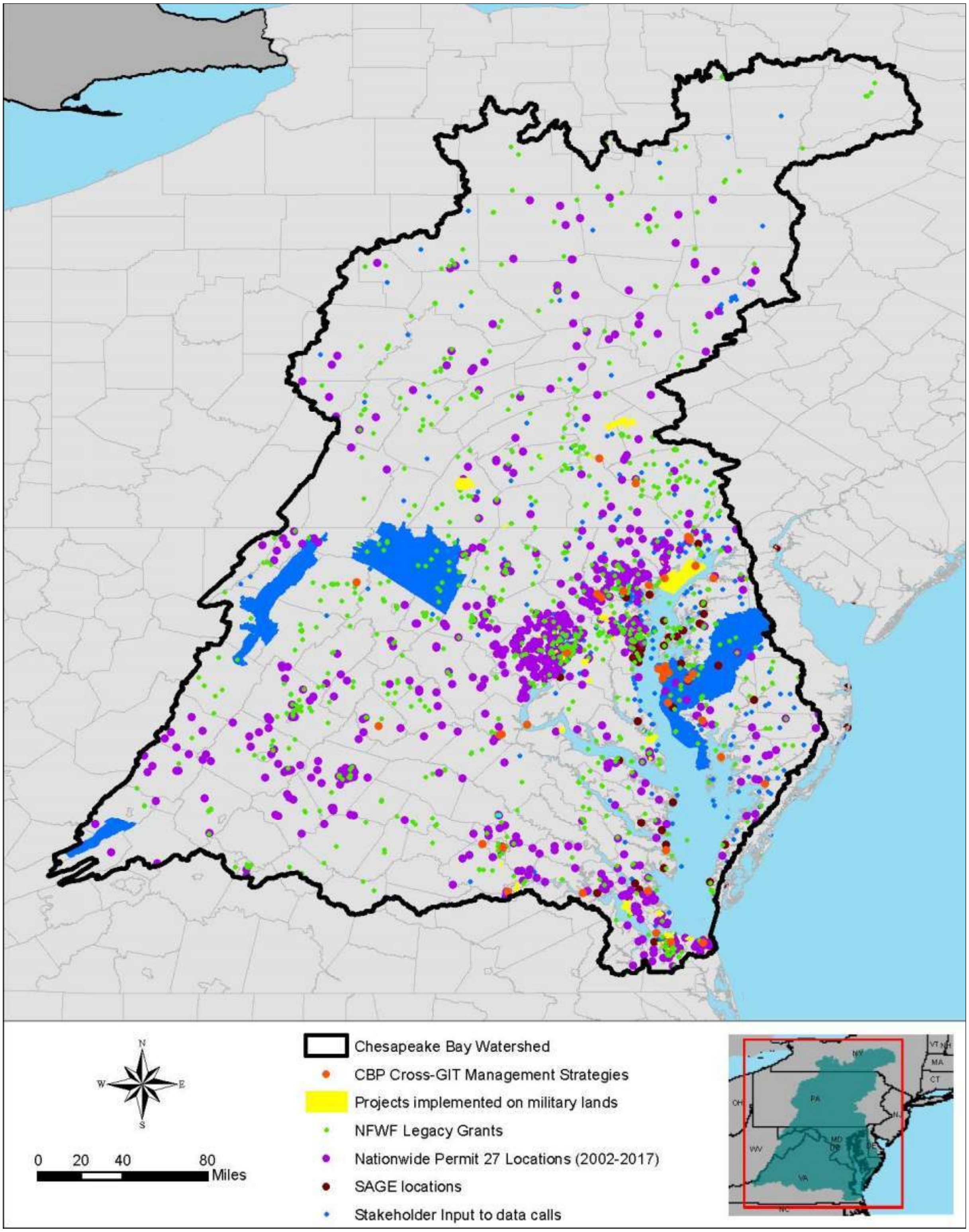


Figure 5. Restoration efforts by others (CA-2-RestEff)

1.3 USACE Mission Analysis and Military Lands

Overview: This compilation provides a spatial representation of USACE involvement in the watershed and provides two maps: (1) map depicting the location of existing USACE projects and military lands and (2) map showing the geographic boundaries of existing USACE authorities.

3a. Data layers: The following layers were overlaid in GIS to develop a map showing existing USACE projects and military lands:

- *Dams and reservoirs*
- *Aquatic ecosystem restoration projects*
- *Navigational channels and structures*
- *Military lands*
- *Levees*
- *Coastal storm damage reduction projects*
- *Dredged material placement sites*

Conceptual model and computations: Data are depicted as points representing the location of each project or military facility (**Figure 6**). Therefore, no computations or manipulations of the data were completed.

Key points:

1. USACE has been extensively involved across mission areas in the Chesapeake Bay mainstem.
2. Projects throughout the broader watershed have focused on one mission area; in few instances multiple missions have been pursued by projects.
3. Ecosystem restoration projects have been largely focused in Maryland; coastal storm damage reduction projects have been largely focused in Virginia.

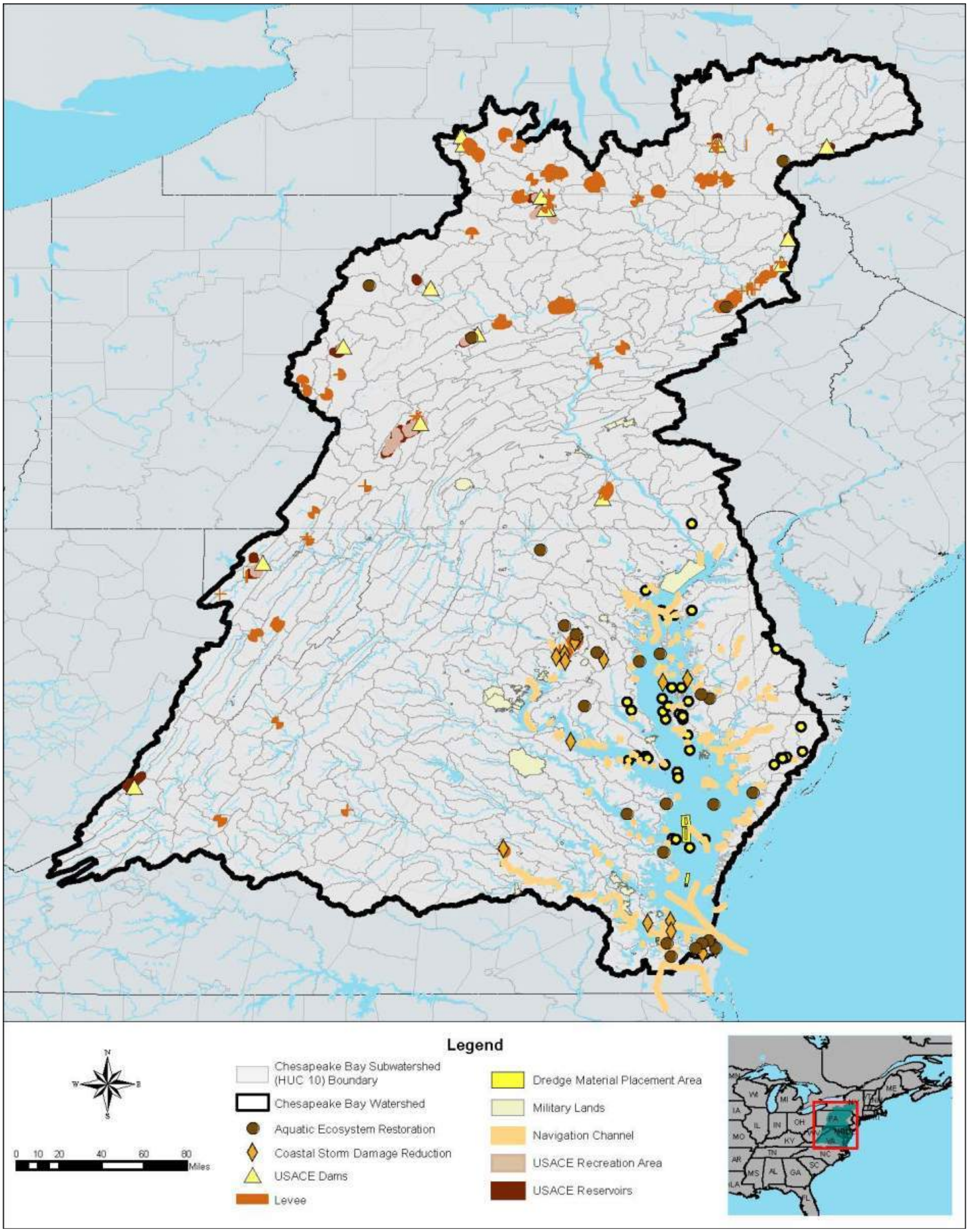


Figure 6. USACE Projects (CA-3-USACE-A)

3b. Data layers: The following layers were overlaid in GIS to develop a map that shows the geographic boundaries of existing USACE investigations or study resolution authorities **(Figure 7)**:

- *Boundaries of individual USACE authorities.*

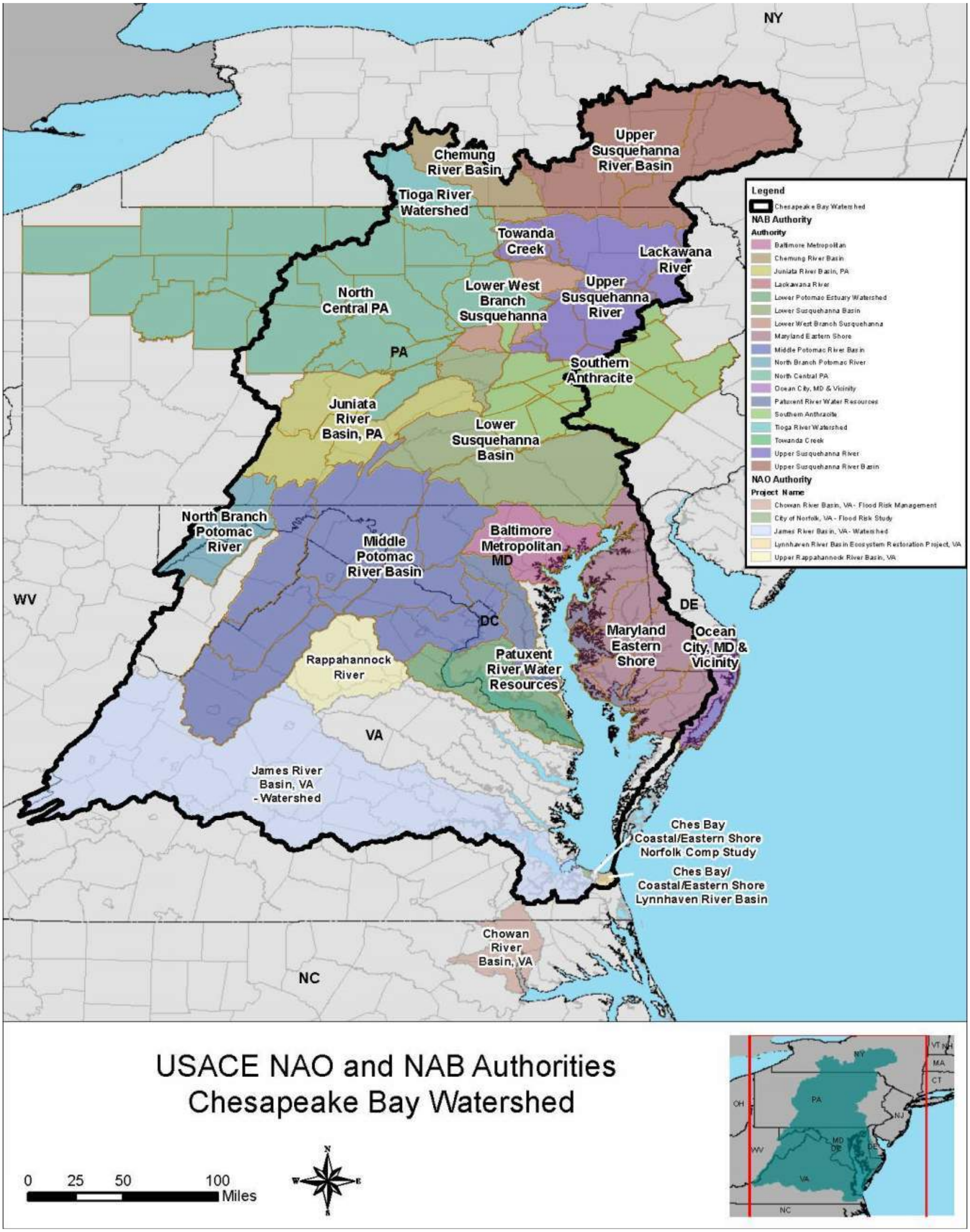


Figure 7. USACE Study Authorities (CA-3-USACE-B)

Key points:

1. USACE watershed authorities for investigations cover most of the Chesapeake Bay Watershed.

2. Areas not covered by a specific authority: (1) Mainstem portion of the Rappahannock River and York River; (2) South, Rhode, and West Rivers on the western shore in Maryland; the (3) upper Potomac River in West Virginia, and the eastern shore of Virginia. However, these areas are covered by the broader Section 729 watershed assessment authority, Continuing Authorities, and Section 510 Programs.

1.4 Healthy/High-value Habitats

Overview: This analysis identifies areas in the watershed that have the healthiest habitats.

Data layers: The following data were overlaid in GIS to develop the nontidal habitats evaluation:

- *State-identified healthy watersheds* – Healthy watersheds based on state-derived definitions and classifications of respective state healthy waters and watersheds.

- *Subwatersheds identified as brook trout catchments* – National Hydrography Dataset plus catchments identified as potentially supporting EBT based on the Eastern Brook Trout Joint Venture Salmonid Catchment Assessment.

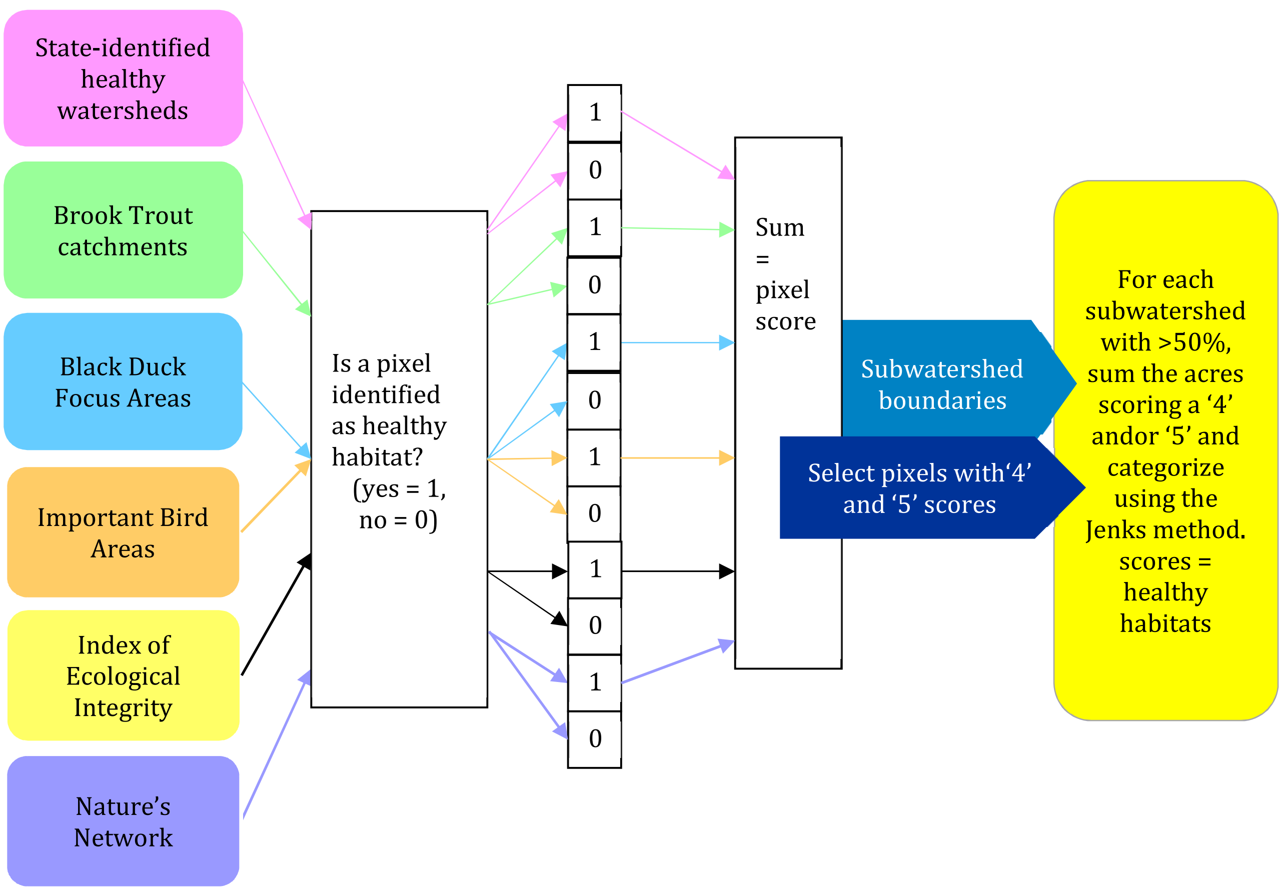
- *CBP Black Duck Focus Areas* – This dataset depicts the potential capability of the landscape throughout the northeastern U.S. to provide habitat for American black duck, during the nonbreeding season, based on environmental conditions existing in 2010. Landscape capability integrates factors influencing climate suitability, habitat capability, and other biogeographic factors affecting the species' prevalence in the area. This data was generated by the CBP Habitat GIT Black Duck Workgroup.

- *Audubon Important Bird Areas* – Important Bird Areas are coordinated by Audubon and are defined by state-level committees and state criteria as areas vital for bird migration, wintering, foraging, breeding, and roosting habitats including areas in need of restoration and enhancement. Important Bird Areas are considered priority sites for biodiversity conservation.

- *Index of Ecological Integrity (IEI)* – The IEI is a measure of relative intactness (i.e., freedom from adverse human modifications and disturbance) and resiliency to environmental change (i.e., capacity to recover from or adapt to changing environmental conditions driven by human land use and climate change) on a 0–1 scale. It is a composite index derived from up to 21 different landscape metrics, each measuring a different aspect of intactness (e.g., road traffic intensity, percent impervious) and/or resiliency (e.g., ecological similarity, connectedness) and applied to each 30 meter (m) cell. The IEI data were accessed from North Atlantic Landscape Conservation Cooperative data sets http://northatlanticlcc.org/spatial-data.

- *Nature's Network core and connector habitat* – Nature's Network is a collaborative effort facilitated by the USFWS. The effort's vision is to identify and map a connected network of resilient and ecologically intact habitats that will support biodiversity under changing conditions to prioritize restoration and inform land protection.

Conceptual diagram and computations: The datasets listed above were analyzed as raster (pixel) data. The respective vector data layers (i.e., polyline, polygon layers) were converted to raster data layers for the analysis. The grid resolution used for the raster analyses included 30m pixels for all analyses except wetland analyses, which used a 10m pixel. Additionally, considering the high-resolution land cover dataset used in several analyses was high quality, a higher resolution grid at 10m pixel size was used for all raster analyses that used that data, such as impervious surfaces and percent forest cover used as inputs into the Watershed Stressors Analysis. The computations were performed for each pixel rather than for each individual subwatershed. Therefore, within each pixel, the presence of healthy habitat (within any individual dataset) was assigned a '1', and scores were tallied across all datasets to compute a total pixel score. The areas with a total score of '4' or '5' were selected and joined with subwatershed boundaries. The total number of acres scored as a '4' or '5' was calculated per subwatershed and categorized using the Jenks method into five groups. **Figure 8** shows the resulting image of healthy/high-value habitats.



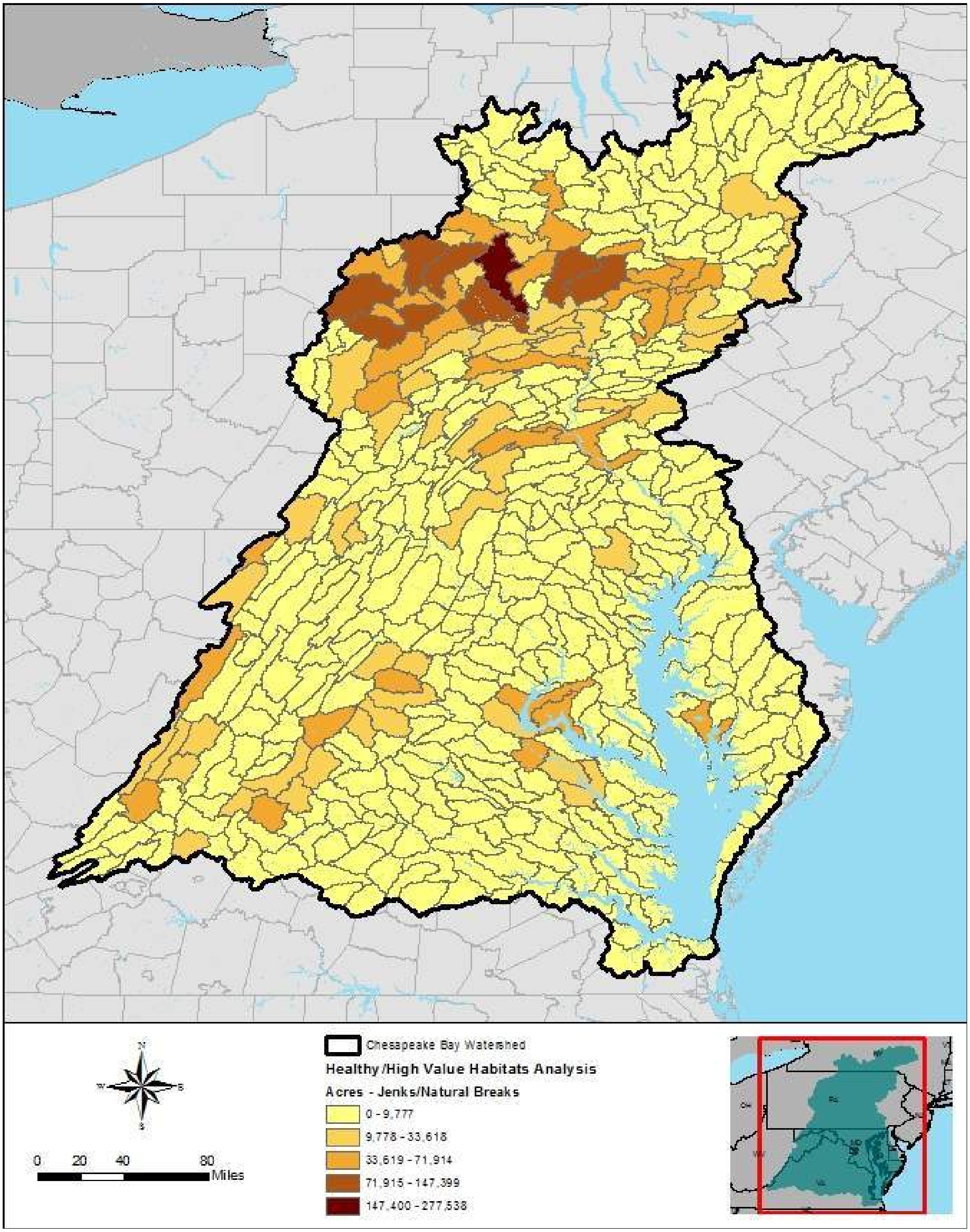


Figure 8. Healthy/High-value Habitats Analysis (CA-4-HHVH)

Key points:

1. The healthiest subwatersheds based on the data layers used are in the upper West Susquehanna River Watershed in Pennsylvania.
2. Healthy subwatersheds are also located along the western edge of the bay watershed in the upper Potomac River Watershed in West Virginia and in western Virginia.

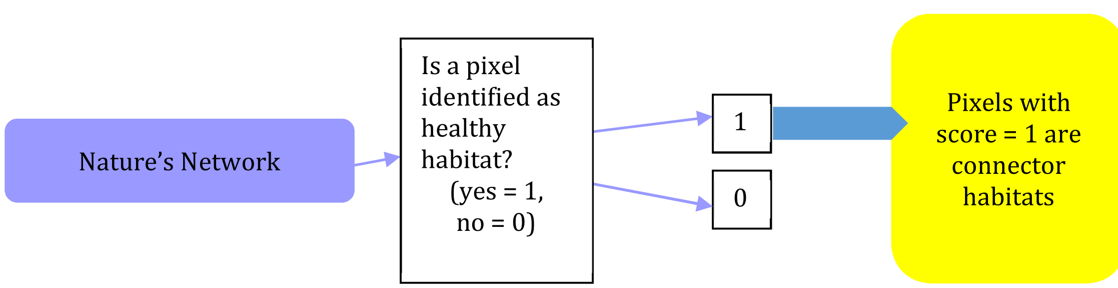
1.5 Connectivity Analysis

Overview: This analysis characterizes where the corridors and other landscape features are located that serve as critical habitat connectors in the watershed.

Data layers: One data layer was identified and used to represent critical habitat connectors and is shown in **Figure 9**:

- *Nature's Network connector habitat* – Described in the Healthy/High-value Habitats Analysis

Conceptual diagram and computations: The datasets listed above were analyzed as raster (pixel) data. The respective vector data layers (i.e., polyline, polygon layers) were converted to raster data layers for the analysis. The grid resolution used for the raster analyses included 30m pixels for all analyses except wetland analyses, which used a 10m pixel. Additionally, considering the high-resolution land cover dataset used in several analyses was high quality, a higher resolution grid at 10m pixel size was used for all raster analyses that used that data, such as impervious surfaces and percent forest cover used as inputs into the Watershed Stressors Analysis. The computations were performed for each pixel rather than for each individual subwatershed. Therefore, within each pixel, the presence of healthy habitat (within any individual dataset) was assigned a '1', and scores were tallied across all datasets to compute a total pixel score. The areas with a total score of '4' or '5' were selected and joined with subwatershed boundaries. The total number of acres scored as a '4' or '5' was calculated per subwatershed and categorized using the Jenks method into five groups.



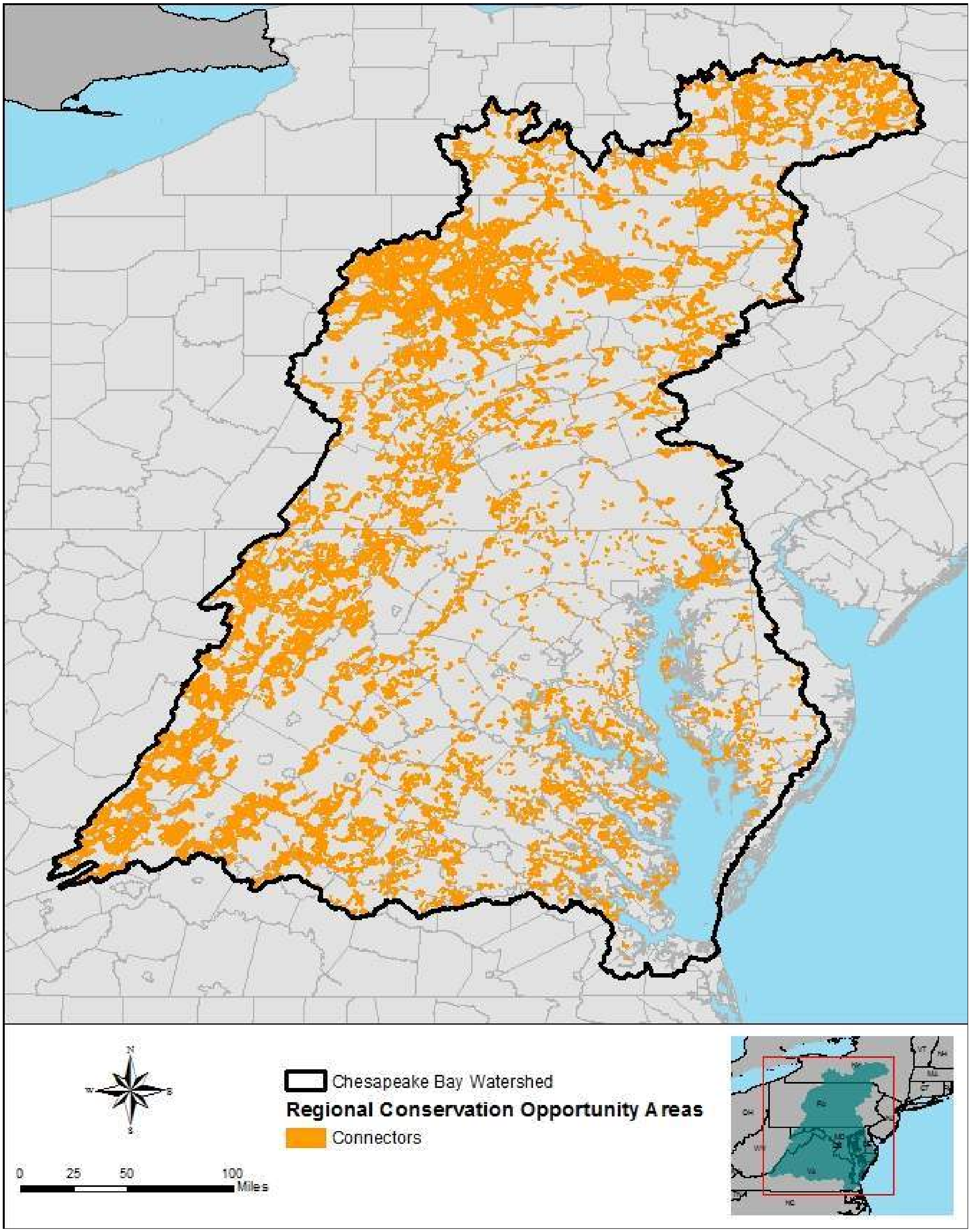


Figure 9. Connector habitats in the Chesapeake Bay Watershed as identified by Nature's Network (CA-5-CON)

Key points:

1. Connector habitats are distributed throughout the watershed.
2. The greatest connectivity exists in:
    a) Upper Potomac River Watershed in the western portions of the watershed in western Virginia and West Virginia
    b) Upper Susquehanna River in New York
    c) Western portions of the Susquehanna River Watershed in Pennsylvania
    d) James River Watershed in Virginia
    e) Southern portions of tributaries on the western shore in Virginia
3. The regions with the greatest opportunity to improve connectivity are:
    f) Eastern Shore of Maryland and Virginia
    g) Lower Susquehanna River Watershed in south-central Pennsylvania
    h) Subwatersheds in the corridor between Baltimore, Maryland and the District of Columbia including the subwatershed to the west of this corridor
    i) Along the Blue Ridge Mountains in Virginia

1.6 Watershed Stressors Analysis

Overview: The Watershed Stressors Analysis (WSA) evaluates the presence of stressors to watershed health and function in each individual subwatershed based on six metrics: (1) percent impervious cover, (2) percent forest, (3) percent of stream network with forested riparian buffers, (4) streams miles listed as impaired on the 303(d) list, (5) CBP Benthic Index of Biotic Integrity, and (6) nitrogen (N) and phosphorus (P) yields as predicted by Spatially Referenced Regressions on Watershed (SPARROW) modeling. Subwatersheds are ranked by their resulting scores to identify the least degraded areas. The least degraded areas have higher scores.

Data layers: The following data were used in the Watershed Stressors Analysis.

- *Percent impervious cover* – Percent impervious cover for each subwatershed was determined from high resolution land cover data collected in 2016 by the Chesapeake Bay Conservancy. Percent impervious cover represents the amount of development within a watershed. As percent impervious cover increases in a watershed, the stream network becomes degraded. The impervious cover model (ICM) developed by the Center for Watershed Protection (CWP) estimates that most stream quality indicators decline when impervious cover is greater than 10 percent (CWP 2003). Severe degradation is likely to occur once 25 percent imperviousness is reached (CWP 2003). Maryland Department of Natural Resources (MDDNR) General Guidelines for Impervious Cover incorporated these metrics. The scoring scheme used to rate percent impervious cover in the watershed screening is based on MDDNR's guidelines and the findings of the CWP (CWP 2003).

- *Percent forest cover* – Percent forest cover for each subwatershed was determined from high-resolution land cover data collected in 2016 by the Chesapeake Bay Conservancy. *The State of Chesapeake Forests* (The Conservation Fund 2006) identifies a relationship between stream health rating and percent tree cover within a watershed. The scoring scheme used to rate percent forest cover in the watershed screening is based on that relationship.

- *Percent of stream network within a subwatershed with forested riparian buffers* – Percent forested riparian buffer in each subwatershed was calculated by determining the percent of forested land within a 100 foot (ft) distance from each streambank. *The State of Chesapeake Forests* identifies a relationship between stream health rating and percent tree cover within a riparian area and sets a goal of increasing the percent of forested riparian areas to 70 percent. The scoring scheme used to rate percent forested riparian buffer in the watershed screening is based on that relationship.

- *303(d) impaired waterways list* – Under section 303(d) of the Clean Water Act (CWA), states are required to develop a list of impaired waters and report them to the U.S. Environmental Protection Agency (EPA). Impaired waters are those waters where water quality standards cannot be attained or maintained. The number of stream miles listed as impaired on the 303(d) list were calculated for each subwatershed. The scoring scheme for the impaired waterways data layer was determined using the Jenks method available in GIS.

- *CBP Benthic Index of Biotic Integrity (B-IBI)* – Stream health is incorporated into the watershed screening by inclusion of the average Chesapeake Bay basin wide B-IBI. The B-IBI was developed from benthic macroinvertebrate data collected across the entire Chesapeake Bay Watershed and synthesized into a basin-wide evaluation by the CBP (CBP 2012). The average B-IBI was determined by subwatershed boundaries except in Pennsylvania and New York. In these two states, monitoring programs collected data from many "targeted" sampling sites (such as sites below an outfall of a pollutant source), as opposed to "random." These data were not included by CBP in the basin wide evaluation to avoid the presumed bias introduced by targeted site data (CBP 2012). CBP determined watershed B-IBI ratings in Pennsylvania and New York using the HUC 8 watershed boundaries, which are less certain because they are derived from fewer random/systematic sampling sites. Watershed stream health ratings were included in the watershed screening of this plan based on subwatershed boundaries. GIS was used to assign the subwatersheds in Pennsylvania and New York a rating from the CBP's HUC 8 watershed designations. The scoring scheme for the watershed screening of this plan was determined by assigning scores based on the health rating of the watershed.

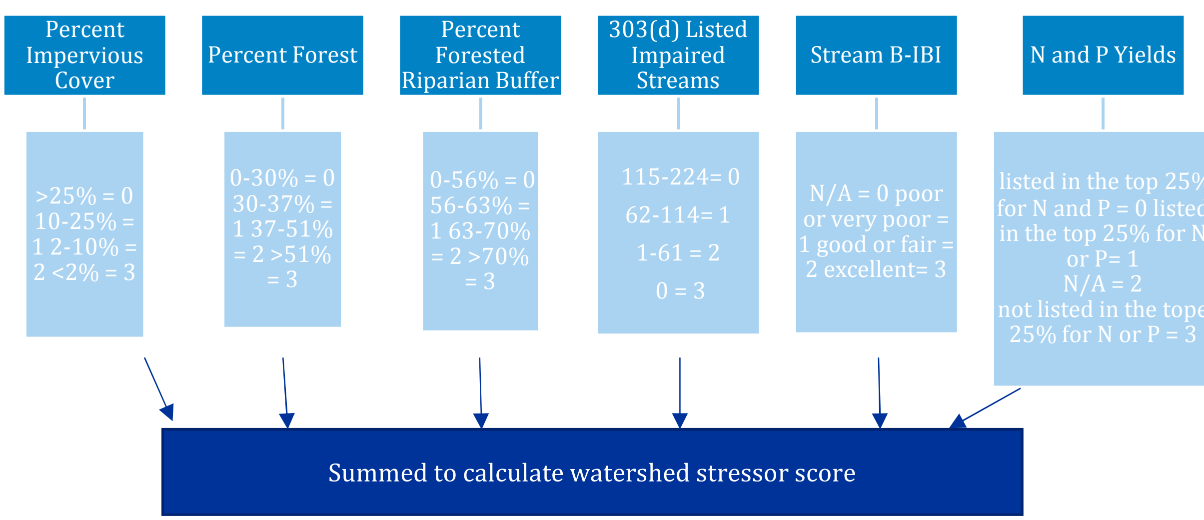
- *Nitrogen and phosphorus yield projections from SPARROW modeling* – This dataset contains mean-annual incremental phosphorus (TP) fluxes and mean-annual incremental nitrogen (TN) fluxes predicted by the SPARROW models, CBTN_v4 and CBTP_v4, for individual stream and shoreline reaches in the Chesapeake Bay Watershed as defined by NHDPlus, a 1:100,000 scale representation of stream hydrography built upon the National

Hydrography Dataset (NHD) (Horizon Systems 2010; Simley and Carswell 2010). Areas shown represent the top 25 percent of all Chesapeake Bay NHD catchments for phosphorus yields and nitrogen yields.

Conceptual diagram and computations: Individual data layers were assigned scores from 0 to 3 based on the criteria specified in **Table 1**. Scores were then totaled for all data layers into a final WSA score. The Jenks method was used to group the subwatersheds into categories based on the WSA score, and is depicted in **Figure 10**.

Table 1. Scoring framework for the Watershed Stressors Analysis

Parameter	Data Source	Metric	Scoring
Landuse (measures of landscape alterations from development)	Chesapeake Conservancy 2016	Percent impervious cover. Scoring based on MDNR General Guidelines for Impervious Surface Thresholds.	0 = >25% 1 = 10- 25% 2 = 2-10 % 3 = <2 %
	Chesapeake Conservancy 2016	Percent forest cover. Scoring based on goals set and relationships determined in USFS State of Chesapeake Forests (2006)	0 = 0-30% 1 =>30-37 2 =>37-51% 3 = >51
	EPA 2010 (Army Comp Plan)	Percent of stream network within subwatershed with forest (riparian buffer). Scoring based on goals set and relationships determined in USFS State of Chesapeake Forests (2006).	0 = 0-56% 1 = >56-63% 2 = >63-70% 3 = >70%
Stream health- water quality	303(d) Impaired waterways list (EPA)	Stream miles listed as impaired within subwatershed (scoring based on groups determined using Natural Breaks Method (Jenks) in GIS).	0 = 84.64 - 183.33 1 = 34.45 - 84.64 2 = 0.02 - 34.45 3 = 0
Stream health- biological integrity	Chesapeake Bay Program Benthic Index of Biotic Integrity 2000-2010 (watershed-wide B-IBI)	Subwatershed rating assigned by Chesapeake Bay Program based on B-IBI determined by stream monitoring.	0 = NA 1 = poor or very poor 2 = good or fair 3 = excellent
Nitrogen and Phospurus Impairments	SPARROW model output	Top 25 % of all Chesapeake Bay NHD catchments for nitrogen and phosphorus yields	0 = a subwatershed in the top 25% for N and P 1 = a subwatershed in the top 25% for N or P 3 = not a subwatershed in the top 25% for N or P



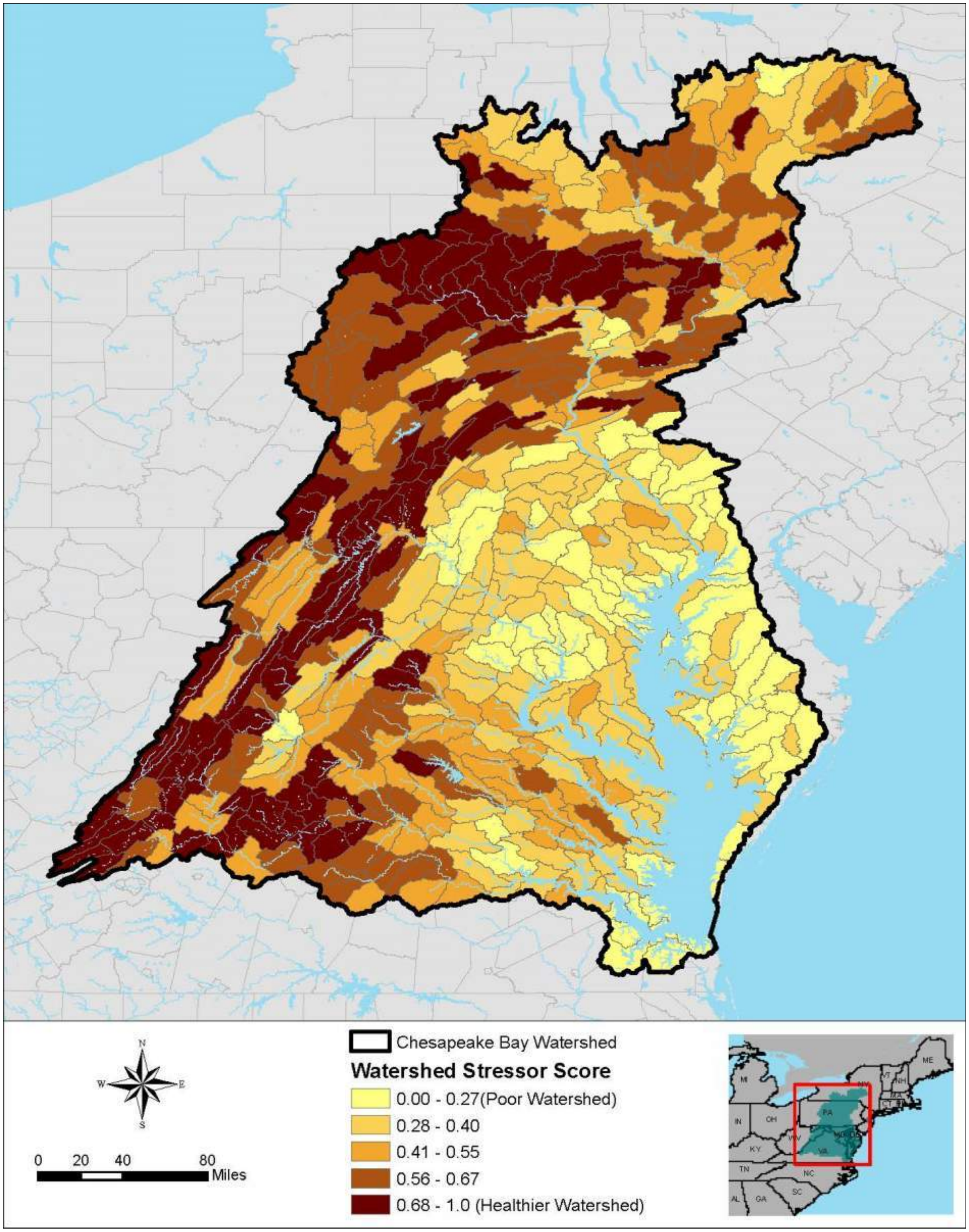


Figure 10. Watershed Stressors Analysis scores (CP-6-WSA)

Key points:

1. Watershed stressor scores generally follow patterns of development.

2. The least stressed regions of the watershed are generally in the western and northern subwatersheds, furthest from the mainstem of the Bay:

    a) Upper Susquehanna River Watershed in Pennsylvania

    b) Upper Potomac River Watershed in West Virginia and western Virginia

    c) Upper James River in Virginia

3. Along the mainstem of the Bay, the least stressed subwatersheds are located in the Virginia portions in the York and James Rivers Watersheds.

4. The most heavily stressed subwatersheds are located:

    d) On the Eastern Shores of Maryland and Virginia and the Delmarva Peninsula in Delaware,

    e) In the subwatersheds on the western shore of Maryland including the corridor from Baltimore, Maryland to the District of Columbia, and

    f) The lower Susquehanna River Watershed in Pennsylvania.

5. Subwatersheds in New York are moderately stressed in the Chemung River Watershed and other parts of the upper Susquehanna River Watershed.

1.7 Threats Analysis

Overview: This compilation identifies areas within the watershed threatened by urbanization and climate change, as well as areas prone to increased/persistent flooding in the future. An analysis is presented for nontidal portions of the watershed as well as for tidal regions.

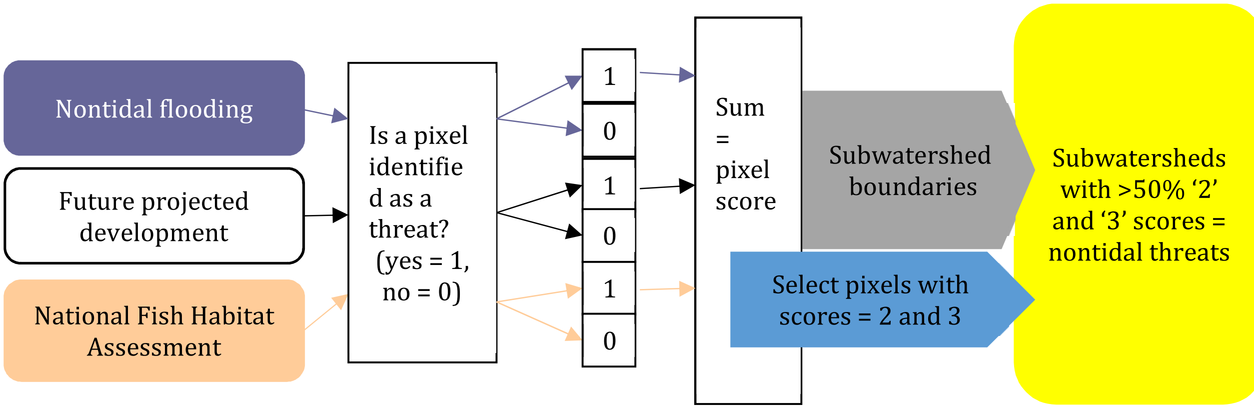
7a. Nontidal data layers: The following layers are incorporated into the nontidal Threats Analysis:

- *Nontidal flooding* – Flood Mask. Data provided by Quentin Stubbs, U.S. Geological Survey (USGS) CBP Office GIS Team

- *Future projected development* – Data developed as part of USACE's North Atlantic Coast Comprehensive Study (NACCS). This data shows the future population and residential development increase by 2070 using information and datasets generated as part of EPA's Integrated Climate and Land Use Scenarios (ICLUS) (USEPA 2009). Housing Density, files hc_b2_01012070/hc_b2_01012010. Values calculated on change from 2010 compared to 2070; any change greater than 0 was counted.

- *National Fish Habitat Assessment* – High risk of habitat degradation. The National Fish Habitat Partnership compiled freshwater datasets available at the national scale to develop habitat vulnerability scores across the U.S. Datasets included anthropogenic disturbances and accounted for natural variation at different spatial scales. Chesapeake Bay Watershed scores depict the current risk of habitat degradation and do not represent regional or local datasets for specific watersheds or geographies.

Conceptual diagram and computations: The datasets listed above were analyzed as raster (pixel) data. The computations were performed for each pixel, rather than for each individual subwatershed. Therefore, within each pixel, the presence of an identified threat (in an individual dataset) was assigned a '1', and scores were tallied across all datasets to compute a total pixel score. For the nontidal Threat Analysis, subwatersheds with greater than 50 percent of pixels with a total pixel score of 2 or 3 were selected as targeted areas. **Figure 11** provides the nontidal threats analysis.



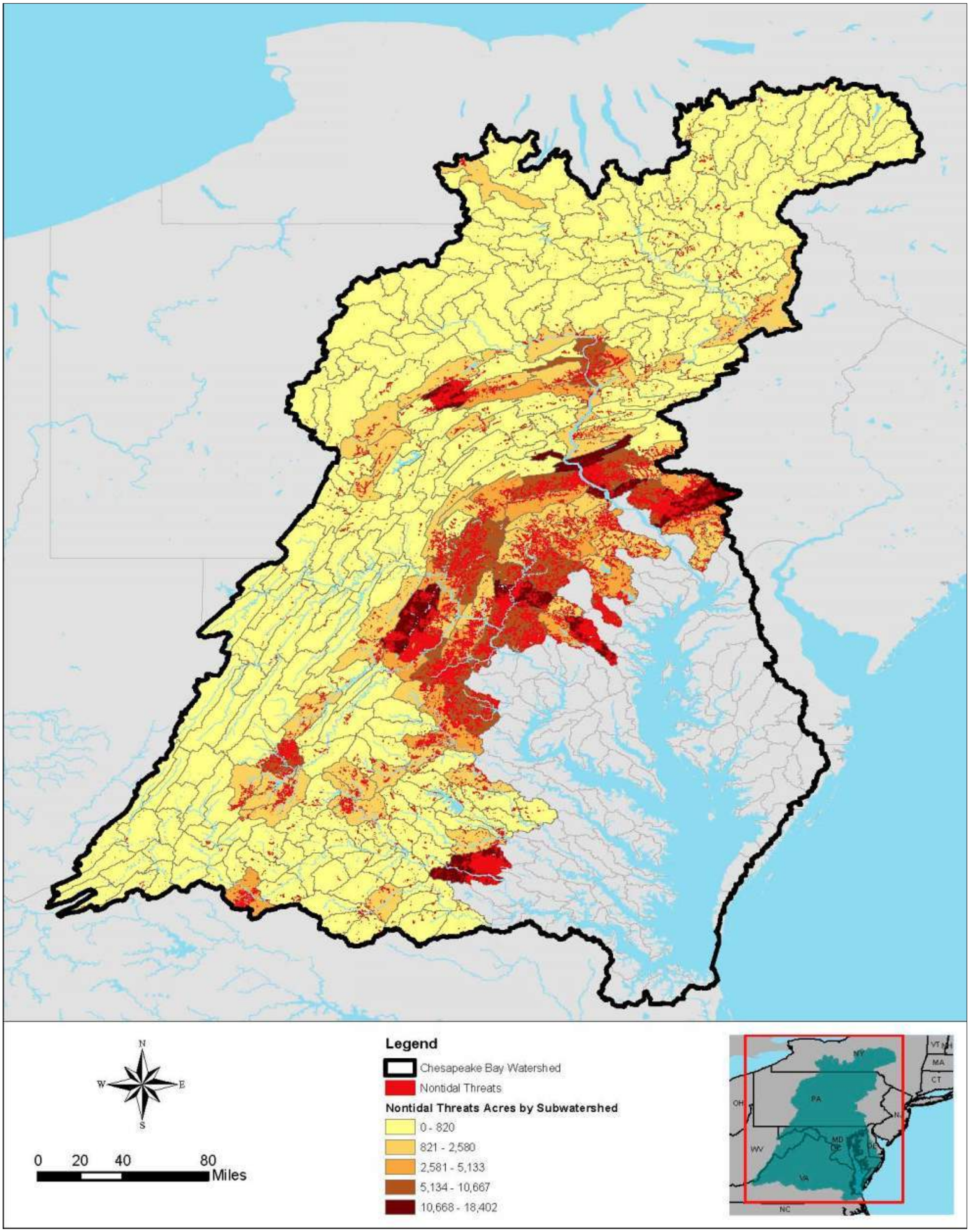


Figure 11. Evaluation of nontidal threats (CA-7-NTT)

Key points:

1. The subwatersheds that are most threatened by nontidal problems are located in:

   a) The Conestoga River, Susquehanna River, Lower Susquehanna, Chiques Creek, Lower Swatara and Lower Conodoguinet Creek in the lower Susquehanna region of Pennsylvania

   b) Spring Creek and West Branch Susquehanna in the West Branch of the Susquehanna River in central Pennsylvania

   c) Subwatersheds in the Potomac River Watershed extending from southwest of the District of Columbia to the Maryland/Pennsylvania line – Middle Monacacy River, Little Patuxent, Lower Monacacy River, Seneca Creek, Double Pipe Creek, and Gwynns Falls in Maryland; Antietam Creek and Conococheague Creek in Maryland and Pennsylvania; and Upper and Lower Goose Creek, Long Marsh Run – Shenandoah River, and Cedar Run in Virginia

   d) Opequon Creek on the Virginia/West Virginia border

   e) The Lower North River in the Potomac basin in Virginia

   f) Tuckahoe Creek- James River and Upper Chickahominy near the mouth of the James River estuary in Virginia

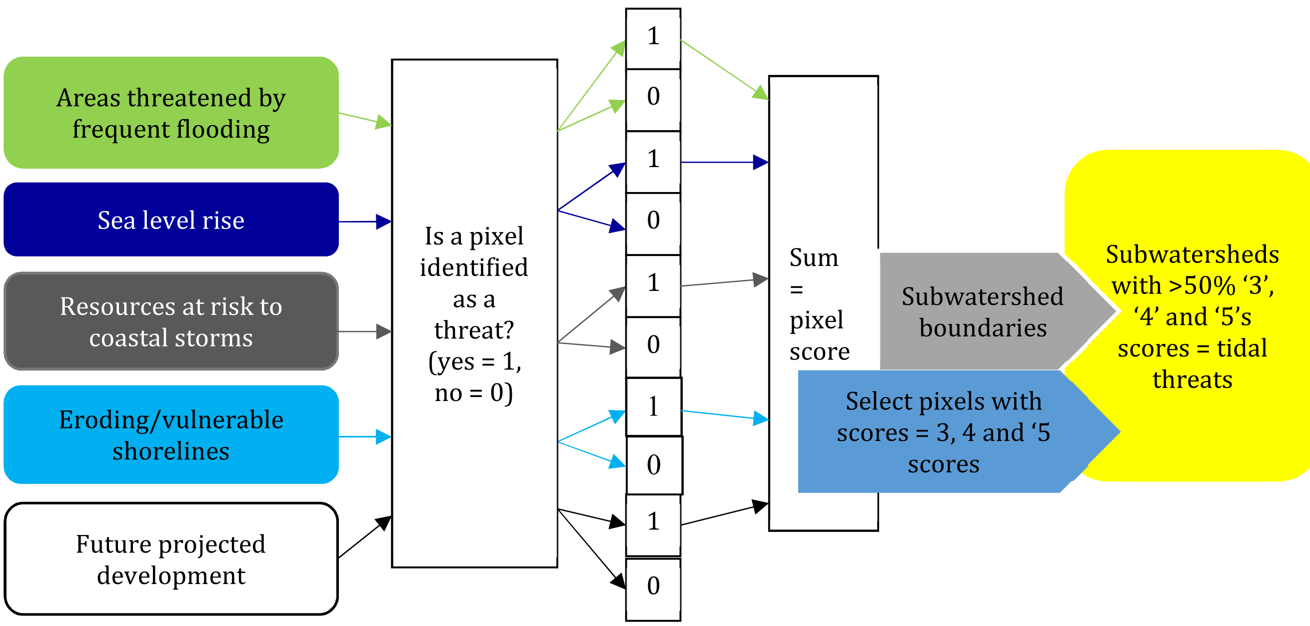
2. In general terms, the northern and western portions of the watershed are at minimal risk to future nontidal threats.

7b. Data layers: The following layers are incorporated into the tidal threats analysis provided in **Figure 12**:

- *Areas projected to have more frequent "normal" flooding* – Data developed from NACCS and USGS 30m digital elevation model (DEM).
- *Future projected development* – Data from NACCS, Housing Density. Values calculated on change from 2010 compared to 2070 and counted any change greater than 0. This shows the future population and residential development increase by 2070 using information and datasets generated as part of the EPA's ICLUS (USEPA 2009)
- *Sea level rise (SLR) curves* – Sea level rise is projected using the USACE Sea Level Rise High Scenario in year 2100 based on USGS Sea Level Rise Calculator
- *Resources at risk to coastal storms* – The NAACS developed a composite coastal risk index. Values greater than 778.05 were viewed as 'high' and used to represent areas at risk to coastal storms
- *Coastal vulnerability index (CVI)* - The coastal vulnerability index was developed by USGS [similar to that used by Gornitz et al. (1994) and Shaw et al. (1998)] and provides a relative ranking of the possibility that physical change will occur along the shoreline as sea level

rises. The index is based on six variables and the relative interaction of the variables that include tidal range, wave height, coastal slope, shoreline erosion rates, geomorphology, and historical rates of relative sea level rise (USGS 2000).

Conceptual diagram and computations: The datasets listed above were analyzed as raster (pixel) data. The computations were performed for each pixel rather than for each individual subwatershed. Therefore, within each pixel, the presence of an identified threat (in an individual dataset) was assigned a '1', and scores were tallied across all datasets to compute a total pixel score. For the tidal Threats Analysis, subwatersheds with greater than 50 percent of pixels with a total pixel score of 3, 4, or 5 were selected as targeted areas.



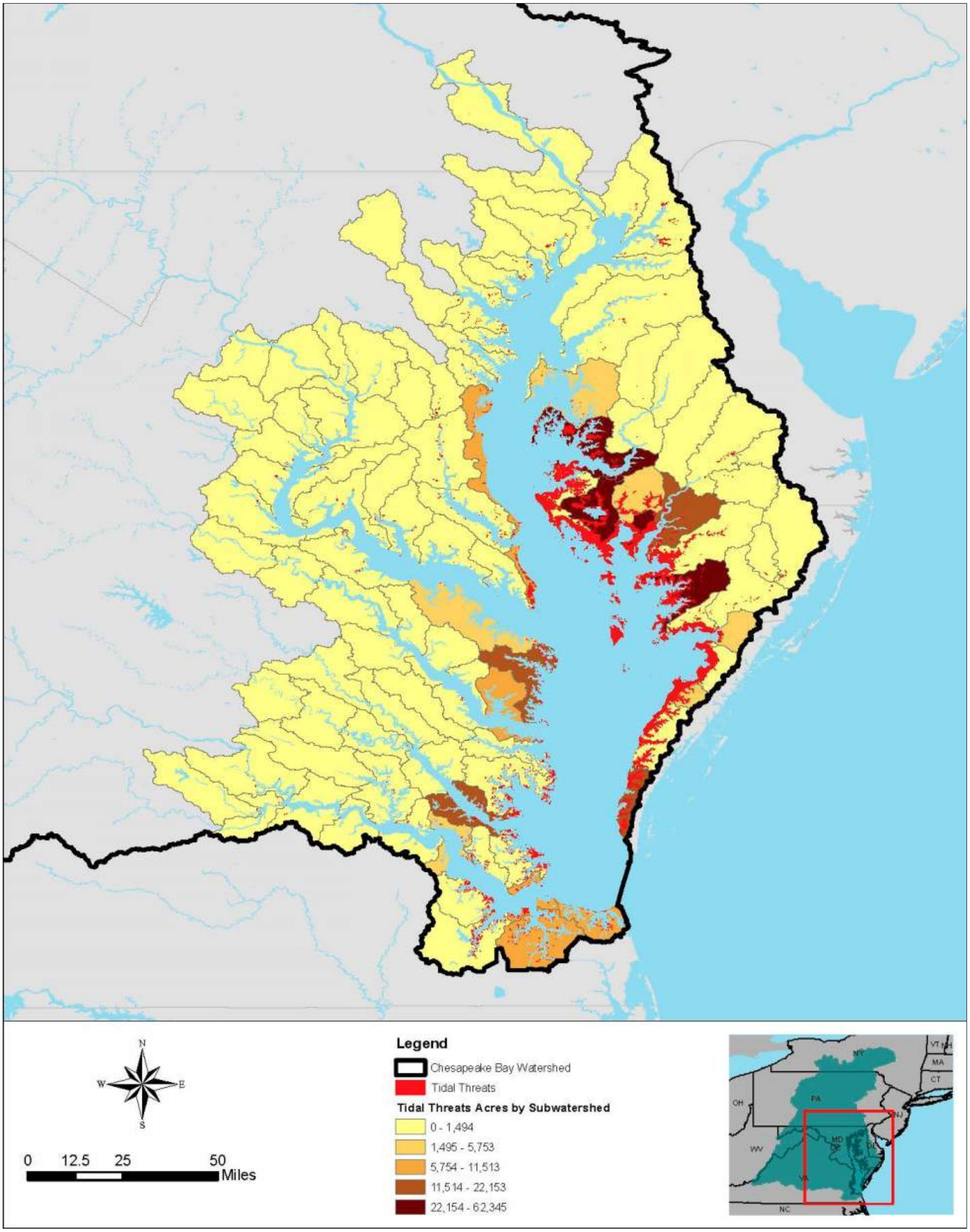


Figure 12. Evaluation of tidal threats (CA-7-TT)

Key points:

- Subwatersheds along the mainstem of the bay below the bay bridge crossing in Maryland face the greatest threats. This area includes those subwatersheds below the South River in Maryland on the western shore and Eastern Bay on the western shore.
- Those subwatersheds that are most threatened include:
    a) Subwatersheds in the Choptank River Watershed in Dorchester County, Maryland
    b) Subwatersheds comprising the Blackwater National Wildlife Refuge in Dorchester County, Maryland
    c) Subwatersheds along the Nanticoke River in Somerset County, Maryland
    d) Subwatersheds along the Wicomico River in Dorchester and Wicomico counties, Maryland
    e) Subwatersheds at the tip of the Delmarva Peninsula in Northampton County, Virginia
    f) Subwatersheds draining to the Great Wicomico River, Virginia (western shore)
    g) Subwatersheds in the lower York River in Virginia
- The Norfolk, Virginia area, the lower Rappahannock in Virginia, and subwatersheds lining the middle western shore in Maryland are at moderate risk.
- The upper bay, inland subwatersheds, and larger river systems did not demonstrate heightened risks.

1.8 Socioeconomic Analysis

Overview: This analysis synthesizes information that reflects societal use of resources within the watershed. The compilation characterizes the locations in the watershed that are important for recreation and public access, water supply, and source water protection and those areas where underserved populations are located.

Data layers: The following layers are incorporated into the Socioeconomic Analysis:

- *Locations of national, state, and local parks*
- *Public access points* – Nationally designated trails and existing and proposed public access sites compiled by the CBP
- *Underserved populations* – Minority and low-income populations provided by the CBP
    - Minority populations – Minority population is defined as all other ethnicities other than Caucasian (generated from EPA's EJSCREEN Platform). Census block groups with a minority population percentage greater than or equal to 37 percent are identified in this dataset; 37 percent was chosen to mirror national average of minority populations.

  - Low-income populations – Low income is defined as a ratio of income to cost of living that is less than 2 (generated from EPA's EJSCREEN Platform). Census block groups are designated that have greater than or equal to 50 percent population that is low income.

- *National Inventory of Dams* (NID) – Congressionally authorized database documenting dams in the U.S. and its territories; maintained and published by USACE
- *Locations of reservoirs* – data provided by Susquehanna River Basin Commission (SRBC)
- *Locations of water supply withdraws in the Susquehanna River Basin* – SRBC/Pennsylvania Boundary dataset credited to USGS and U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS)

Conceptual diagram and computations: Data are depicted as points and polygons in GIS that represent the location of each item. One figure was generated incorporating NID data (**Figure 13**) and one without (**Figure 14**). The figure without NID data was used in the subsequent Restoration Opportunities Analyses.

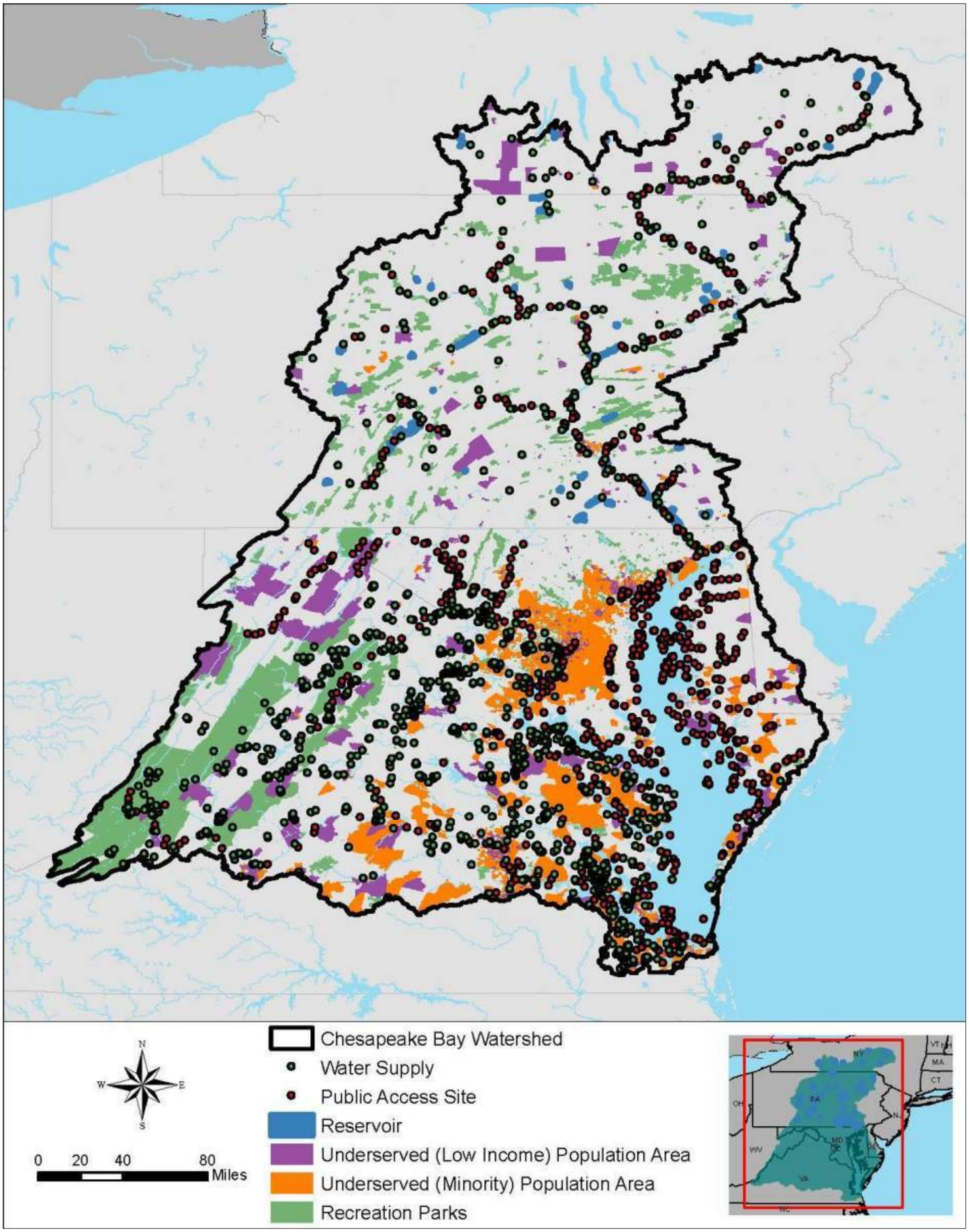


Figure 13. Socioeconomic Analysis without dams (CA-8-SOC-A)

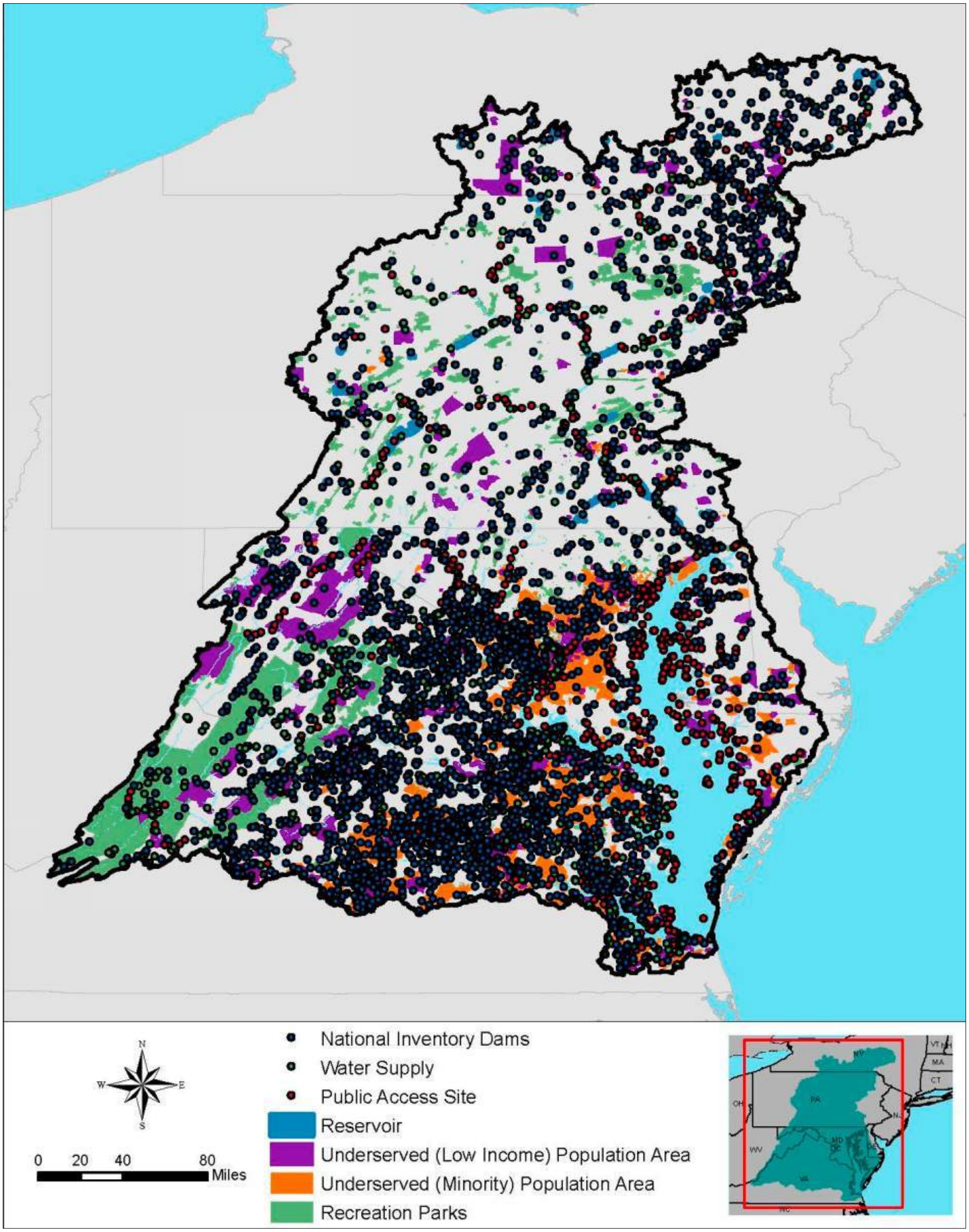


Figure 14. Socioeconomic Analysis with dams (CA-8-SOC-B)

The following tables (**Tables 2** and **3**) identify subwatersheds that contain large minority or low-income populations, but have no or limited access to public access points.

Table 2. Subwatersheds with very little to no recreation parks and public access sites in correlation to large areas of minority populations within the Chesapeake Bay Watershed.

SUBWATERSHED NUMBER	SUBWATERSHED NAME	SUBWATERSHED SIZE (ACRES)	SUBWATERSHED SIZE (SQUARE KILOMETERS)	STATE	RECREATION PARKS (ACRES)	PUBLIC ACCESS SITES COUNTS	UNDERSERVED (MINORITY) POPULATION (ACRES)
208010602	Middle South Anna River	103,063	417	VA	0	0	42,317
208020707	Deep Creek	131,388	532	VA	0	0	39,786
208020603	Upper Chippokes Creek-James River	72,743	294	VA	0	0	37,320
208010504	Maracossic Creek	87,721	355	VA	0	0	35,595
208020314	Lower Slate River	60,504	245	VA	0	0	33,951
208010503	Polecat Creek-Mattaponi River	74,137	300	VA	0	0	29,178
208010608	Northeast Creek-North Anna River	86,060	348	VA	0	0	28,344
208010502	Matta River-Mattaponi River	114,813	465	VA	0	0	26,747
208020705	Flat Creek	90,386	366	VA	26	0	40,853
208020701	Buffalo Creek	74,184	300	VA	177	0	23,996
208020704	Big Guinea Creek-Appomattox River	101,657	411	VA	404	0	47,677
206000309	Gwynns Falls	42,836	173	MD	2,107	0	35,025
206000602	Little Patuxent River	103,420	419	MD	3,725	0	43,653
208010202	Dragon Swamp	89,960	364	VA	4,353	0	50,440
208020703	Bush River	99,205	401	VA	7,914	0	54,899
208020503	Lower Willis River	65,475	265	VA	9,064	0	38,141
208020502	Upper Willis River	112,744	456	VA	9,859	0	46,693
207001007	Bull Run	124,038	502	VA	12,148	0	41,707

Table 3. Subwatersheds with very little to no recreation parks and public access sites in correlation to large areas of low income populations within the Chesapeake Bay Watershed.

SUBWATERSHED NUMBER	SUBWATERSHED NAME	SUBWATERSHED SIZE (ACRES)	SUBWATERSHED SIZE (SQUARE KILOMETERS)	STATE	RECREATION PARKS (ACRES)	PUBLIC ACCESS SITES COUNTS	UNDERSERVED (LOW INCOME) POPULATION (ACRES)
207000306	North River	131,593	533	WV	0	0	71,090
207000204	New Creek-North Branch Potomac River	88,639	359	MD, WV	0	0	41,494
207000302	Little Cacapon River	69,822	283	WV	0	0	39,895
205010403	Tuscarora Creek	82,080	332	NY	0	0	39,488
208020307	Lower Tye River	56,014	227	VA	0	0	22,032
208010608	Northeast Creek-North Anna River	86,060	348	VA	0	0	21,283
205010405	Troups Creek	43,432	176	NY	0	0	20,178
207000207	Patterson Creek	180,703	731	WV	121	0	40,891
205010502	Middle Cohocton River	116,942	473	NY	131	0	32,586
205010404	Canisteo River	172,013	696	NY	436	0	29,690

SUBWATERSHED NUMBER	SUBWATERSHED NAME	SUBWATERSHED SIZE (ACRES)	SUBWATERSHED SIZE (SQUARE KILOMETERS)	STATE	RECREATION PARKS (ACRES)	PUBLIC ACCESS SITES COUNTS	UNDERSERVED (LOW INCOME) POPULATION (ACRES)
207000406	West Branch Conococheague Creek	127,184	515	MD, PA	2,831	0	27,731
205030501	Sherman Creek	156,499	633	PA	3,182	0	27,704
207000202	Stony River-North Branch Potomac River	186,717	756	MD, WV	6,113	0	46,528
208020703	Bush River	99,205	401	VA	7,914	0	28,761
208020403	North Fork Rivanna River	113,226	458	VA	7,963	0	33,103
208020503	Lower Willis River	65,475	265	VA	9,064	0	27,340
205020505	Little Pine Creek	115,478	467	PA	22,668	0	21,565
207000305	Lost River	99,573	403	VA, WV	28,655	0	40,248
205020103	Clearfield Creek	251,554	1,018	PA	40,310	0	22,476
208020204	South River	75,873	307	VA	45,195	0	33,645
208020202	Little Calfpasture River-Upper Maury River	114,649	464	VA	61,057	0	31,633
207000101	North Fork South Branch Potomac River	186,309	754	VA, WV	155,432	0	90,198
208020201	Calfpasture River	150,983	611	VA	407,706	0	27,436

Key points:

1. Public access points are well distributed along major tributaries.
2. There are few to no access points reported in:
    a) Baltimore County, Maryland north of Baltimore City
    b) Carroll County to the west of Baltimore County in Maryland
    c) Western most subwatershed in Maryland
    d) South-central Pennsylvania west of the Susquehanna River
    e) Subwatershed in the James River Watershed in southcentral Virginia along the bay watershed boundary
    f) Tioga and Chemung River Watersheds in the northwestern portion of the bay watershed at the Pennsylvania/New York border
3. Public access points identified in Pennsylvania are predominantly along the course of the Susquehanna River or its main tributaries.
4. Subwatersheds with large minority populations are predominantly located on the western shore and inland Maryland and Virginia and on the Delmarva Peninsula.
5. Water supply withdrawals occur throughout:

a) Susquehanna River Watershed in Pennsylvania

b) Rappahannock River Watershed in Virginia

c) York River Watershed in Virginia

d) James River Watershed in Virginia

e) Delmarva Peninsula in Virginia

6. The greatest concentration of park lands is located in the ridge and valley and Blue Ridge Mountain subwatersheds in western Virginia and West Virginia. These subwatersheds are part of the upper Potomac and James River Watersheds.

2.0 Restoration Opportunities Analysis

The restoration opportunities analysis investigated a set of focused questions to identify spatially specific strategies and projects to assist with achieving 2014 Bay Agreement goals and outcomes and to optimize restoration and conservation efforts. These questions were developed and refined with stakeholder input. The results for each unique analysis is a set of subwatersheds, identified as *Opportunities*. Each geospatial evaluation identified the *Opportunities* as holding the greatest potential, need, or impairment, depending on the nature of the evaluation. Therefore, the *Opportunities* highlight those subwatersheds that provide the highest potential to support resiliency or address the specific 2014 Bay Agreement Goal or Outcome investigated by that evaluation. The initial results of this analysis were also refined with stakeholder input. The questions identified were:

1. Where do opportunities exist to implement habitat restoration and enhancement opportunities (streams, freshwater fish, SAV, oysters, black duck, riparian buffer) to further the 2014 Bay Agreement goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, and community resilience benefits?
2. Where do opportunities exist to implement wetland restoration and enhancement opportunities and protect existing wetlands, maximize/optimize aquatic ecosystem restoration, flood risk management, beneficial use of dredged material, and community resilience benefits?
3. Where do opportunities exist to improve or enhance habitat connectivity and human connectivity to healthy habitats?
4. Where do conservation opportunities exist to increase connectivity, enhance restoration success, and address social and economic vulnerabilities?
5. Where can shoreline and streambank opportunities for restoration and conservation be implemented to maximize/optimize aquatic ecosystem restoration and community resilience?
6. Can restoration and conservation opportunities within the watershed be leveraged to assist with addressing toxic contamination?

The following section describes the analyses undertaken to investigate each respective question for restoration opportunities. Each analysis and the results are presented based on the naming scheme that aligns with the specific restoration question (No. 1-6), and the corresponding analsyis (e.g., WR is the acronym for wetland restoration).

2.0.1 Habitat Restoration

(1) Where do opportunities exist to implement habitat restoration and enhancement opportunities (e.g., riparian buffer, streams, freshwater fish, wetlands, SAV, oysters, black duck) to further the 2014 Bay Agreement goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, and community resilience benefits?

This series of questions is focused on identifying habitat restoration opportunities within the watershed and in the mainstem bay. It excludes wetlands, as they are the focus of Question #2. There are a number of components to this analysis as described in the sections below.

Note: An analysis was attempted to investigate whether restoration for species with spatially targeted habitats within the 2014 Bay Agreement (black duck, EBT, fish passage blockages) could be co-located to benefit multiple species or goals. The following data were included: EBT catchments, Black Duck Focus Areas, and fish passage prioritized blockages. The results of the analysis identified that there was little to no overlap of these resources; therefore, EBT is included here with the riparian and stream restoration considerations, and black duck is evaluated with wetlands.

2.1 Riparian Buffer Analysis (1-HR-RFB)

Overview: Purpose is to identify subwatersheds in which to focus riparian forested buffer restoration. Riparian buffer restoration can be implemented to target various impairments and varying benefits. This analysis identifies subwatersheds where riparian buffer restoration opportunities exist to:

a) Address watershed stressors (high yielding N and P subwatersheds)

b) Improve EBT habitat

c) Support improving stream habitat for resident fish and migratory species

Data layers: The following layers were included:

- *Riparian buffer restoration opportunities* – Data were generated by the CBP and document the number of acres of riparian buffer (opportunity) (30 m (100-ft) buffers) within each subwatershed. USACE developed a GIS layer and categorized subwatersheds based on the acreage of opportunity within a subwatershed using the Jenks method.
- *Highest yielding N and P watersheds* – Description provided in the Watershed Stressors Analysis (raster dataset)
- *Brook trout watersheds* – Description provided in the Healthy/High-value habitats Analysis (raster dataset)
- *National Fish Habitat Assessment* – Low and very low risk of current habitat degradation (description provided in the Threats Analysis) (raster dataset)
- *Trout Unlimited conservation strategies for EBT* – Identifies general conservation strategies for each EBT population and a general sense of the magnitude of restoration needed. The strategies identified are (1) secure strongholds, (2) enhance stronghold, (3) secure and restore persistent population strategy, (4) restore persistent populations and habitats, (5) restore unique life history strategy, (6) restore other populations, and (7) re-establish EBT.

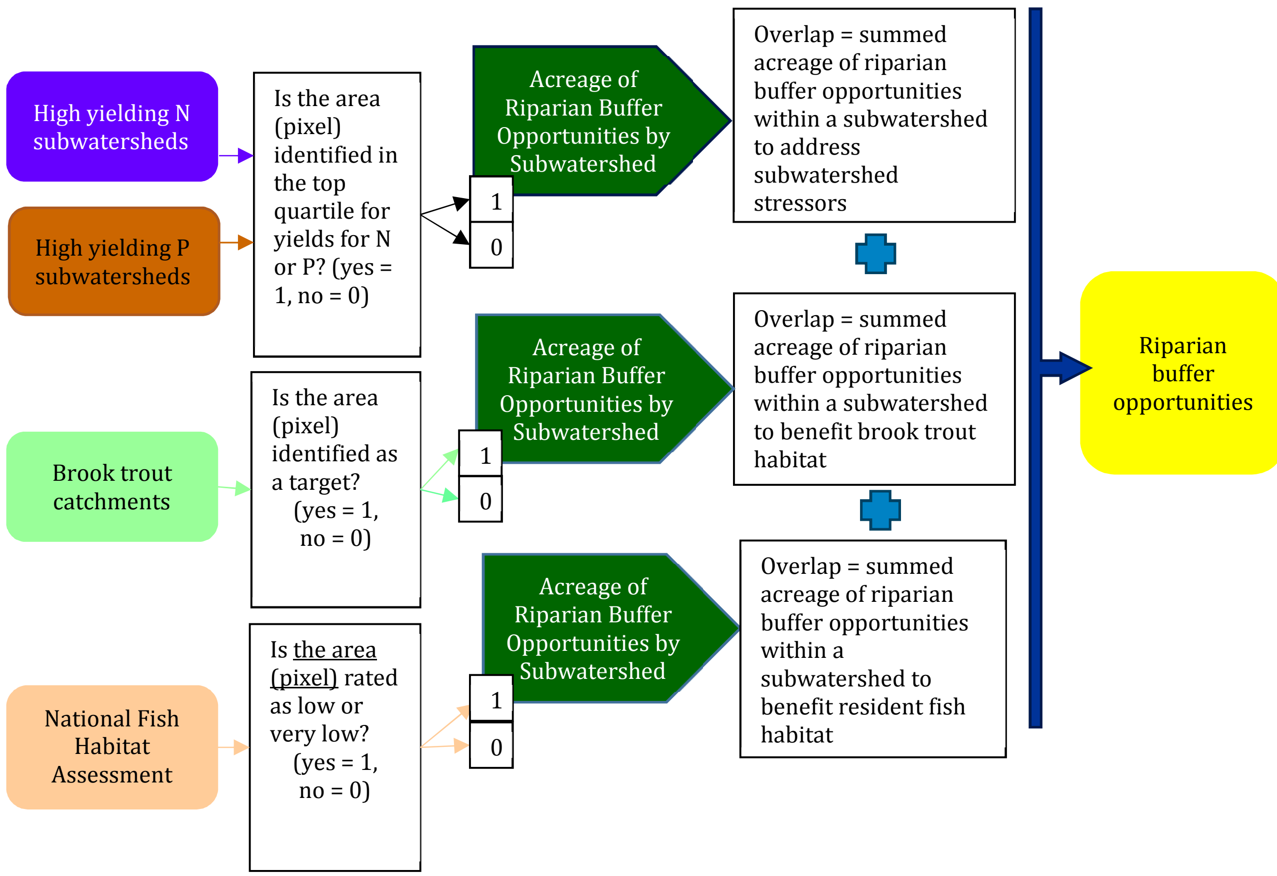
Conceptual diagram, computations, and opportunity selection process: The Riparian Buffer Analysis identifies subwatersheds in which to focus riparian buffer efforts. Initially, the riparian buffer opportunities were categorized into five divisions based on the acreage of opportunity in each subwatershed (**Figure 15**)**.** That product was then joined with the datasets identified above to address each of the three focused objectives (a, b, and c) (**Figures 16 - 18, respectively)**. Selected data layers were each overlaid separately with the riparian buffer data provided by the CBP. This overlay isolated those subwatersheds that were identified as opportunities by the datasets, and quantified the number of acres of riparian buffer opportunity that was also highlighted for one of the other focused objectives. The results were categorized based on the acreage of opportunity within a subwatershed using the Jenks method. The top two categories were selected as opportunities. These individual evaluations were then compiled together to produce one map (**Figure 19**) that shows all the subwatersheds targeted for riparian restoration/conservation. The subwatersheds targeted in **Figure 19** are color coded by the objective they would meet (a, b, or c).

Analyses were taken one step further for EBT opportunities. The conservation strategies developed by Trout Unlimited were considered within the context of the riparian buffer opportunities identified by this analysis to benefit EBT **(Figure 20**)**. Figure 20** was developed to portray the conservation strategies and the boundaries of the riparian buffer opportunities for brook trout. The conservation strategies were incorporated into the Restoration Roadmap to assist with prioritizing riparian buffer opportunities.

Following the analyses described above, the CBP was able to provide the breakdown of land cover within the buffer area including forest, crop, pasture, impervious nonroad, impervious road, mixed open, tree canopy over impervious, tree canopy over turf, turf grass, floodplain wetlands, other wetlands, and tidal wetlands. An estimate was made using the data to estimate the level of implementation needed on a subwatershed basis to meet the 70% target within each subwatershed. The following assumptions were made:

1. Tidal wetlands are not forested.
2. Not all nontidal wetlands are forested. Therefore, floodplain wetlands was included, and “other wetlands” was not included in the calculation of forested buffer acreage. This decision was made to capture some portion of the wetlands in the 'forested buffer category'.
3. Included the following cover types in the calculation of existing forested buffer: forest, tree canopy over turf, and floodplain wetland.
4. Include the following cover types in the calculation of area where buffers could be implemented (crop, pasture, mixed open, turf grass).

The 2014 Bay Agreement outcome for forested buffers is to have forested riparian buffers established on 70% of all stream buffers bay wide. Applied to the subwatershed level, a list was generated of all those subwatersheds that have less than 70% forested riparian buffers based on the assumptions listed above. Most of these subwatersheds have been identified as having the potential for establishment of riparian forest buffers to benefit EBT, resident/migratory fish, or to reduce N or P inputs (denoted with yellow highlighting).



Map products:

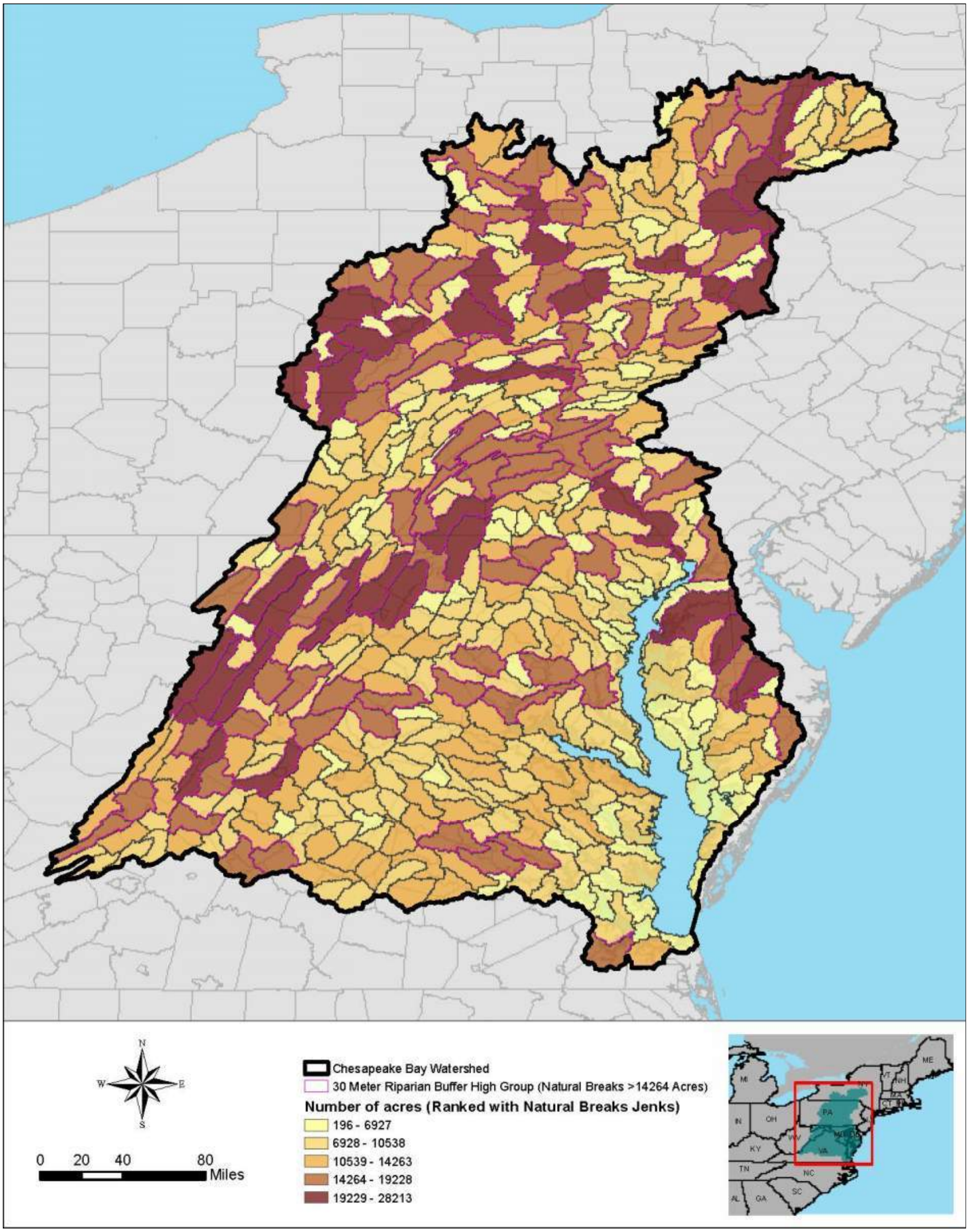


Figure 15. Acres of riparian buffer restoration *Opportunities* by subwatershed (1-HR-RFB-A)

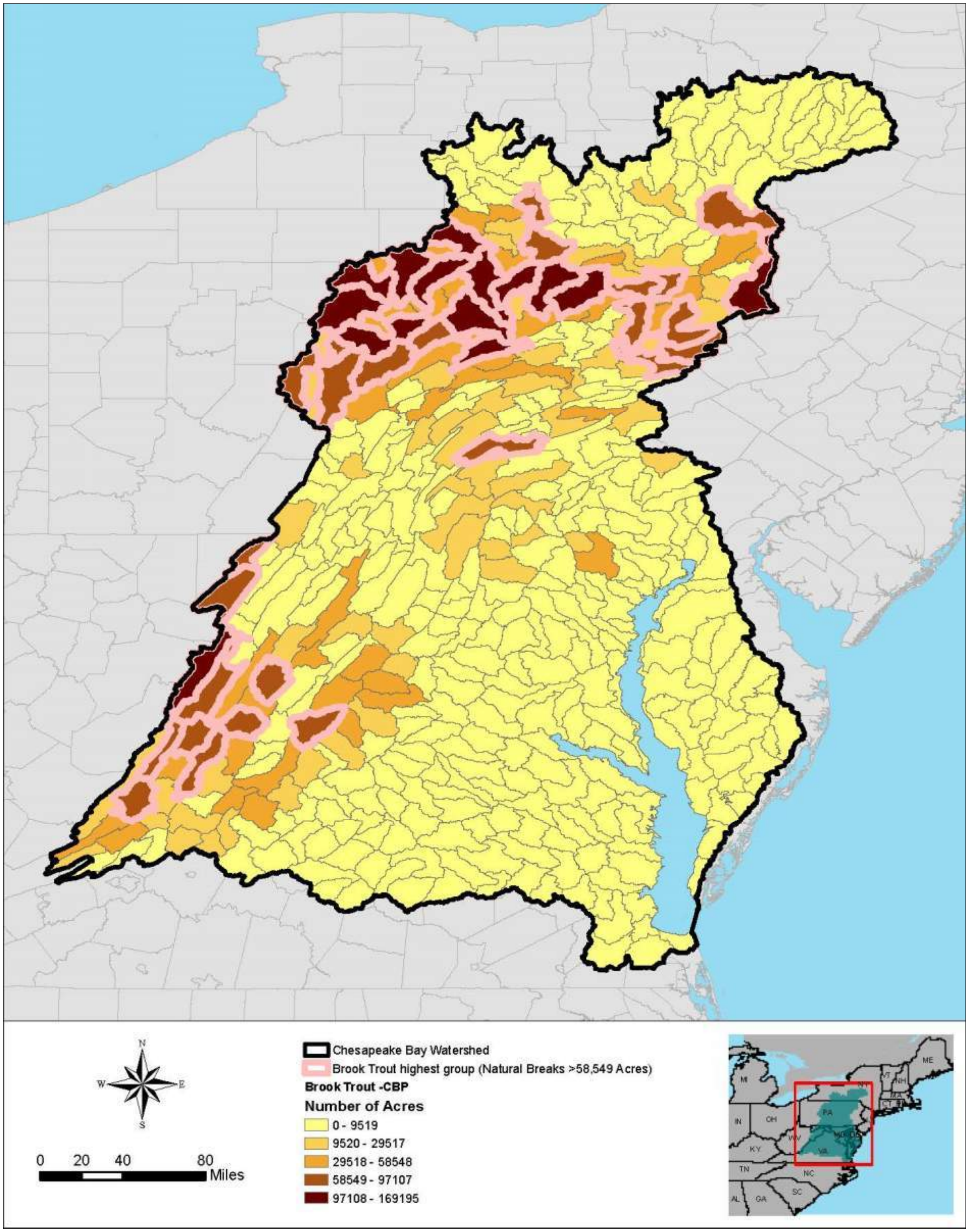


Figure 16. Riparian buffer restoration *Opportunities* to benefit EBT habitat (1-HR-RFB-B1)

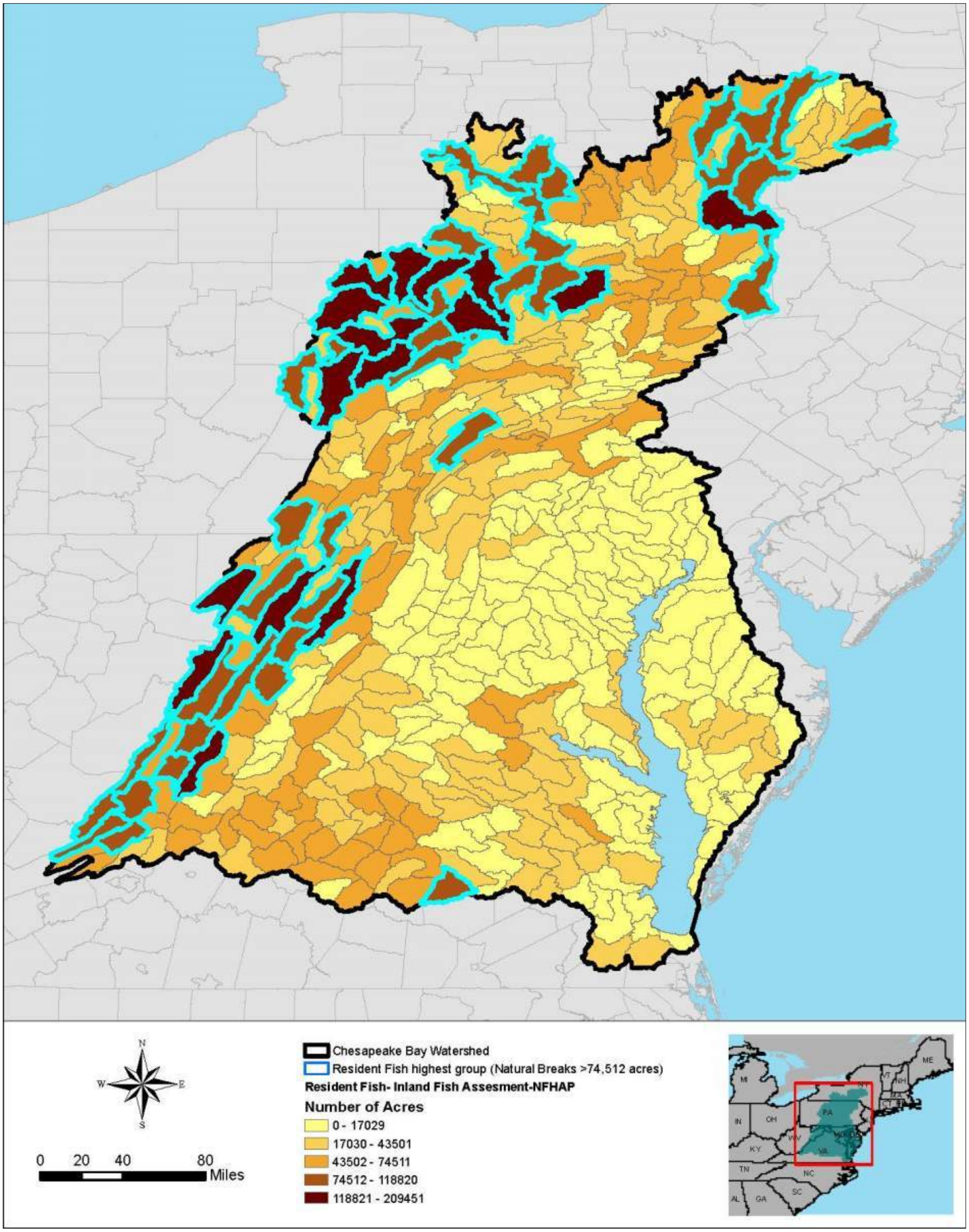


Figure 17. Riparian buffer restoration *Opportunities* to benefit resident fish habitat (1-HR-RFB-C)

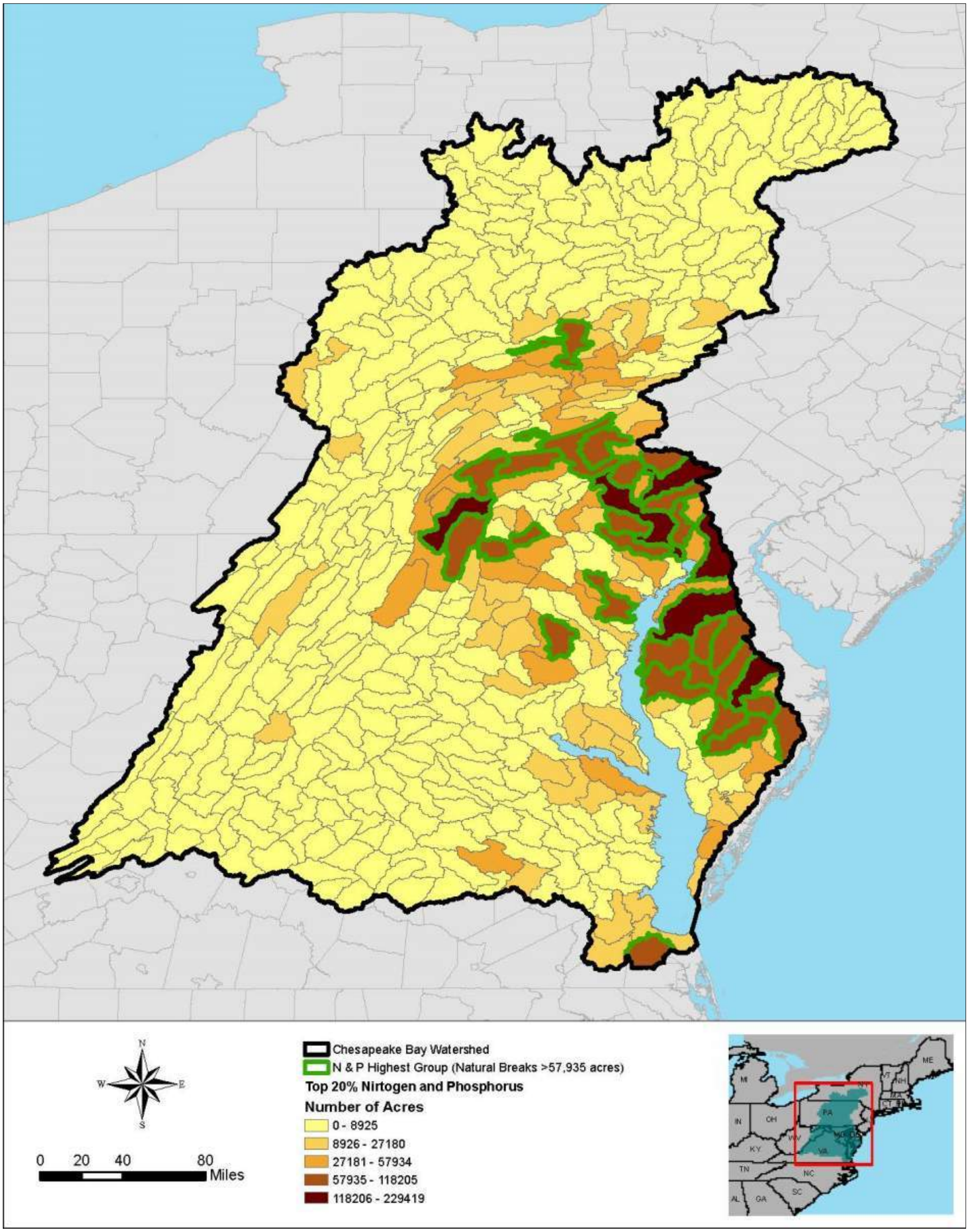


Figure 18. Riparian buffer restoration *Opportunities* to address nitrogen and phosphorus loads (1-HR-RFB-D)

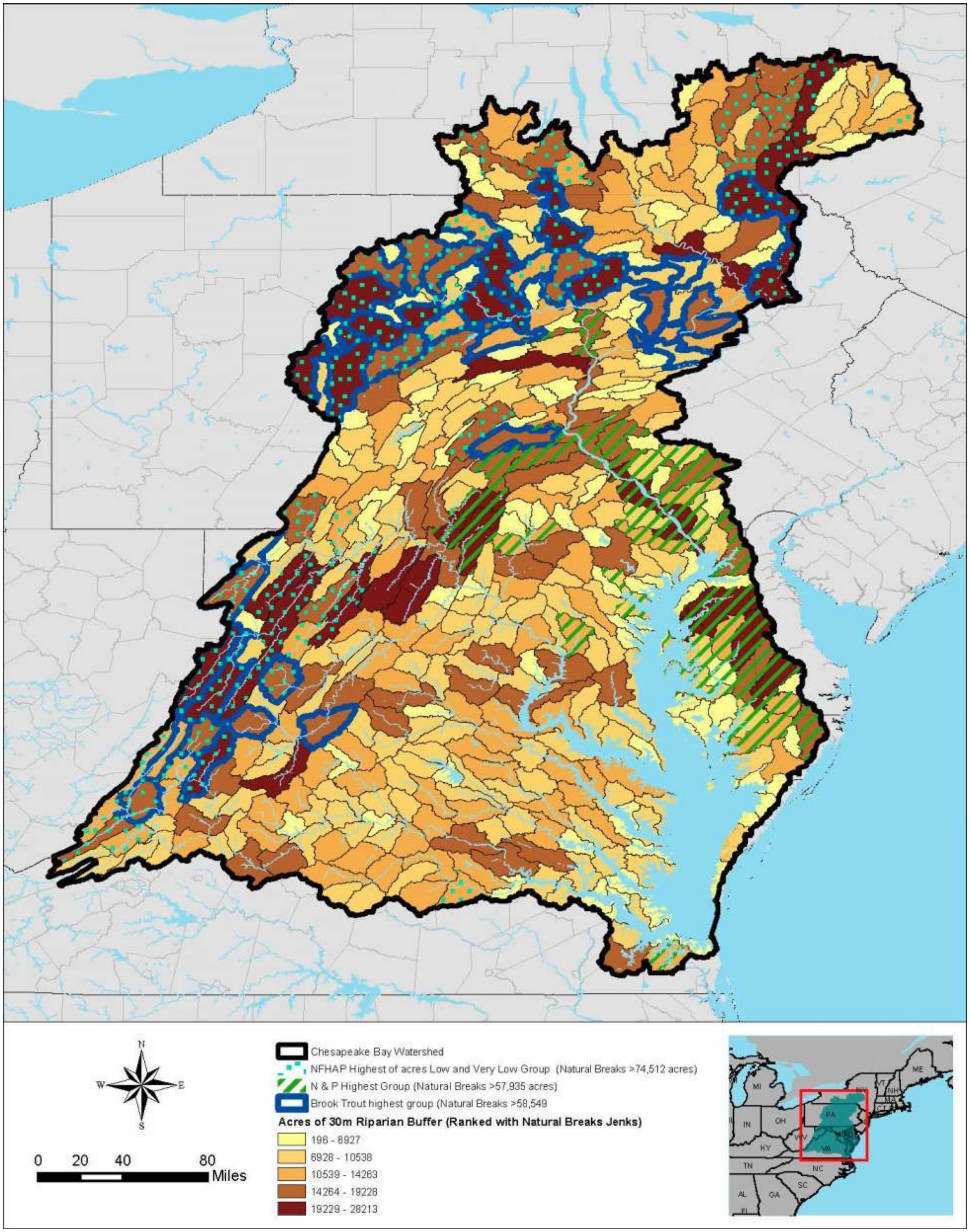


Figure 19. Compiled riparian buffer restoration *Opportunities* (1-HR-RFB-E)

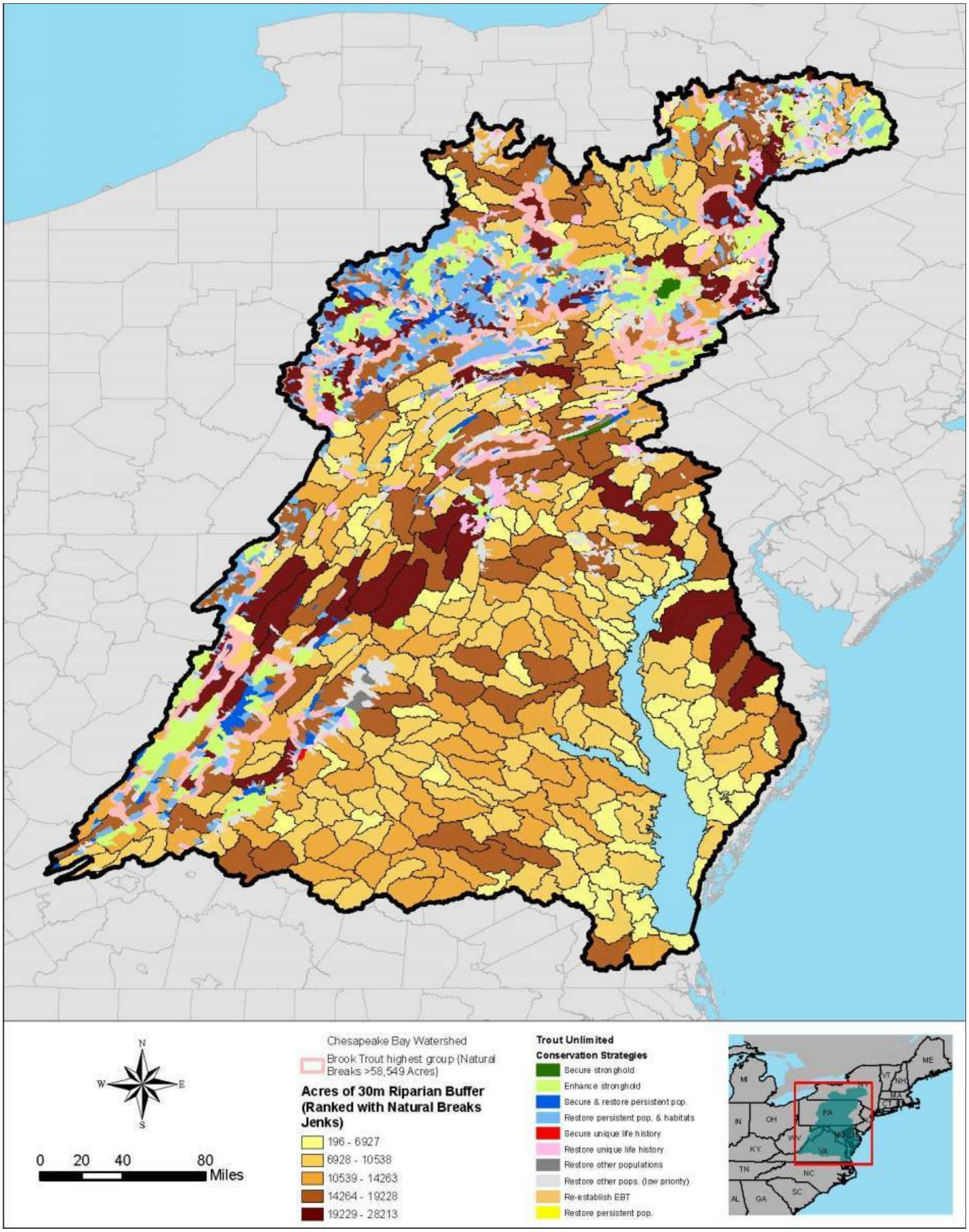


Figure 20. Alignment of riparian buffer restoration *Opportunities* for EBT with Trout Unlimited conservation strategies (1-HR-RFB-B2)

The CBCP Master Results Database provides the percentage of forest within the 100 ft (30 m) buffer for each subwatershed. Of the 425 subwatersheds, 236 subwatersheds are less than 70% forest within the 100 ft buffer.

Key points:

1. In general, there are broad riparian buffer opportunities throughout the Chesapeake Bay Watershed spanning all jurisdictions. Concentrated areas are located in eastern New York, northern and south-central Pennsylvania, West Virginia, western Maryland, Maryland's Eastern Shore, western Virginia, and subwatersheds in the James River in southern Virginia.
2. Riparian buffer restoration opportunities to improve EBT habitat are located primarily in:
   a) North and South Fork subwatersheds of the Potomac River in West Virginia, western Maryland, and western Virginia
   b) Subwatersheds in the upper Susquehanna River basin and the West Branch Susquehanna River basins in Pennsylvania
   c) Tioga River and Lower Susquehanna River Watershed in New York and Pennsylvania
   d) Yellow Breeches Creek in the lower Susquehanna River basin in central Pennsylvania
3. Riparian buffer restoration opportunities to improve resident fish habitat are concentrated in the following regions:
   a) Eastern subwatershed in New York
   b) Subwatersheds throughout the upper Susquehanna River basin in New York and Pennsylvania
   c) Subwatersheds throughout the West Branch Susquehanna River basin in Pennsylvania
   d) Tuscarora Creek in the lower Susquehanna River basin in central Pennsylvania
   e) Subwatersheds along the southwestern border of the bay watershed in Maryland, West Virginia, and Virginia in the upper Potomac and James River basins
   f) Lake Chesdin and Appomattox River in the James River basin in Virginia
4. Riparian buffer restoration opportunities to reduce N and loads are located primarily in:
   a) Lower Susquehanna River corridor
   b) Maryland and Delaware portions of the Delmarva Peninsula
   c) Patapsco River, Maryland
   d) Anacostia River in the District of Columbia and Maryland

e) Elizabeth River in Virginia

f) Antietam Creek, Conococheague Creek, and Upper Monacacy Creek in the Potomac River basin along the Pennsylvania and Maryland border

5. When the riparian buffer restoration opportunities to benefit EBT and resident fish, and to reducing N and P layers are compiled into one map (**Figure 20**), there are opportunities to undertake riparian buffer restoration to benefit EBT and resident fish in:

   a) Susquehanna River Watershed in upper Pennsylvania

   b) Upper Potomac River in West Virginia, Virginia, and Maryland

   c) Upper James River in Virginia and West Virginia

6. Opportunities to manage N and P loadings are isolated from opportunities to improve fish habitat with riparian buffer restoration.

7. There are Trout Unlimited EBT conservation strategies identified for catchments within opportunities for EBT. This information has potential for siting projects on a smaller scale by follow-up investigations.

2.2 Stream Restoration Analysis (1-HR-SR)

Overview: To identify stream restoration opportunities to benefit:

a) EBT,

b) Anadromous fish, and

c) Resident fish.

Data layers:

- *Watershed Stressors Analysis* (description provided in Section 3.5.6, Watershed Stressors Analysis)
- *National Fish Habitat Assessment* – Moderate risk of current habitat degradation (description provided in Section 3.5.7, Threats Analysis)
- *Brook trout watersheds* – (description provided in Section 3.5.4, Healthy/high-value Habitats Analysis)
- *Extent of anadromous fish habitat* – Stream path accessible to anadromous fish from CBP (Fish Passage Prioritization Tool)
- *Trout Unlimited conservation strategies for EBT* (description provided in Section 3.6.1, Riparian Buffer Restoration Analysis)

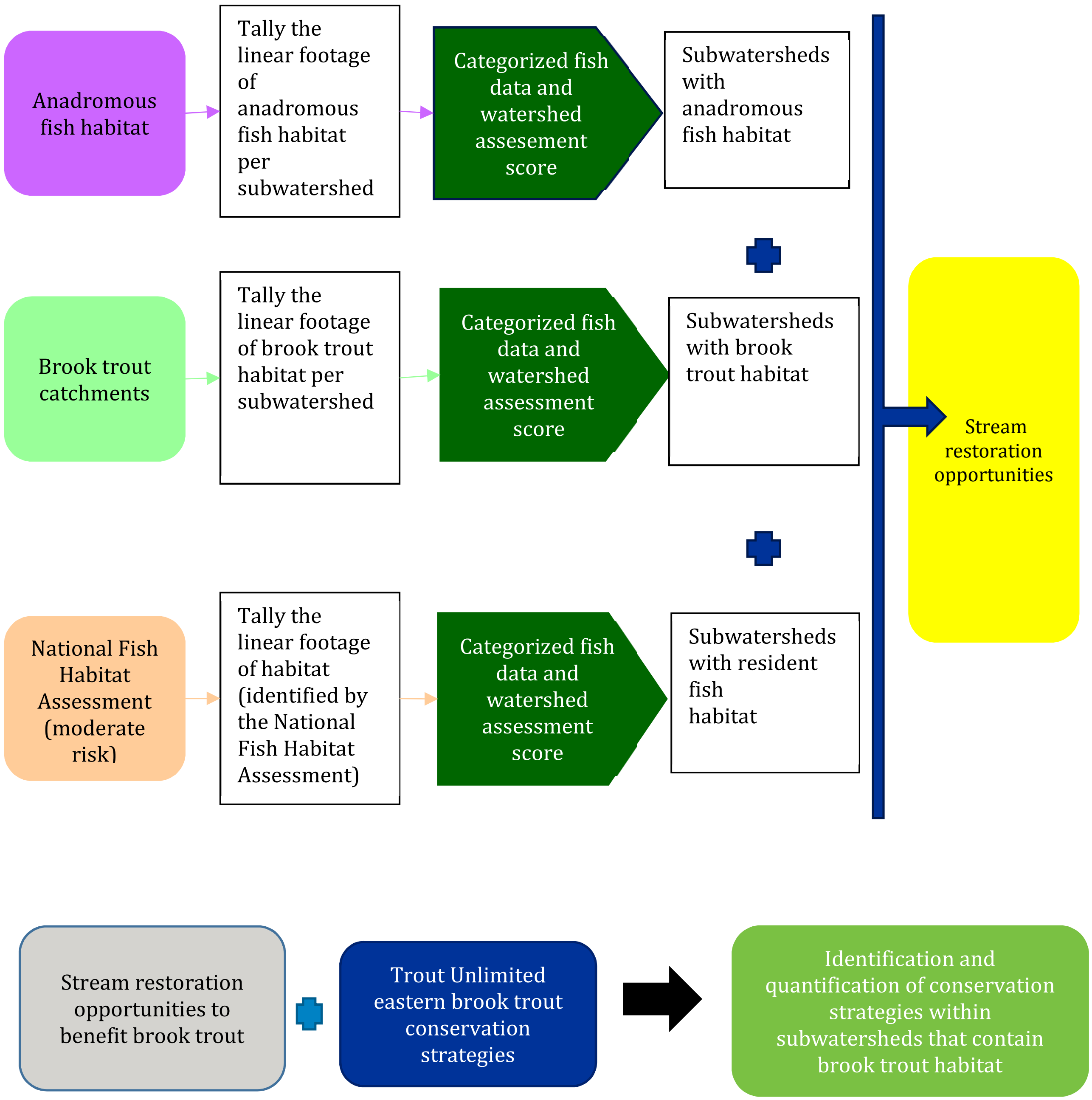
Conceptual diagram, computations, opportunity selection process: The Stream Restoration Analysis identified stream restoration opportunities that could benefit EBT, anadromous species, and resident fish species. The National Fish Habitat Assessment (moderate risk) was compiled with the Watershed Stressors Analysis to identify stream restoration opportunites that could benefit resident fish. The potential extent of EBT habitat was compiled with the Watershed Stressors Analysis to identify stream restoration opportunities that could benefit EBT. Subwatersheds that include anadromous fish habitat were compiled with the Watershed Stressors Analysis to identify subwatersheds where stream restoration could benefit anadromous fish.

The linear footage of streams containing anadromous fish habitat was quantified for each subwatershed. The linear footage of habitat (identified by the National Fish Habitat Assessment) at moderate risk was quantified for each subwatershed. Additionally, the linear footage of streams containing EBT habitat was quantified for each subwatershed. For each fish habitat dataset, the data layers were classified into five categories using the Jenks method in GIS based on the summed linear footage of habitat. The categorized dataset was then intersected with subwatersheds that received a watershed stressor score of >0.45 suggesting moderate to good conditions or a B-IBI of good or fair. These individual evaluations were then compiled together to produce one map that shows all of the subwatersheds targeted for stream restoration (stream restoration opportunities). The subwatersheds targeted in this map are color coded to reflect the fish that the opportunities could benefit.

Figures 21, 22, and 23 depict the tallied area of fish-specific data by subwatershed prior to application of the Watershed Stressors Analysis and identify those subwatershed that fall within the top two categories based on the Jenks method for each of the three objectives (a, b, and c), respectively.

Figure 24 compiles the subwatersheds with the results of the Watershed Stressors Analysis to consider the stress of a subwatershed for undertaking stream restoration. The 2014 Bay Agreement stream health outcome is focused on improving the health of degraded streams. As such, the stream restoration opportunities were further narrowed to identify those streams in the middle of the spectrum; that is, those with marginal health. Marginal health is defined by the CBCP as a Chessie-IBI of good or fair with a watershed assessment score >0.45. This provided a subset of 71 stream restoration opportunities within streams characterized as being in marginal health across the three objectives. **Table 4** provides a complete list of the stream restoration opportunities within streams characterized as being in marginal health (watershed assessment score >0.45 and an IBI of “good” or “fair”).

Analyses were taken one step further for EBT opportunities. The conservation strategies developed by Trout Unlimited were considered within the context of the stream buffer opportunities identified by this analysis to benefit EBT **(Figure 25**). **Figure 25** was developed to portray the conservation strategies and the boundaries of the stream restoration opportunities for EBT. The conservation strategies were incorporated into the Restoration Roadmap to assist with prioritizing riparian buffer opportunities.



Anadromous fish habitat
Tally the linear footage of anadromous fish habitat per subwatershed
Categorized fish data and watershed assesement score
Subwatersheds with anadromous fish habitat
Brook trout catchments
Tally the linear footage of brook trout habitat per subwatershed
Categorized fish data and watershed assessment score
Subwatersheds with brook trout habitat
National Fish Habitat Assessment (moderate risk)
Tally the linear footage of habitat (identified by the National Fish Habitat Assessment)
Categorized fish data and watershed assessment score
Subwatersheds with resident fish habitat
Stream restoration opportunities
Stream restoration opportunities to benefit brook trout
Trout Unlimited eastern brook trout conservation strategies
Identification and quantification of conservation strategies within subwatersheds that contain brook trout habitat

Map products:

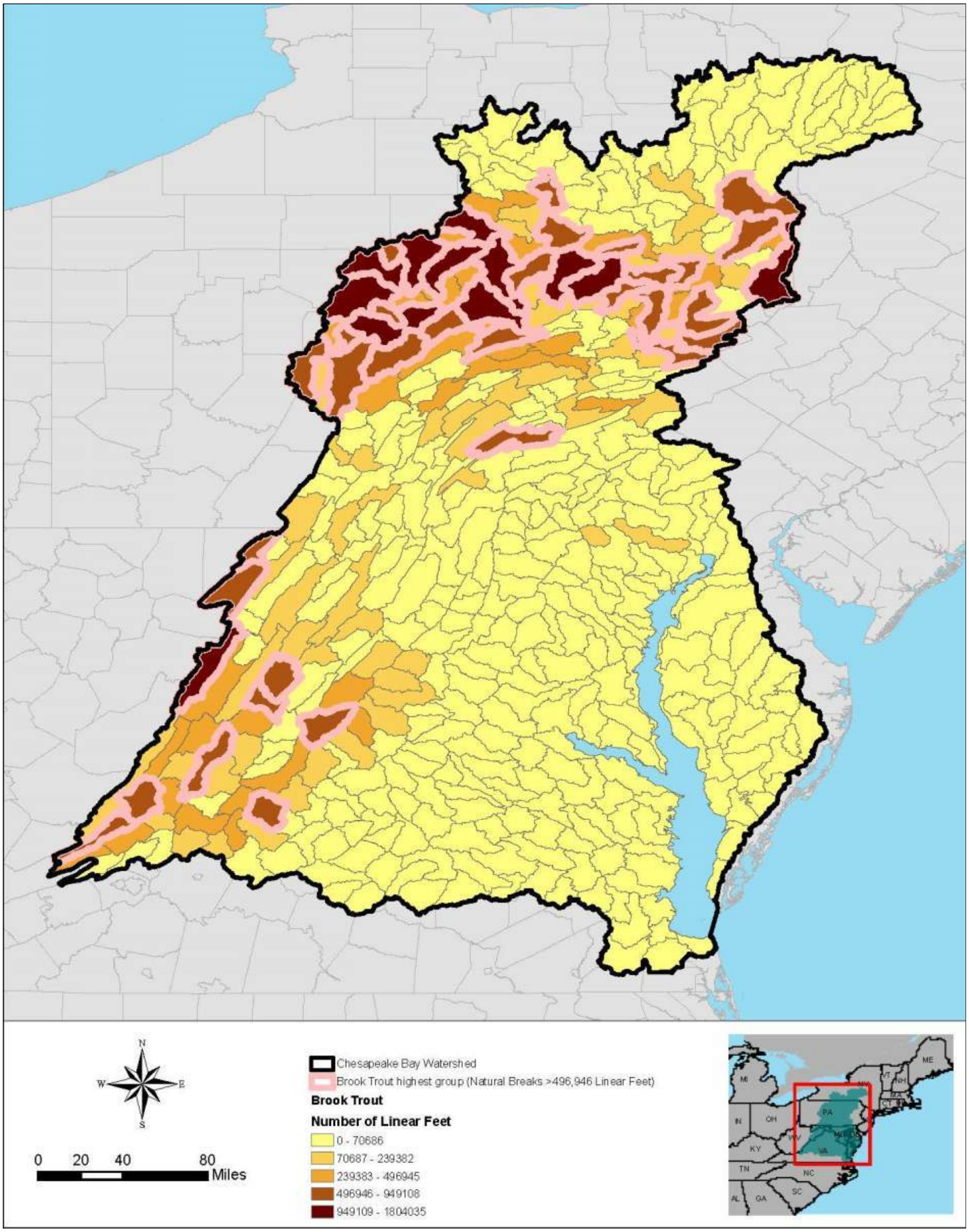


Figure 21. Stream restoration *Opportunities* to benefit EBT habitat (1-HR-SR-A)

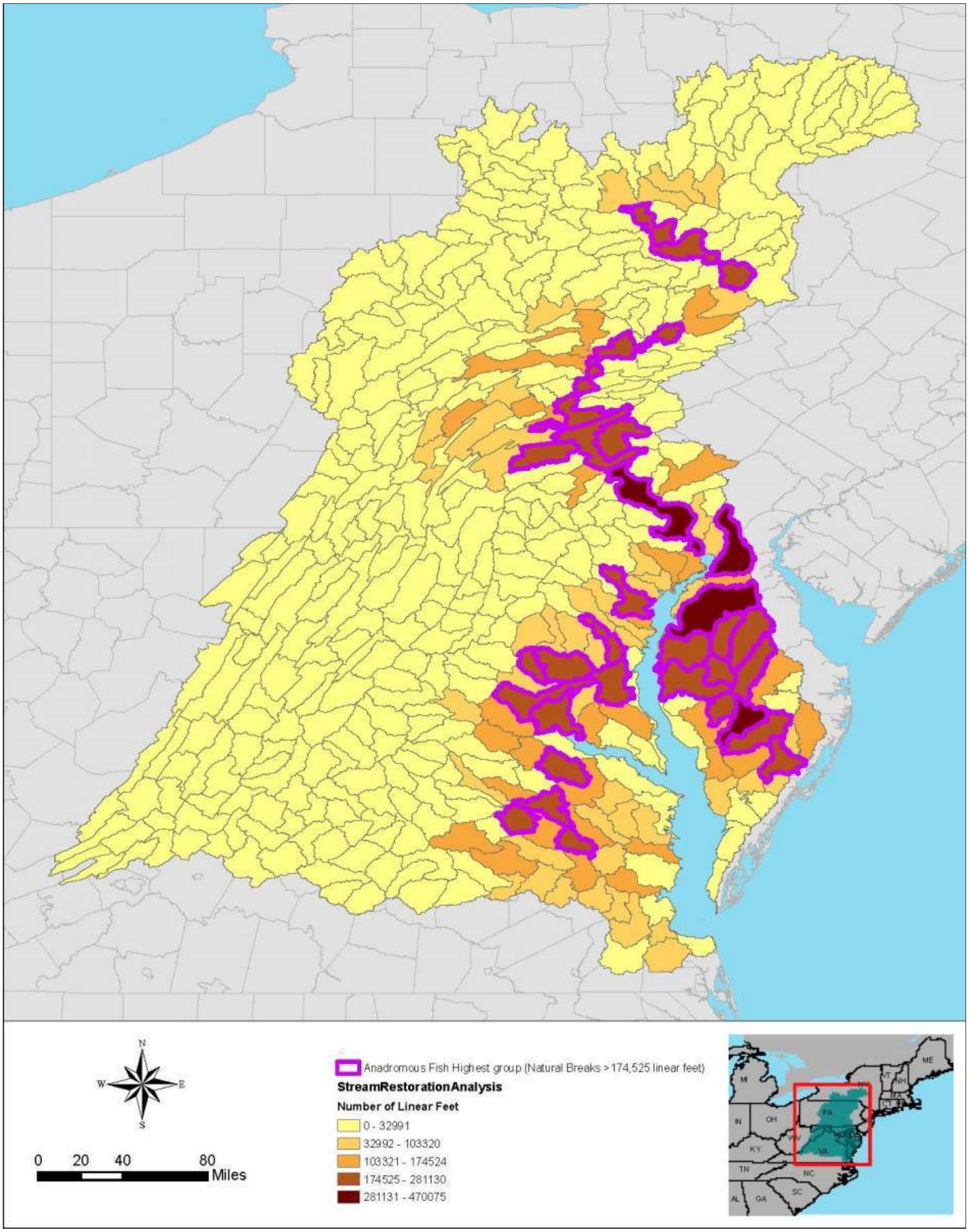


Figure 22. Stream restoration *Opportunities* to benefit anadromous fish habitat (1-HR-SR-B)

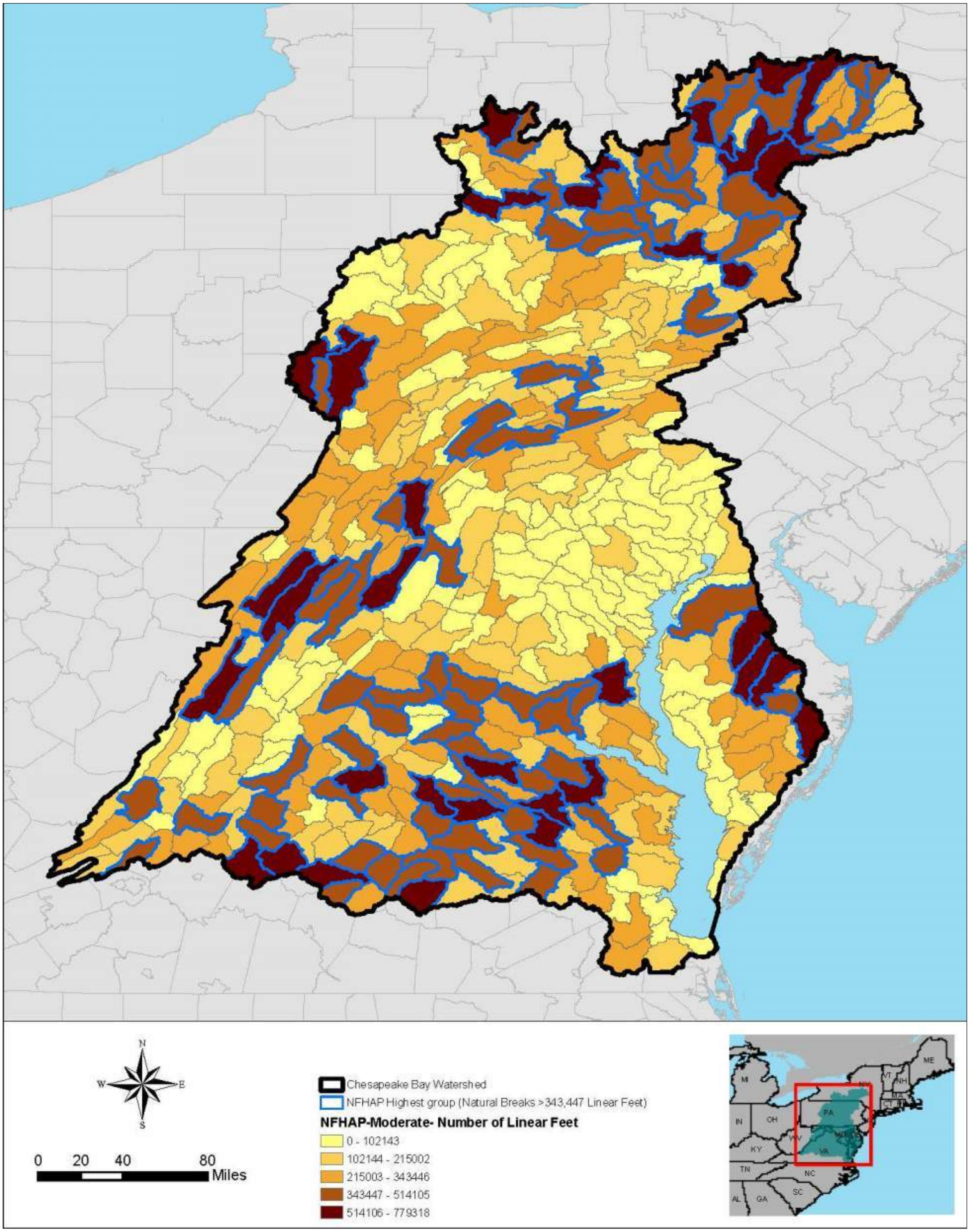


Figure 23. Stream restoration *Opportunities* to benefit resident fish habitat (1-HR-SR-C)

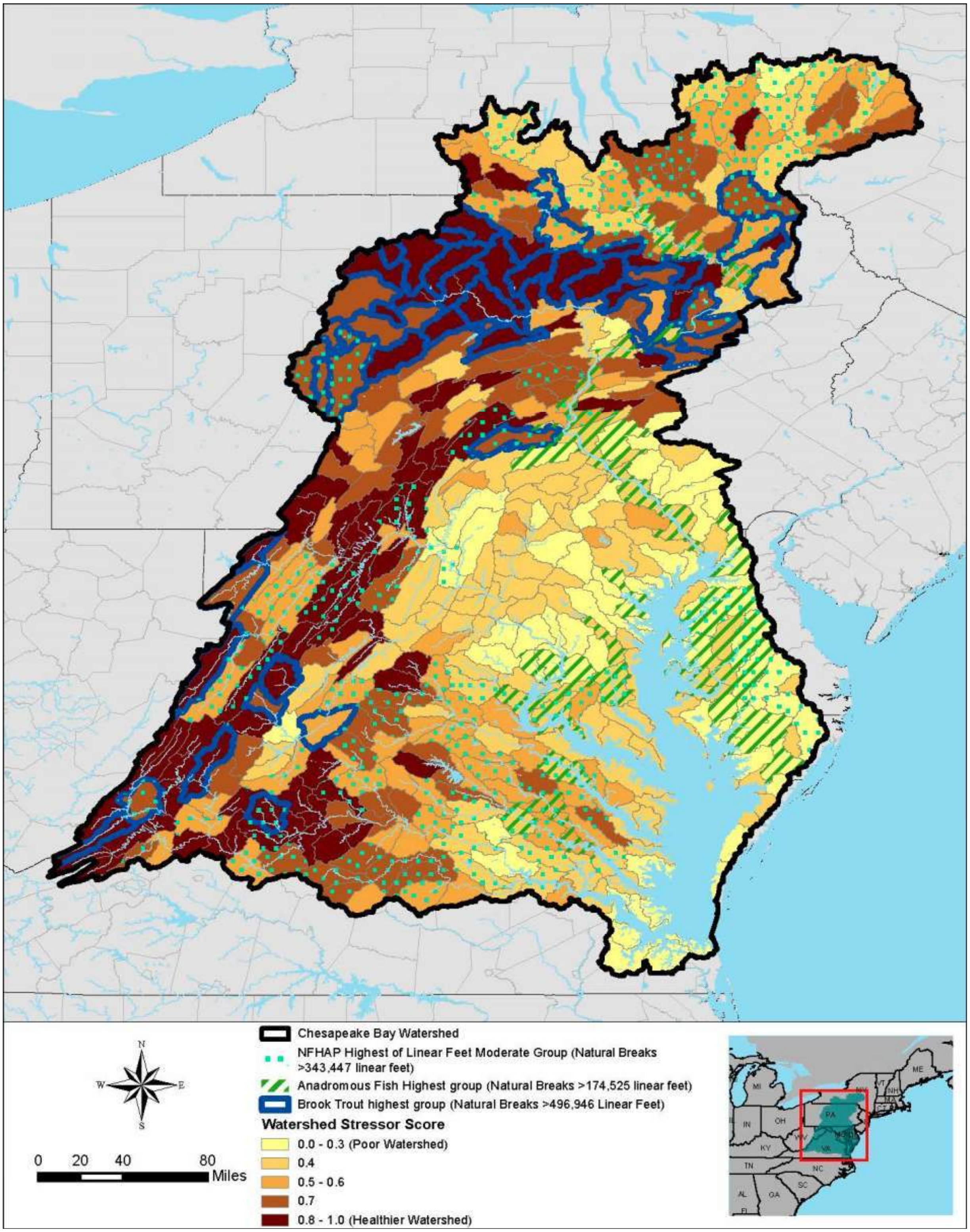


Figure 24. Compiled stream restoration *Opportunities* (1-HR-SR-D)

Table 4. Focused list of stream restoration opportunities for streams with marginal health.

watershed Nur	Subwatershed Name	STATES	Watershed Stressor Scores	Anadromous Fish (linear feet)	Brook Trout (Linear Feet)	National Fish Habitat Assesment - (Linear Feet)	IBI Scores
0208020104	Potts Creek	VA	0.83	0	515505	239334	GOOD
0208020201	Calfpasture River	VA	0.83	0	576241	81507	FAIR
0208020305	Upper Tye River	VA	0.78	0	676372	446989	FAIR
0208020306	Buffalo River	VA	0.78	0	107351	417872	FAIR
0207000307	Cacapon River	WV	0.78	0	239382	413286	FAIR
0207000302	Little Cacapon River	WV	0.78	0	6251	345150	FAIR
0205020602	Lycoming Creek	PA	0.78	0	1121430	269173	FAIR
0205020403	Fishing Creek	PA	0.78	0	828169	242094	FAIR
0205020204	First Fork Sinnemahoning Creek	PA	0.78	0	1653693	107261	GOOD
0205020402	Beech Creek	PA	0.78	0	773448	79373	FAIR
0205010609	Mehoopany Creek	PA	0.78	0	614422	72516	FAIR
0207000601	Shoemaker River-North Fork Shenandoah	VA	0.78	0	645626	58499	GOOD
0205020201	Sinnemahoning Portage Creek	PA	0.78	0	514463	25875	GOOD
0207000403	Licking Creek	MD,PA	0.72	0	0	608348	FAIR
0207000401	Tonoloway Creek	MD,PA	0.72	0	0	495136	GOOD
0208020312	Hardware River	VA	0.72	0	0	405693	FAIR
0207000306	North River	WV	0.72	0	22604	394574	FAIR
0207000105	South Fork South Branch Potomac River	VA,WV	0.72	0	213873	363160	GOOD
0205030409	Tuscarora Creek	PA	0.72	56772	79197	349682	FAIR
0205020105	Moshannon Creek	PA	0.72	0	717539	321381	FAIR
0207000101	North Fork South Branch Potomac River	VA,WV	0.72	0	1276369	271150	GOOD
0205020505	Little Pine Creek	PA	0.72	0	949108	161752	FAIR
0205020502	Upper Pine Creek	PA	0.72	0	1170368	122284	FAIR
0205020304	Lower West Branch Susquehanna River	PA	0.72	0	1336607	116706	FAIR
0205020608	Muncy Creek	PA	0.72	0	512567	114865	GOOD
0205020301	Kettle Creek	PA	0.72	0	1442818	97311	GOOD
0205020506	Lower Pine Creek	PA	0.72	0	1320049	60027	FAIR
0205020202	Driftwood Branch Sinnemahoning Creek	PA	0.72	0	1369107	58501	GOOD
0207000404	Back Creek	VA,WV	0.67	0	0	754506	FAIR
0208020702	Vaughans Creek-Appomattox River	VA	0.67	0	0	706597	FAIR
0205030501	Sherman Creek	PA	0.67	81766	617716	474366	FAIR
0208020502	Upper Willis River	VA	0.67	0	0	468710	FAIR
0208020113	Catawba Creek	VA	0.67	0	0	378108	GOOD
0208020105	Lower Jackson River	VA	0.67	0	801641	369675	GOOD
0205020603	Upper Loyalsock Creek	PA	0.67	0	754078	24665	FAIR
0207000505	Dry River	VA	0.67	0	539017	15955	GOOD
0208020304	Wreck Island Creek-James River	VA	0.61	0	0	639472	FAIR
0205010603	Towanda Creek	PA	0.61	0	256269	459863	FAIR
0205010305	Pipe Creek-Susquehanna River	NY	0.61	90396	115888	438116	FAIR
0208010607	Little River	VA	0.61	0	0	414641	FAIR
0208010304	Hazel River	VA	0.61	0	146226	407775	GOOD
0208010309	Robinson River	VA	0.61	0	78476	407340	FAIR
0205030103	Middle Creek	PA	0.61	0	195923	382805	FAIR
0208010504	Maracossic Creek	VA	0.61	74	0	374935	FAIR
0205010303	Catatonk Creek	NY	0.61	0	0	354667	FAIR
0208010202	Dragon Swamp	VA	0.61	68036	0	347050	FAIR
0208020704	Big Guinea Creek-Appomattox River	VA	0.61	0	0	345715	FAIR
0205010408	Cowanesque River	NY,PA	0.56	0	275480	762883	GOOD
0207000106	Lower South Branch Potomac River	WV	0.56	0	105638	761129	FAIR
0207000207	Patterson Creek	WV	0.56	0	57381	757969	FAIR
0207000103	Upper South Branch Potomac River	VA,WV	0.56	0	496945	624296	GOOD
0208010502	Matta River-Mattaponi River	VA	0.56	8350	0	604585	FAIR
0208010602	Middle South Anna River	VA	0.56	0	0	534376	FAIR
0205010409	Tioga River	NY,PA	0.56	0	819559	451328	GOOD
0208010501	Poni River	VA	0.56	0	0	440294	GOOD
0205010506	Lower Chemung River	NY,PA	0.56	101825	0	414211	FAIR
0205010307	Wappasening Creek-Susquehanna River	NY,PA	0.56	81483	0	409811	FAIR
0205010612	Tunkhannock Creek	PA	0.56	0	512948	401037	FAIR
0205010101	Canadarago Lake	NY	0.56	0	0	389504	FAIR
0207000507	South River	VA	0.56	0	465145	373001	FAIR
0208020205	Lower Maury River	VA	0.56	0	294257	370187	GOOD
0205010707	Fishing Creek	PA	0.56	0	756932	203426	FAIR
0205010614	Lower Susquehanna River	PA	0.50	281130	119119	659645	FAIR
0208010505	Chapel Creek-Mattaponi River	VA	0.50	181453	0	582115	FAIR
0208010610	Middle Pamunkey River	VA	0.50	123161	0	533388	FAIR
0207001104	Zekiah Swamp Run	MD	0.50	45910	0	447857	FAIR
0208010306	Marsh Run-Rappahannock River	VA	0.50	84568	0	414181	GOOD
0208010608	Northeast Creek-North Anna River	VA	0.50	61803	0	413411	FAIR
0208010311	Mine Run-Rapidan River	VA	0.50	0	0	367038	GOOD
0205030110	Susquehanna River	PA	0.50	216066	90875	362818	FAIR
0208010611	Lower Pamunkey River	VA	0.50	190304	0	157702	FAIR

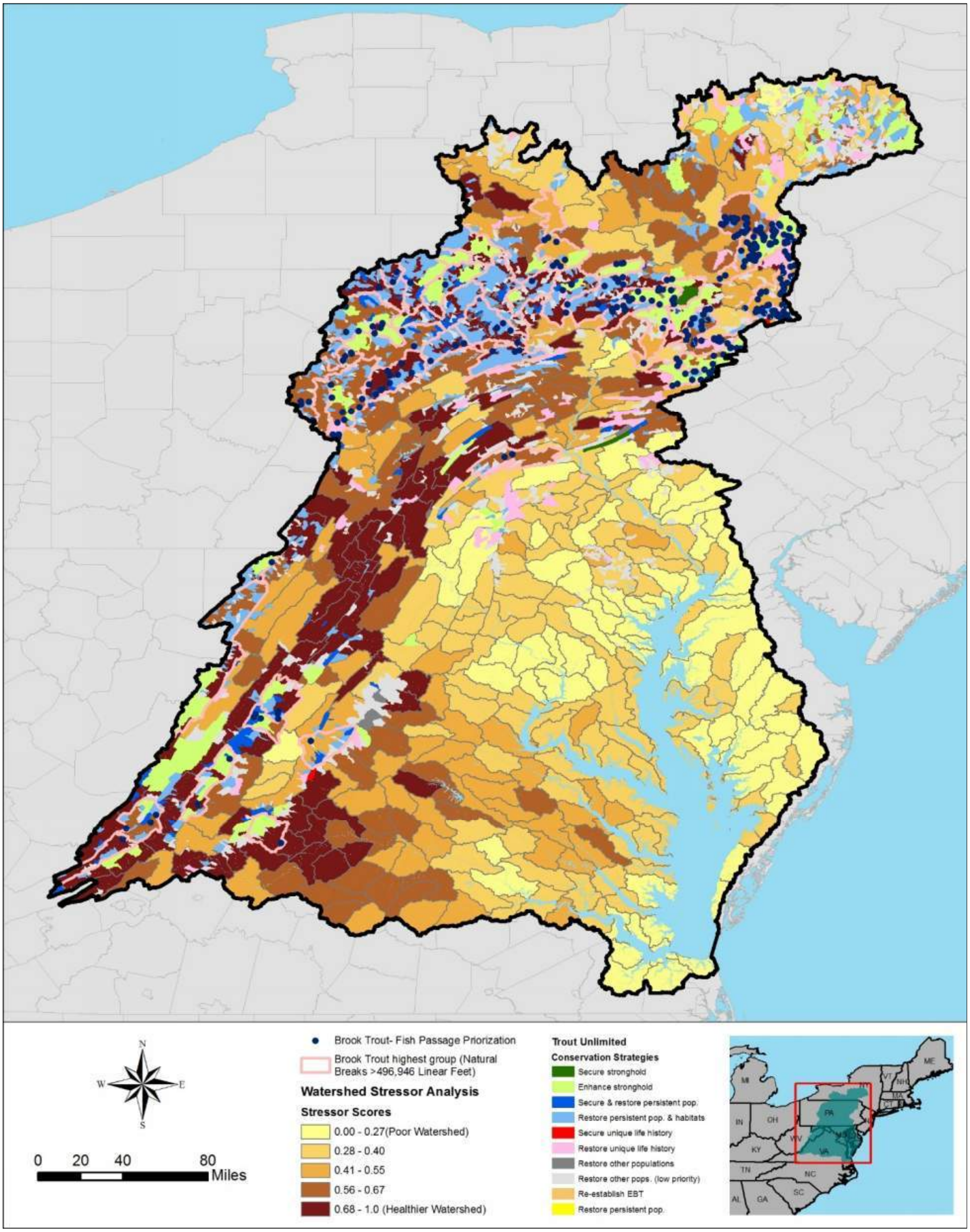


Figure 25. Alignment of stream restoration *Opportunities* for EBT with Trout Unlimited conservation strategies and prioritized fish passage blockages (see next section for explanation of blockages) (1-HR-SR-A2)

The CBCP Master Results Database identifies stream restoration opportunities for each of the three objectives, IBI scores, and watershed assessment scores.

Key points:

1. The analysis identified that watershed assessment scores were highest (least stressed subwatershed) in:

    a) Subwatersheds with opportunities to benefit EBT habitat in the upper Susquehanna River and the West Branch Susquehanna River in Pennsylvania and in the western portions of the watershed in Virginia and West Virginia.

    b) Subwatersheds with opportunities to benefit resident fish in the Potomac River of western Maryland, Pennsylvania, and West Virginia; upper James River in Virginia; the Upper Susquehanna, western subwatershed in the West Branch Susquehanna, and the central subwatershed in the Lower Susquehanna in Pennsylvania, and throughout the Upper Susquehanna in New York.

2. Subwatersheds exhibit higher stress levels in subwatersheds with opportunities to benefit habitat for anadromous fish along the mainstem of Maryland's Chesapeake Bay and the lower Susquehanna River in Pennsylvania.

3. Subwatersheds on Maryland's Eastern Shore that have opportunities for stream restoration to benefit resident and anadromous fish also are stressed.

4. Subwatersheds in Virginia in the lower Rappahannock, York, and James Rivers for resident and anadromous fish have moderate stress levels.

5. USACE would be most suited to pursue stream restoration for habitat improvements in those subwatersheds with low stressors such as those in New York, in the northern and western Pennsylvania portions of the watershed, western Maryland, West Virginia, and the western half of Virginia in the bay watershed.

6. There are stream restoration opportunities in stressed subwatersheds that could target watershed stressors and greatly benefit the health of those watersheds.

7. There are Trout Unlimited EBT conservation strategies identified for catchments within identified stream restoration opportunities. This information has potential for siting projects on a smaller scale with follow-up investigations.

2.3 Fish Passage Blockages Analysis (1-HR-FP)

Overview: Fish passage within the Chesapeake Bay Watershed is limited by a significant number of blockages that range from large hydroelectric power-generating dams to historical mill dams to road culverts and utility pipes that have been exposed by erosion. The CBP Fish Passage Workgroup in conjunction with TNC has developed a Chesapeake Bay fish passage prioritization tool that documents blockages. Independent prioritizations of blockages for removal have been completed separately to address the needs of EBT, diadromous fish, and resident fish. The intent of the CBCP's Fish Passage Blockages Analysis was to build upon the work completed by the CBP

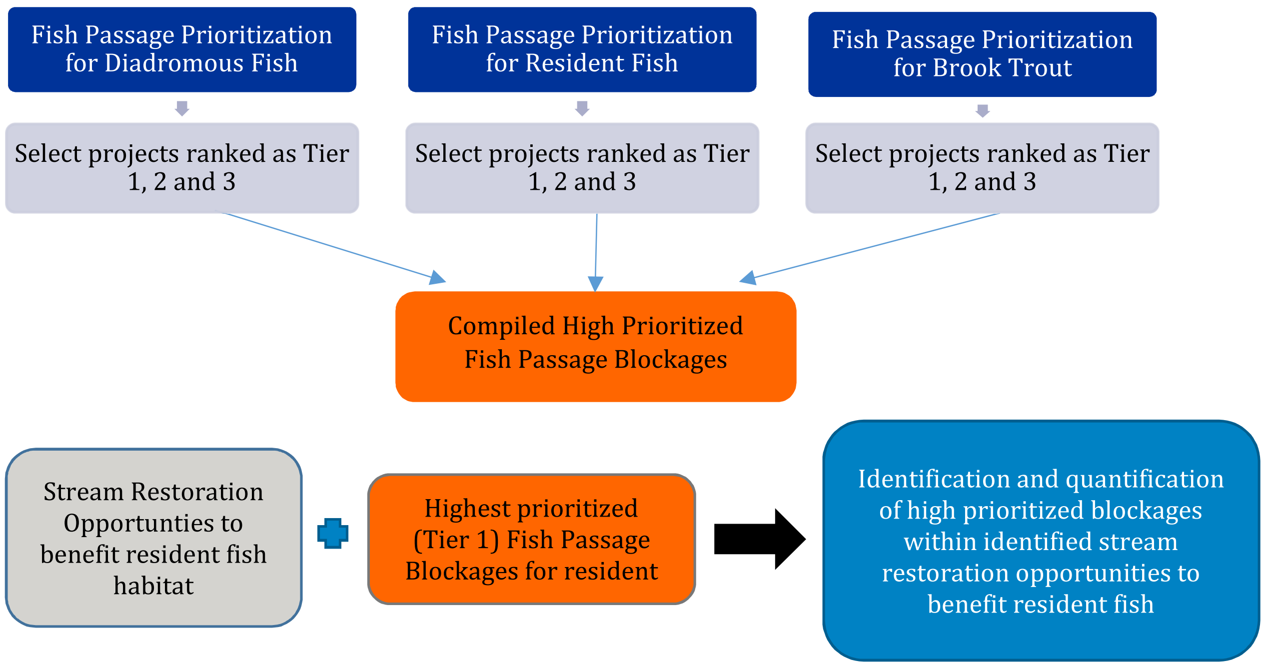
Fish Passage Workgroup to identify where high prioritized blockages are co-located with opportunities for stream restoration.

Fish passage blockage data within the prioritization tool does not include blockages in New York or West Virginia; therefore, neither does the CBCP analyses.

Data layers:

- *High prioritized fish passage blockages from CBP Fish Passage Workgrou*p – USACE developed a layer that identified subwatersheds containing high prioritized blockages based on either prioritization of diadromous fish, resident fish, or EBT. The three separate prioritization schemes were developed by the CBP Fish Passage Workgroup to identify those passages that are most critical to be removed in order to benefit the three different fisheries, respectively.
- *Stream Restoration Analysis results* – Stream restoration opportunities for EBT, anadromous fish, and resident fish.

Conceptual diagram, computations, and opportunities selection process: The Fish Passage Blockages Analysis identifies which stream restoration opportunities contain high prioritized fish passage blockages (Tier 1 by the nomenclature of the prioritization tool). Initially, the top ranking (Tier 1, 2, and 3) blockages from each prioritization were compiled into one layer to visualize if there was any relationship that needed to be recognized (**Figure 26**) and compiled with the WSA scores to understand watershed stress level (**Figure 27**). Following that, separate evaluations were completed for each component (EBT, anadromous fish, and resident fish) and the number of high prioritized blockages within each subwatershed were tallied. The EBT blockage prioritization is combined with the stream restoration opportunities identified for EBT (**Figure 28**). The diadromous fish prioritization is combined with the stream restoration opportunities identified for anadromous fish (**Figure 29**). The resident fish prioritization is combined with the stream restoration opportunities identified for resident fish (**Figure 30**). The highest prioritized blockages were overlaid on the layer depicting all stream restoration opportunities (**Figure 31**).


Fish Passage Prioritization for Diadromous Fish
Fish Passage Prioritization for Resident Fish
Fish Passage Prioritization for Brook Trout
Select projects ranked as Tier 1, 2 and 3
Select projects ranked as Tier 1, 2 and 3
Select projects ranked as Tier 1, 2 and 3
Compiled High Prioritized Fish Passage Blockages
Stream Restoration Opportunities to benefit resident fish habitat
Highest prioritized (Tier 1) Fish Passage Blockages for resident
Identification and quantification of high prioritized blockages within identified stream restoration opportunities to benefit resident fish

Map products:

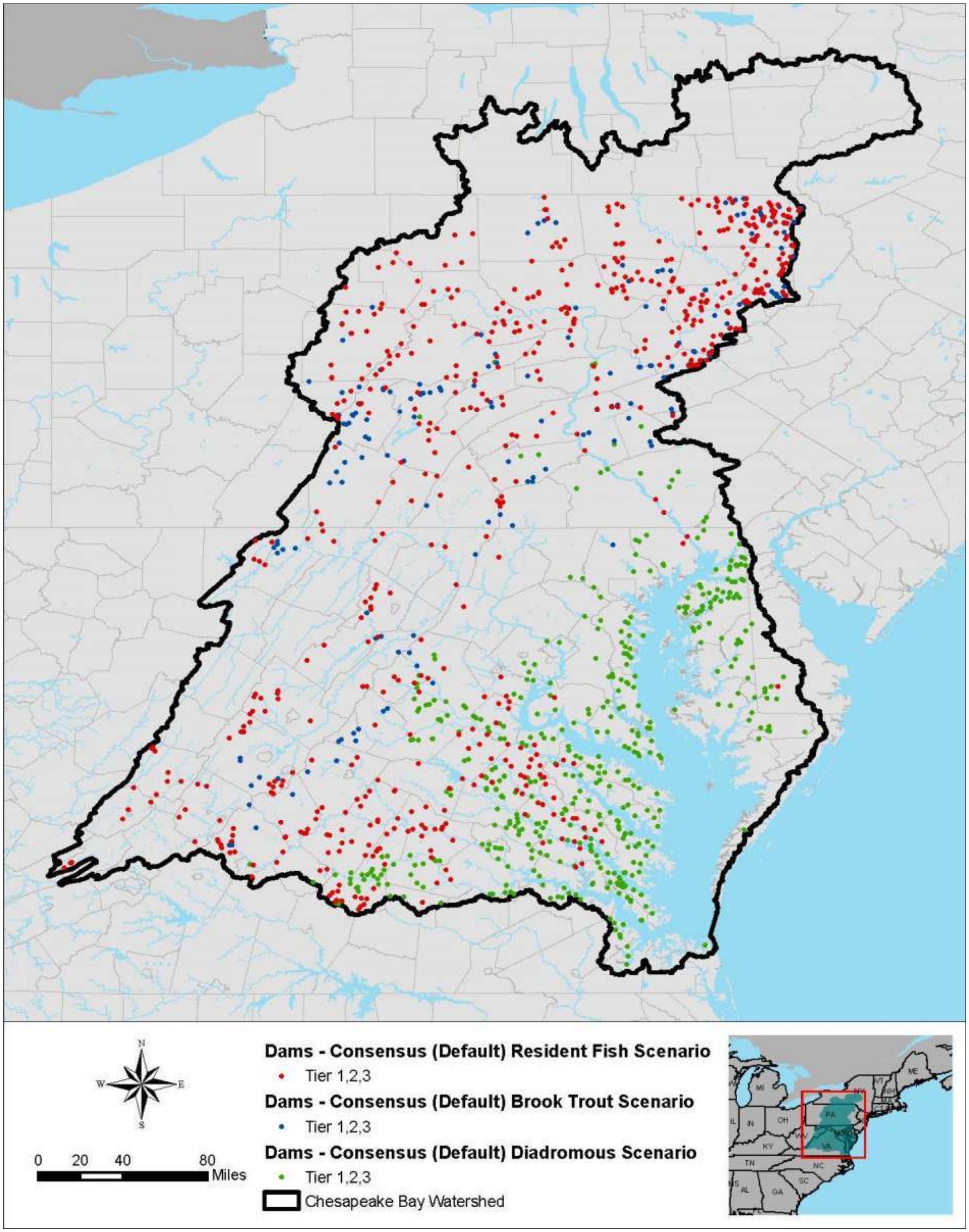


Figure 26. Fish passage prioritizations from the Chesapeake Bay fish passage prioritization tool (1-HR-FP-A)

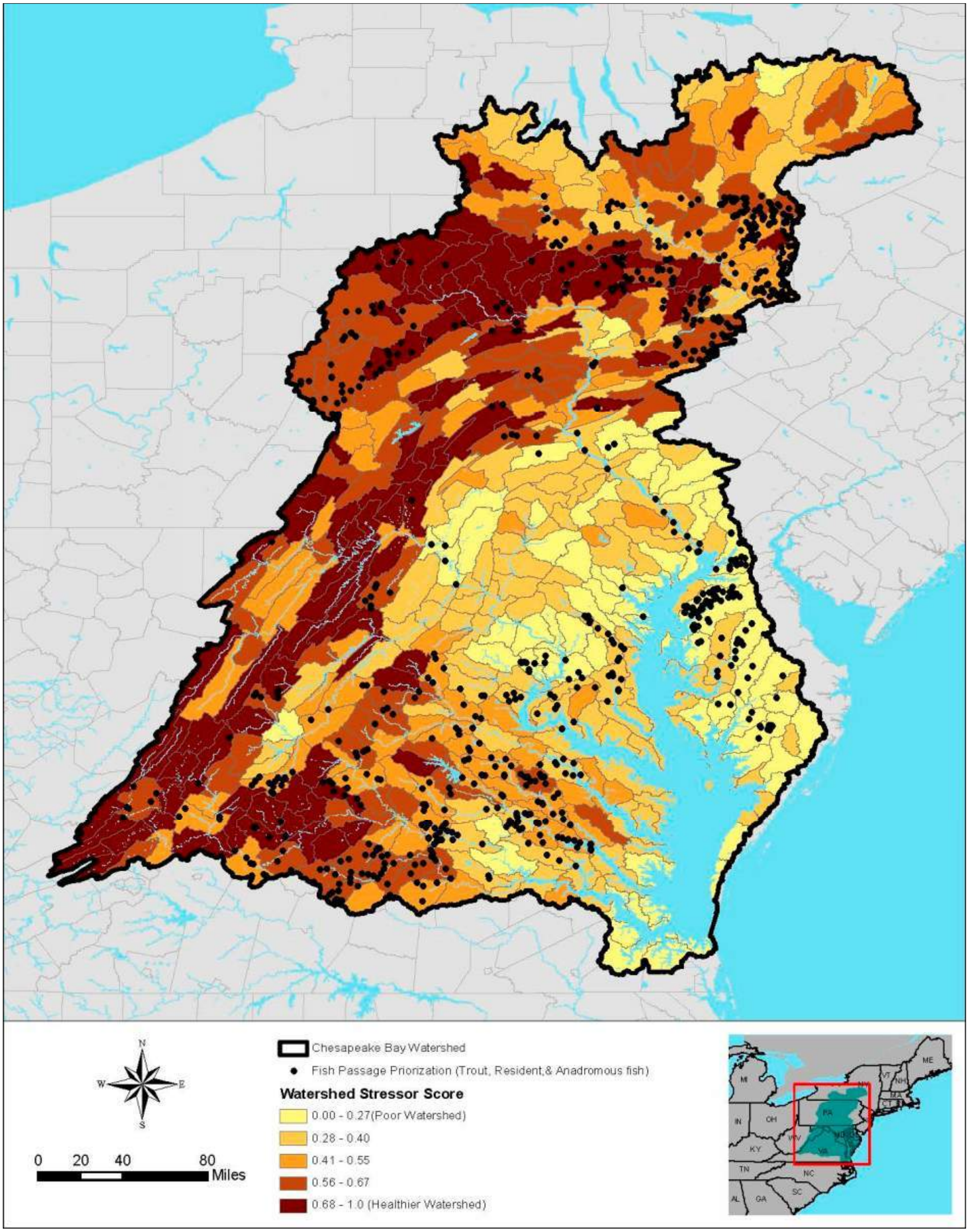


Figure 27. High prioritized fish passage blockages (Tier 1 of three separate scenarios – EBT, diadromous fish, and resident fish scenarios) and watershed stressor scores (1-HR-FP-B)

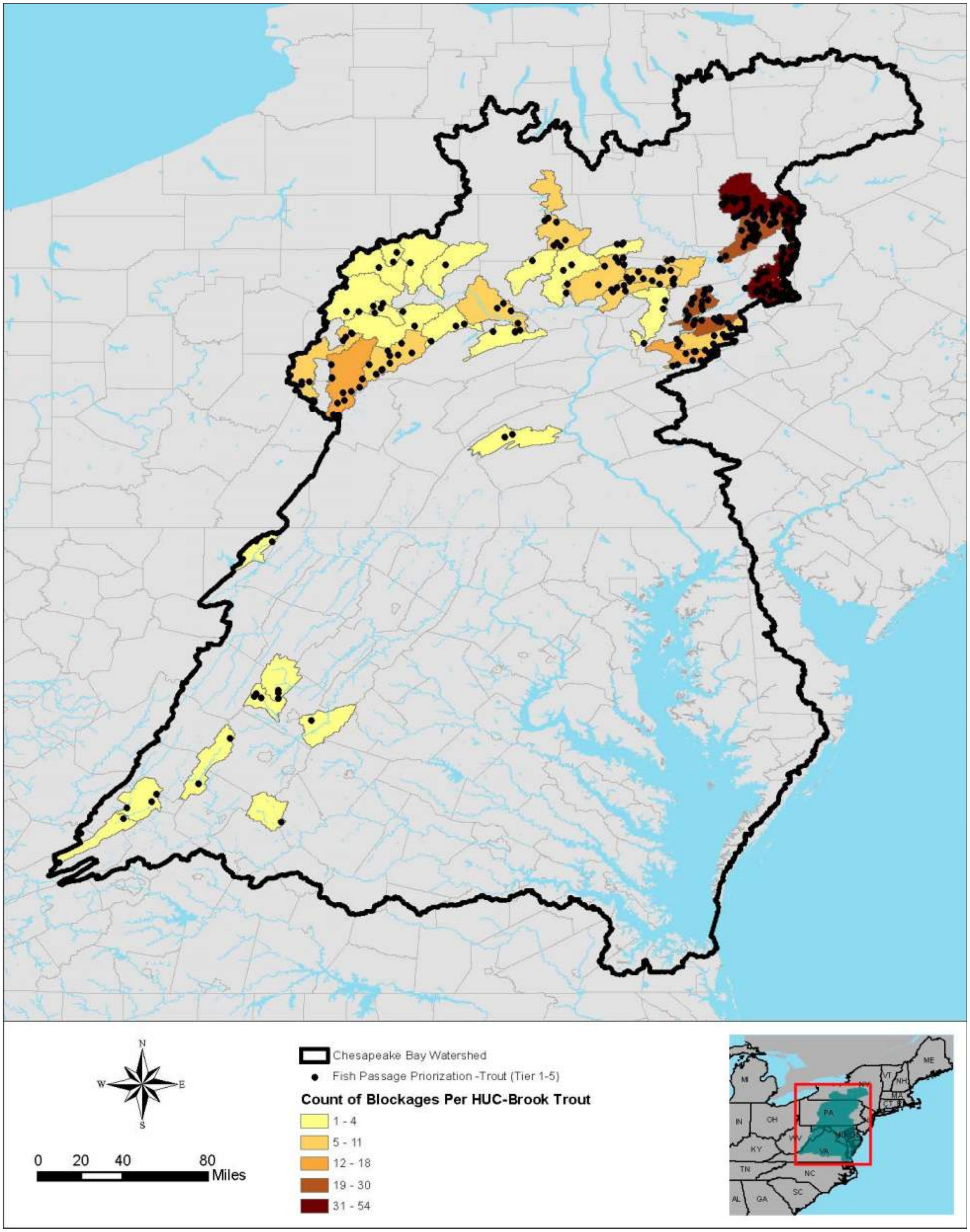


Figure 28. High prioritized fish passage blockages for EBT (Tier 1 of CBP EBT Prioritization) tallied in opportunities for stream restoration to benefit EBT (1-HR-FP-C)

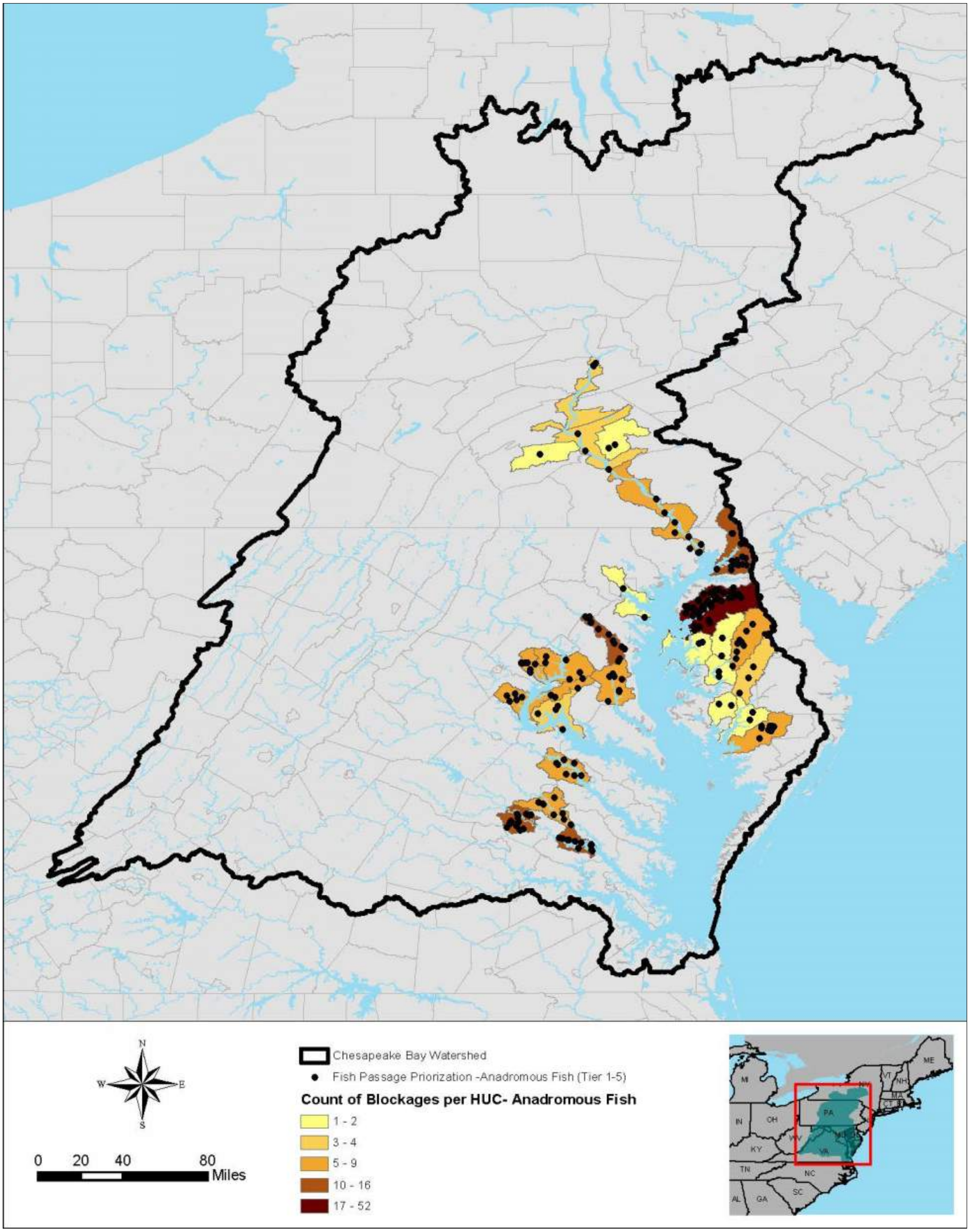


Figure 29. High prioritized fish passage blockages for anadromous fish (Tier 1 of CBP diadromous prioritization) tallied in opportunities for stream restoration to benefit anadromous fish (1-HR-FP-D)

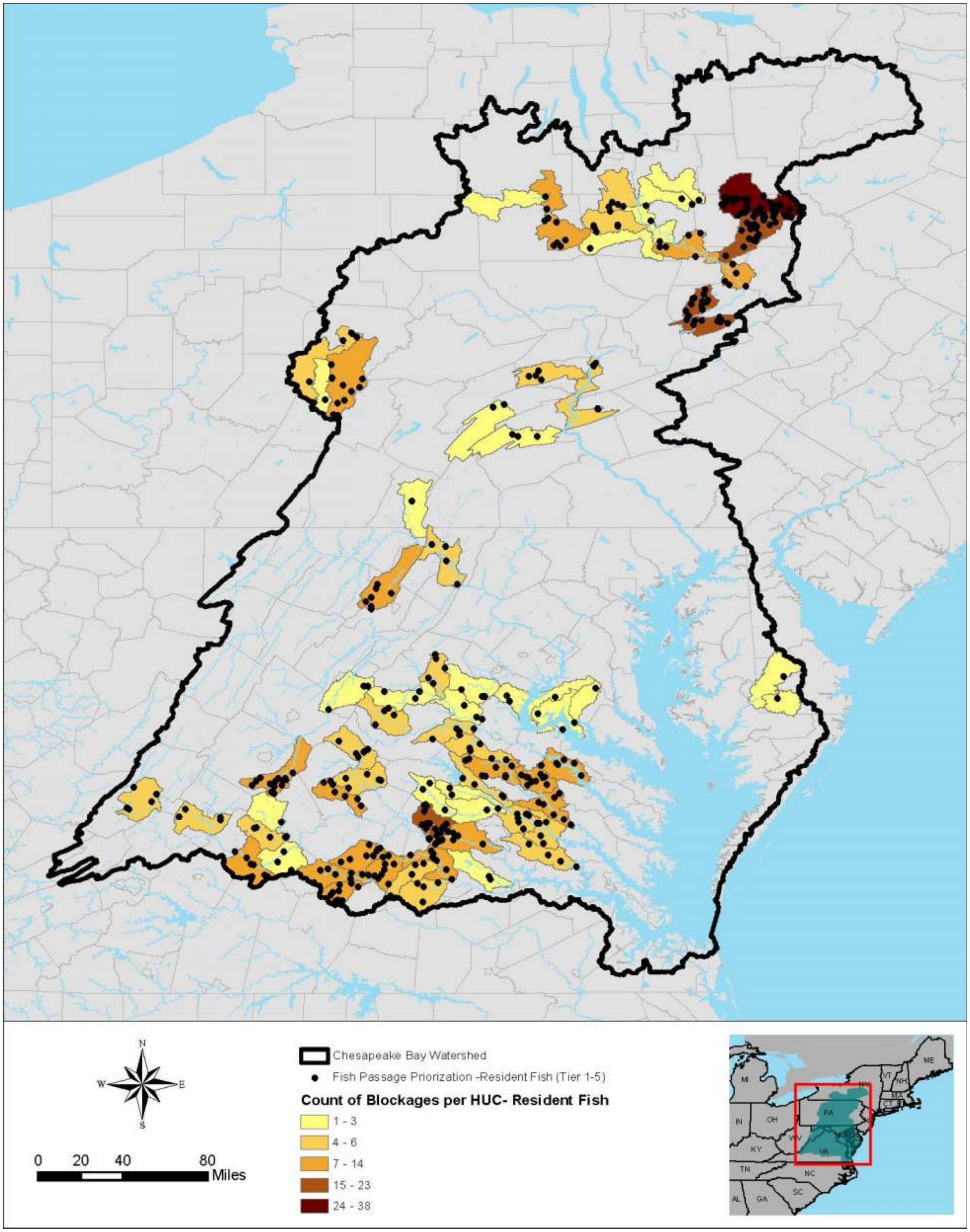


Figure 30. High prioritized fish passage blockages for resident fish (Tier 1 of CBP resident fish prioritization) tallied in opportunities for stream restoration to benefit resident fish (1-HR-FP-E)

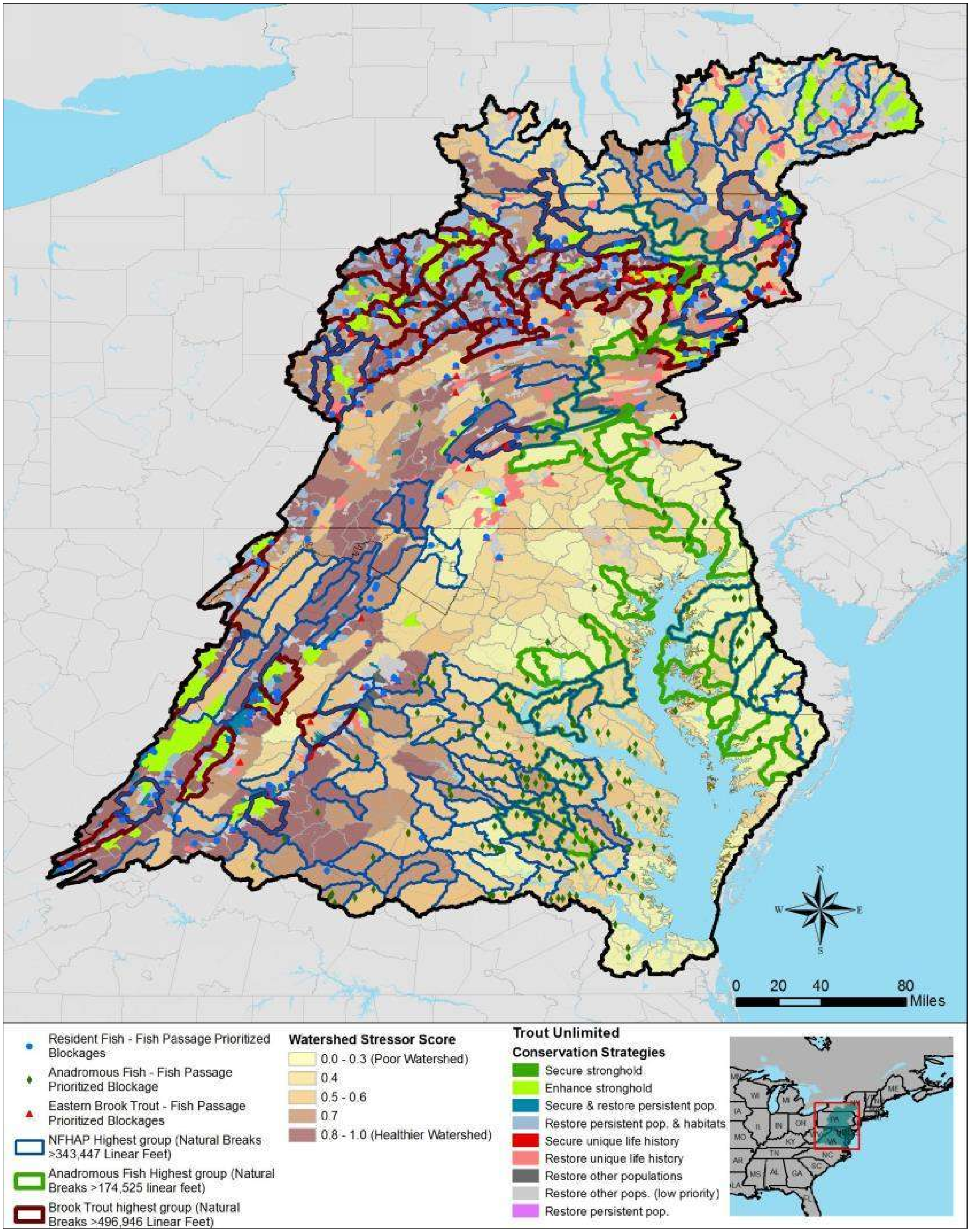


Figure 31. Stream restoration *Opportunities* compiled with associated prioritized fish passage blockages (1-HR-FP-F)

The information compiled in **Figure 31** identifies where fish passage blockages prioritized for a specific objective (resident fish, EBT, or anadromous fish) occur in opportunities for stream restoration for those objectives. Multi-objective projects could be undertaken in these subwatersheds to improve stream habitat and address prioritized fish passage blockages following a finer scale, local analysis.

The Masters Results Database provides the number of high priorized fish passage blockages for each of the three objectives for each subwatershed.

Key points:

1. High prioritized fish passage blockages are concentrated in the upper Susquehanna River in Pennsylvania, the West Branch Susquehanna in Pennsylvania, the Chester-Sassafras Watershed on Maryland's Eastern Shore, and throughout the York, Rappahannock, and James Rivers Watersheds in Virginia.

2. Fish passage blockages on the Eastern Shore of Maryland and along the lower Susquehanna River in Pennsylvania are typically in stressed subwatershed.

3. Fish passage blockages in the upper, middle, and West Branch Susquehanna in Pennsylvania and upper James River in Virginia are in low stress subwatershed.

4. Fish passage blockages in eastern Virginia are in moderately stressed subwatershed.

5. The highest concentration of high prioritized fish passage blockages to benefit EBT are in the upper Susquehanna River Watershed along the New York-Pennsylvania border in eastern Pennsylvania.

6. The highest concentration of high prioritized fish passage blockages to benefit anadromous fish are in the Chester and Elk Rivers Watersheds in the upper Eastern Shore of Maryland, lower and upper Pamunkey River Watersheds in Virginia, and upper Patuxent River in Maryland.

7. The highest concentration of high prioritized fish passage blockages to benefit resident fish populations are in the upper Susquehanna River Watershed along the New York-Pennsylvania border in eastern Pennsylvania, similar but not identical to EBT.

8. High prioritized fish passage blockages are co-located in stream restoration opportunities for all three objectives (resident fish, EBT, and anadromous fish). Multi-objective projects could be undertaken in these subwatersheds to improve stream habitat and address prioritized fish passage blockages following a finer scale, local analysis.

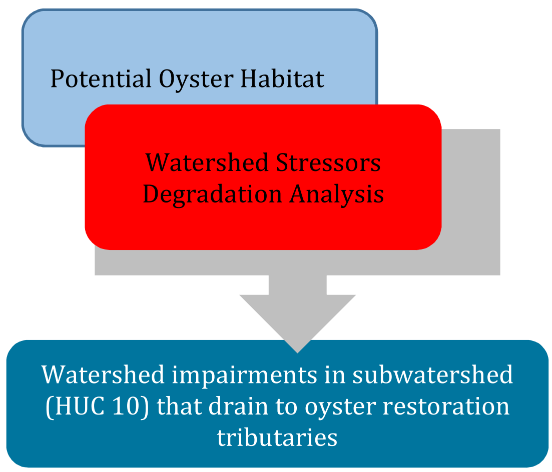
2.4 Oyster Restoration Analysis (1-HR-OY)

Overview: As there are extensive multiagency efforts focused on identifying tributaries in which to undertake oyster restoration in the Chesapeake Bay, this analysis is focused only on those subwatersheds that drain directly to selected oyster restoration tributaries. This strategy is aimed at providing healthy habitat conditions to promote oyster survival and restoration success. The intent is to understand existing watershed impairments in those watersheds draining into tributaries where oyster restoration is being undertaken. Once impairments are understood, opportunities can be proposed to address to improve conditions.

Data layers:

- *Oyster restoration data layer* – compilation of Virginia and Maryland restoration sites
- *Watershed stressors analysis*

Conceptual diagram, computations, and opportunities selection: Select from the watershed stressors analysis those subwatersheds that drain to tributaries that hold historic oyster habitat. The priority tributaries for large-scale oyster restoration—Piankatank River, Lynnhaven River, Lafayette River, Great Wicomico River, and York River in Virginia and Harris Creek, Little Choptank River, and Tred Avon River in Maryland—and those proposed for restoration —St. Mary's River and Breton Bay in Maryland, are highlighted in **Figure 32**. Evaluate the individual scores of the watershed stressors rating in those subwatersheds that drain to restoration tributaries to understand problems in the watersheds draining to oyster restoration sites. Generate strategies within each subwatershed to address existing impairments that will promote healthy habitat conditions in the rivers for oysters.



Map products:

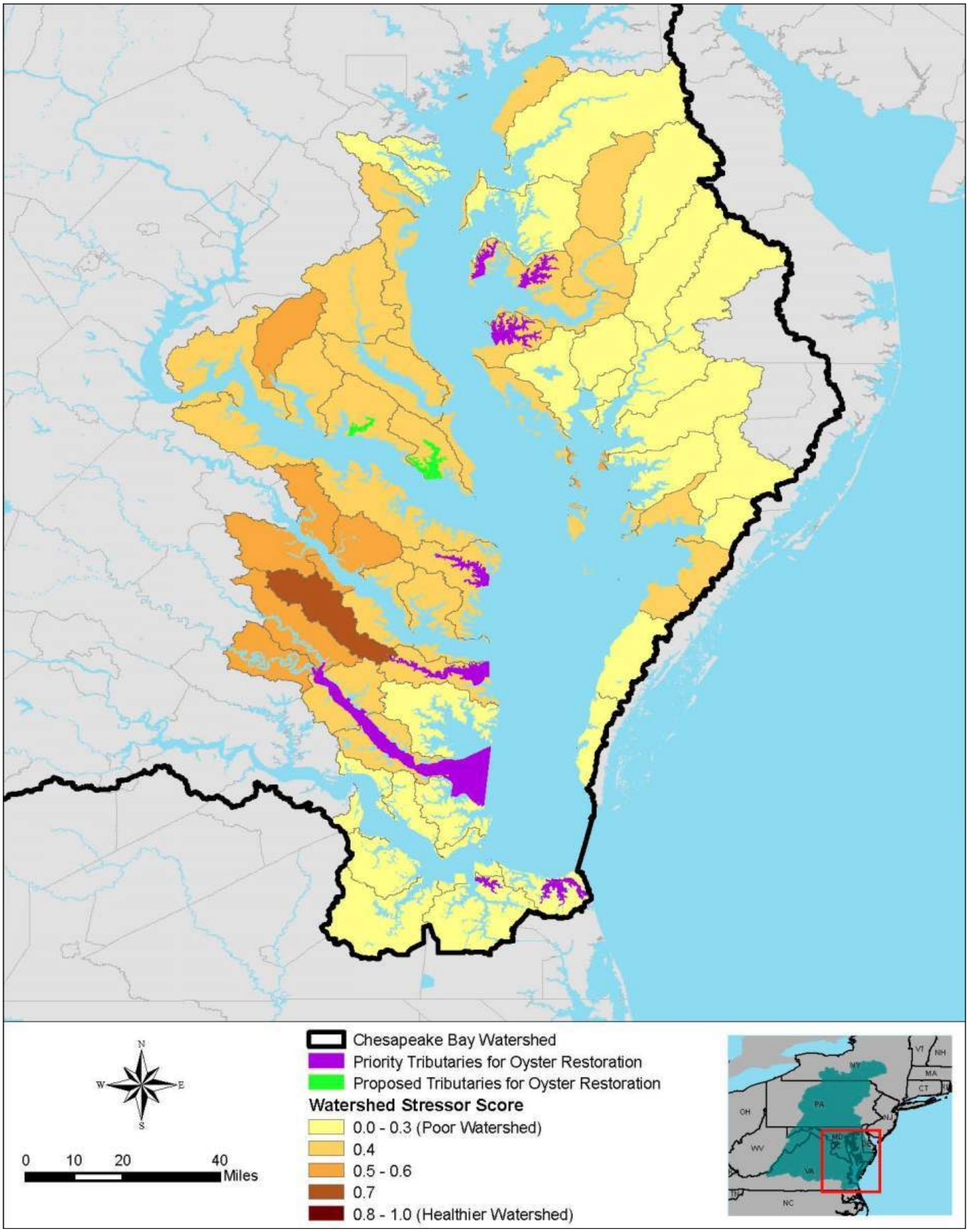


Figure 32. Oyster restoration watershed analysis (1-HR-OY-A)

Key points:

1. Tributaries that have been selected for large-scale tributary restoration efforts exhibit stressed conditions as determined by the watershed stressors evaluation.

2. There are opportunities to address watershed impairments in the subwatershed that drain to the oyster restoration tributaries.

2.5 SAV Restoration Analysis (1-HR-SAV)

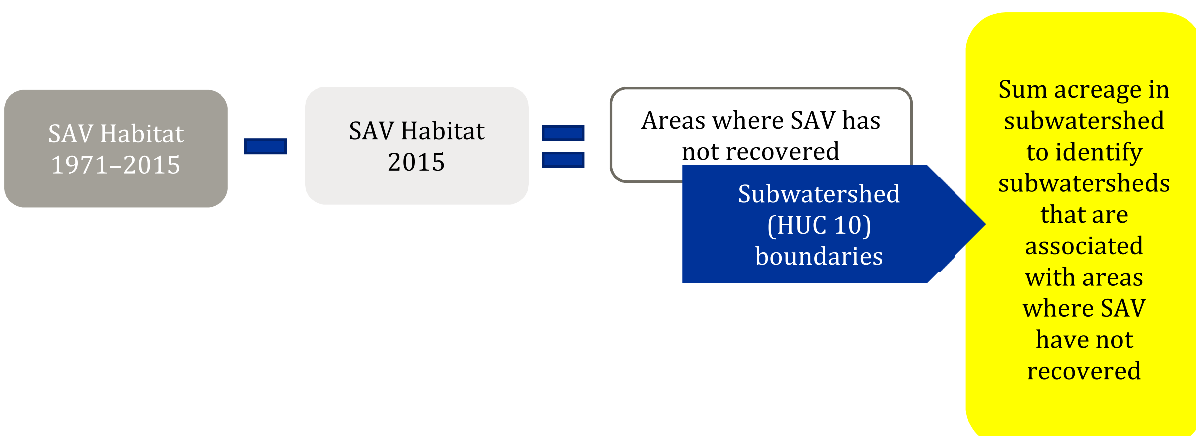
Overview: This analysis compares areas that have experienced significant historical SAV loss and areas where SAV habitat is currently located (2015) to identify potential areas in the bay for SAV restoration. This analysis is focused on those subwatersheds with mainstem shoreline.

Data layers:

- *Virginia Institute of Marine Sciences (VIMS) SAV Survey Data (1971–2015)* – Compiled layer representing all locations where SAV have been detected from 1971 through 2015 (**Figure 33**)

- *VIMS SAV Survey Data (2015)* – Identifies current location of SAV habitat (**Figure 34**)

Conceptual diagram, computations, and opportunities selection: Identify those areas that have experienced the most significant SAV losses. Using GIS clip the 2015 SAV coverage from 1971–2015 compiled layer to identify those areas where SAV habitat existed in the past, but does not support SAV beds currently. For each subwatershed along the mainstem, total the number of acres of SAV beds that have been lost to identify *SAV Opportunities* (**Figure 35)**.



Map products:

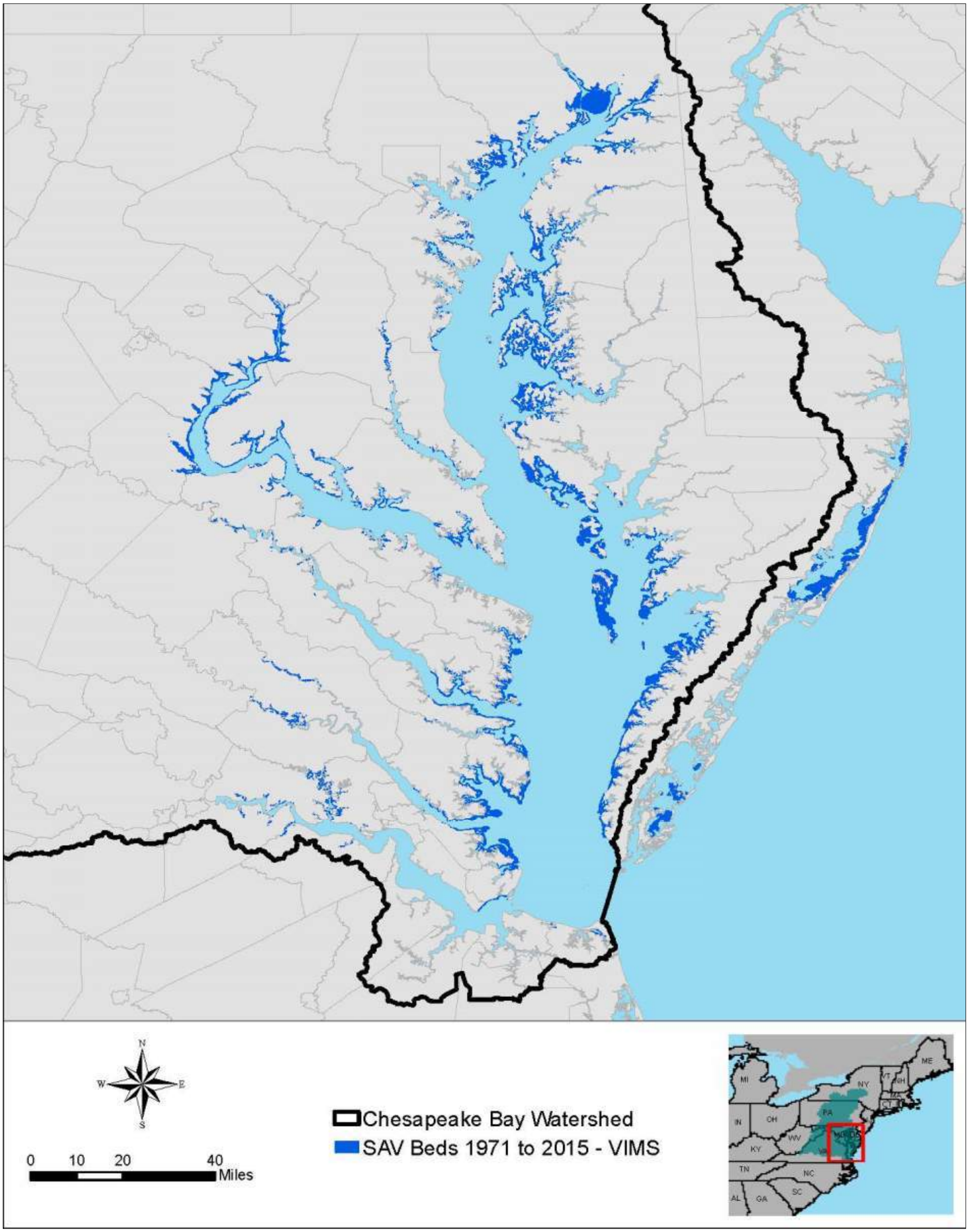


Figure 33. Chesapeake Bay SAV bed locations- Compiled from 1971 to 2015 from VIMS surveys (1-HR-SAV-A)

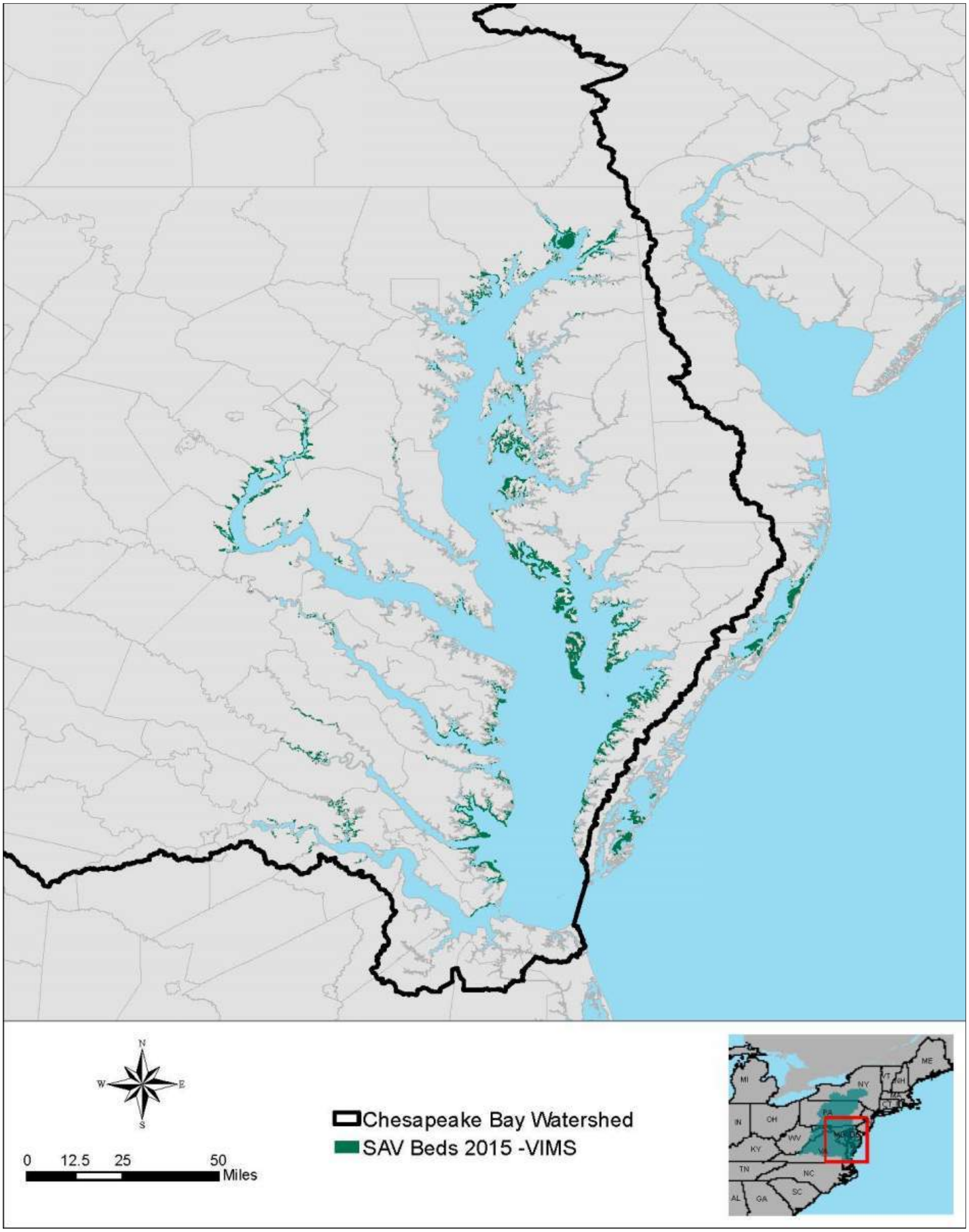


Figure 34. Chesapeake Bay SAV 2015 from VIMS surveys (1-HR-SAV-B)

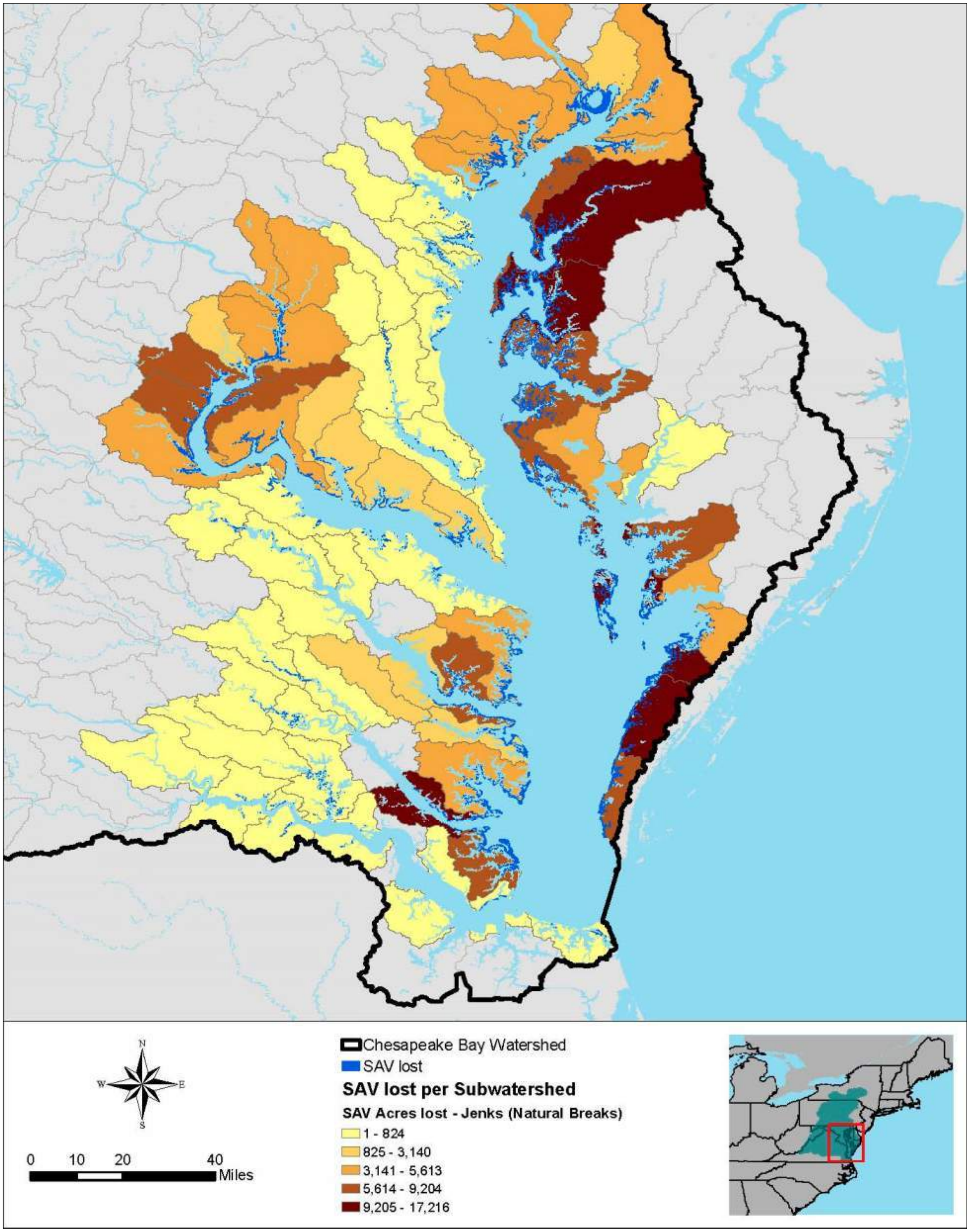


Figure 35. SAV restoration *Opportunities* (1-HR-SAV-C)

Key points:

1. Recommendations for opportunities for SAV restoration are positioned on the Eastern Shore of Maryland and Virginia, along the Potomac River in Maryland and Virginia, and along the lower York and Rappahannock rivers in Virginia. These include:

   a) Chester River (MD, DE)

   b) Eastern Bay (MD)

   c) Upper Tangier Sound (MD)

   d) Honga River (MD)

   e) Little Choptank River (MD)

   f) Lower Choptank River (MD)

   g) Manokin River (MD)

   h) Upper Chesapeake Bay (MD)

   i) Lower Chesapeake Bay (MD, VA)

   j) Deep Creek-Pocomoke Sounds (MD, VA)

   k) Lower Tangier Sounds (MD, VA)

   l) Occoquan River- Potomac River (MD, VA)

   m) Quantico Creek- Potomac River (MD, VA)

   n) Pungoteague Creek (VA)

   o) Lower York River (VA)

   p) Cherrystone Inlet – Lower Chesapeake Bay (VA)

   q) Corrotoman River – Rappahannock River (VA)

   r) Back River – Lower Chesapeake Bay (VA)

2. In these subwatersheds, there has been significant loss of SAV acreage without subsequent natural recovery. Conditions in these subwatersheds could be investigated to determine if the lack of recovery is due to water quality or rather is associated with a deficient seed bank, or if other factors are at play. If it is determined that water quality is the primary driver, efforts could be undertaken to address those impairments in the watershed.

2.5.1 Wetlands Restoration

(2) Where do opportunities exist to implement wetland restoration opportunities and protect existing wetlands to further Chesapeake Bay Agreement 2014 Goals and outcomes, maximize/optimize aquatic ecosystem restoration, flood risk management, beneficial use of dredged material, and community resilience benefits?

This series of questions is focused on identifying wetland restoration opportunities within the watershed and in tidal regions where wetlands could be restored to benefit wildlife, incorporate beneficial use of dredged material, and where wetlands and restoration opportunities are at risk to future threats.

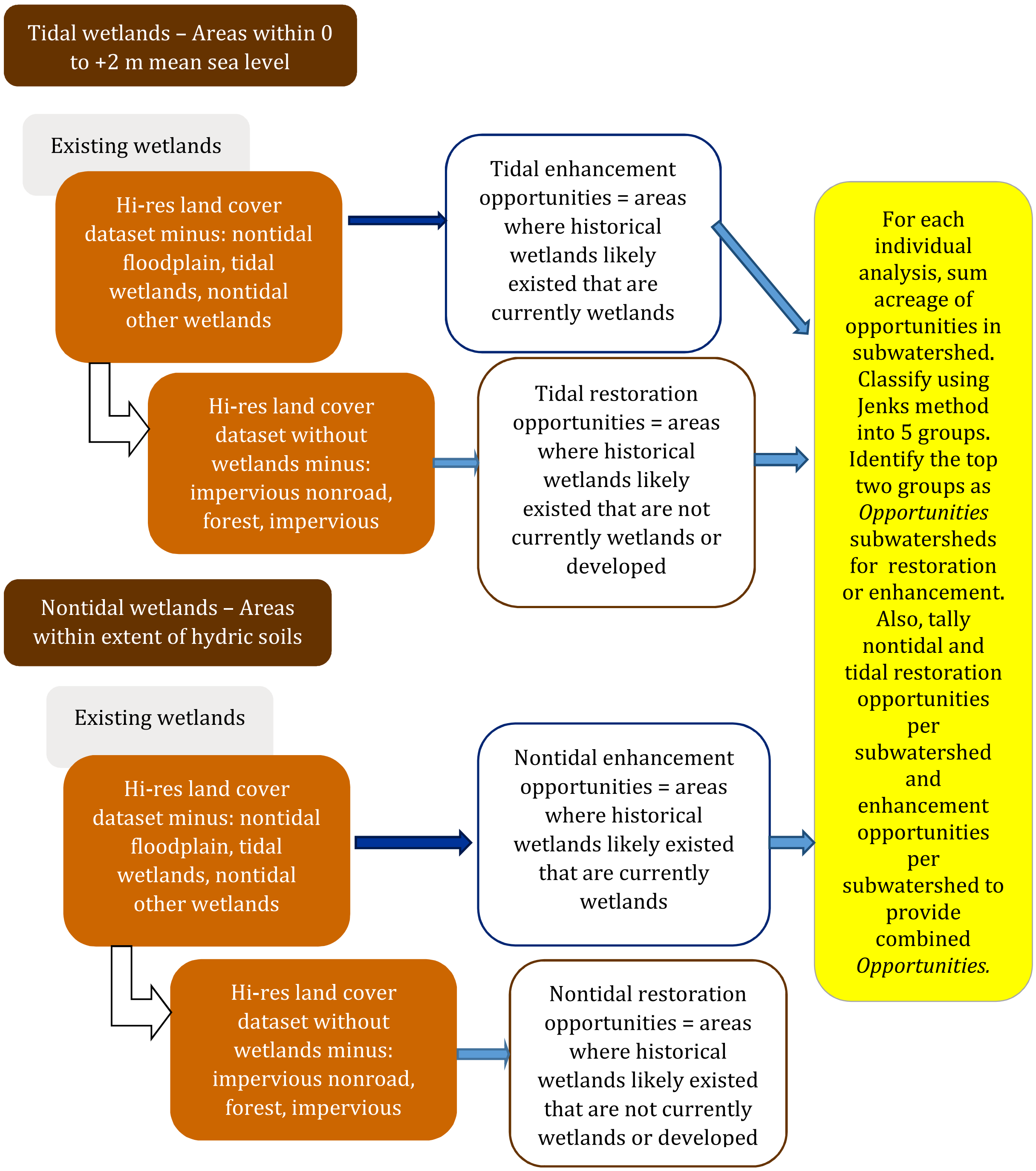
2.6 Identify wetland restoration and enhancement opportunities (2-WR)

Overview: Compile a layer that identifies tidal and nontidal wetland restoration and enhancement opportunities.

Data layers: Include the following data layers to create this compilation:

- *High resolution land cover data* - collected in 2016 by the Chesapeake Bay Conservancy and provided by NFWF
- USGS Digital Elevation Model
- *CBP hydric soils layers*

Conceptual diagram, computations, and opportunities selection: Information was compiled in GIS to develop a layer that identifies wetland restoration opportunities as well as wetland enhancement opportunities. The existing wetlands layer was used as a representation of locations for wetland enhancement. This layer was developed in GIS by selecting the following three classification categories from the high-resolution land cover dataset: nontidal floodplain, tidal wetlands, nontidal other wetlands. Existing wetlands and Wetland Restoration Opportunities within 0–2 m mean sea level were proposed as potential tidal wetland opportunities. For nontidal wetland opportunities, the USGS DEM was used to establish the potential boundaries above 2 m mean sea level. Within that region, the following classification categories were removed from the high resolution dataset: impervious nonroad, forest, impervious roads, water, and tree canopy over impervious surface, and three wetland categories because these land uses are either already wetlands or are land uses that could not be restored as wetlands. The areas that remained could potentially be restored as tidal wetlands. For nontidal wetland opportunities, the boundaries of the CBP hydric soils layers were used as potential project extent. Within those boundaries, the following classification categories were removed from the high-resolution dataset: impervious nonroad, forest, impervious roads, water, and tree canopy over impervious surface, and 3 wetland categories. The areas that remained could potentially be restored as nontidal wetlands. The acreage of existing wetlands within those boundaries are proposed as potential nontidal wetland enhancement opportunities. For restoration and enhancement, the total acreage of each was calculated for each subwatershed. The total acreage of restoration opportunity was classified into 5 groups utilizing the Jenks method in ArcGIS. The top 2 groups of watersheds based on acreage of opportunity are identified as opportunities. The same classification was carried out for the enhancement opportunities. A layer was also created and classified to include all (both tidal and nontidal) wetlands restoration opportunities. A similar combined layer was developed for wetland enhancement opportunities. **Figures 36 – 41** depict the resuls of all wetland restoration and enhancement opportunities.



Map products:

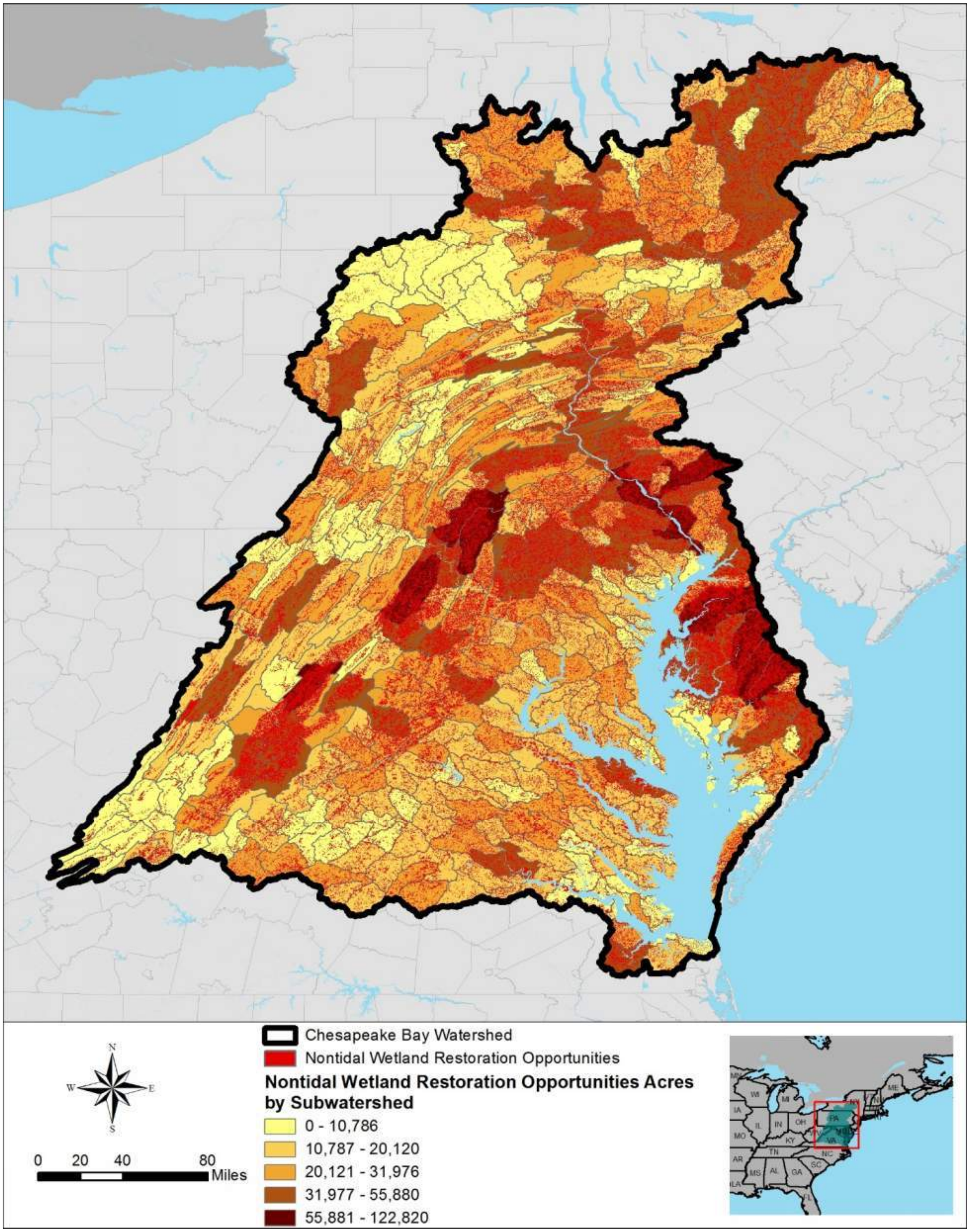


Figure 36. Nontidal wetlands restoration *Opportunities*: Total acres by subwatershed (2-WR-A)

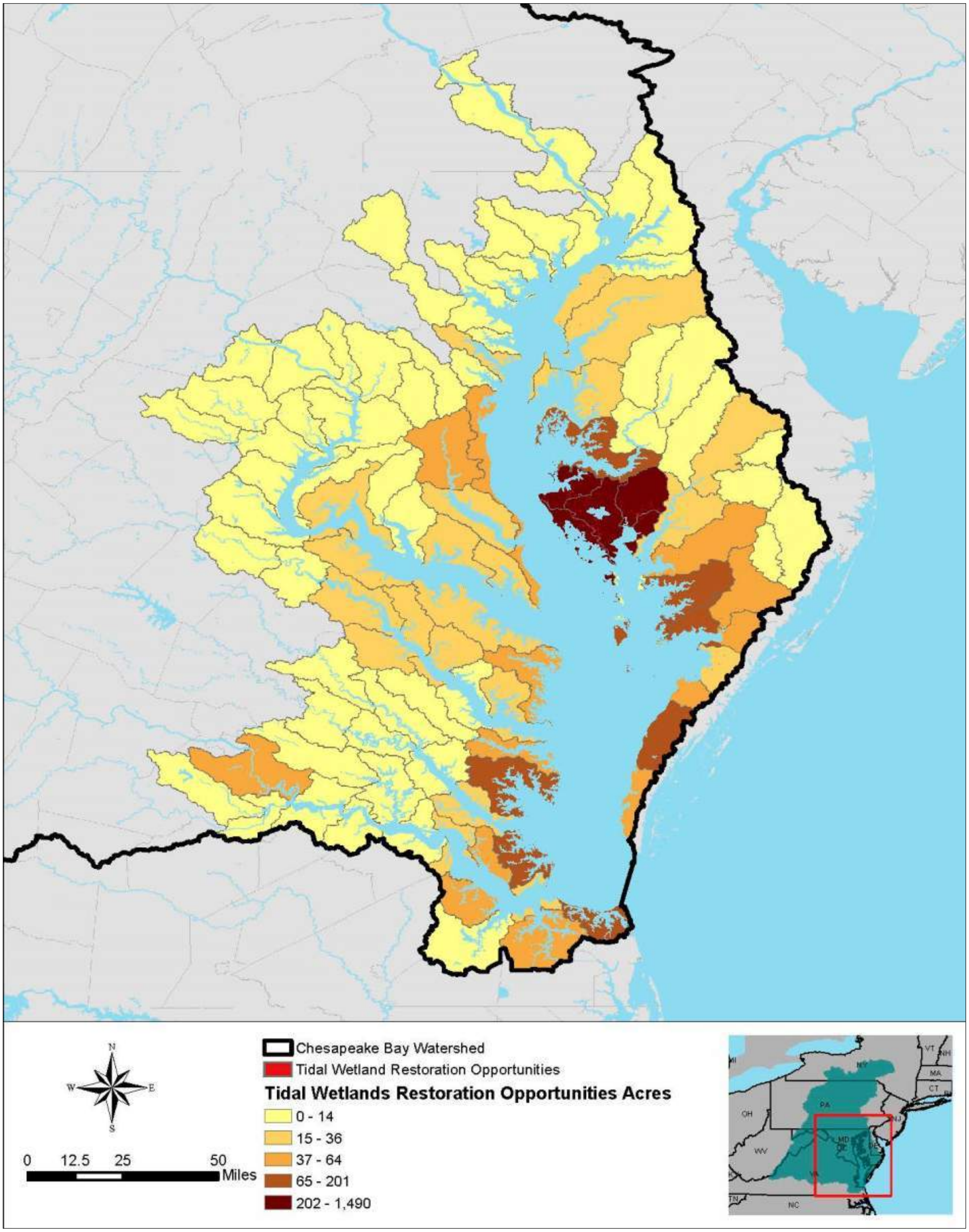


Figure 37. Tidal wetlands restoration *Opportunities*: Total acres by subwatershed (2-WR-B)

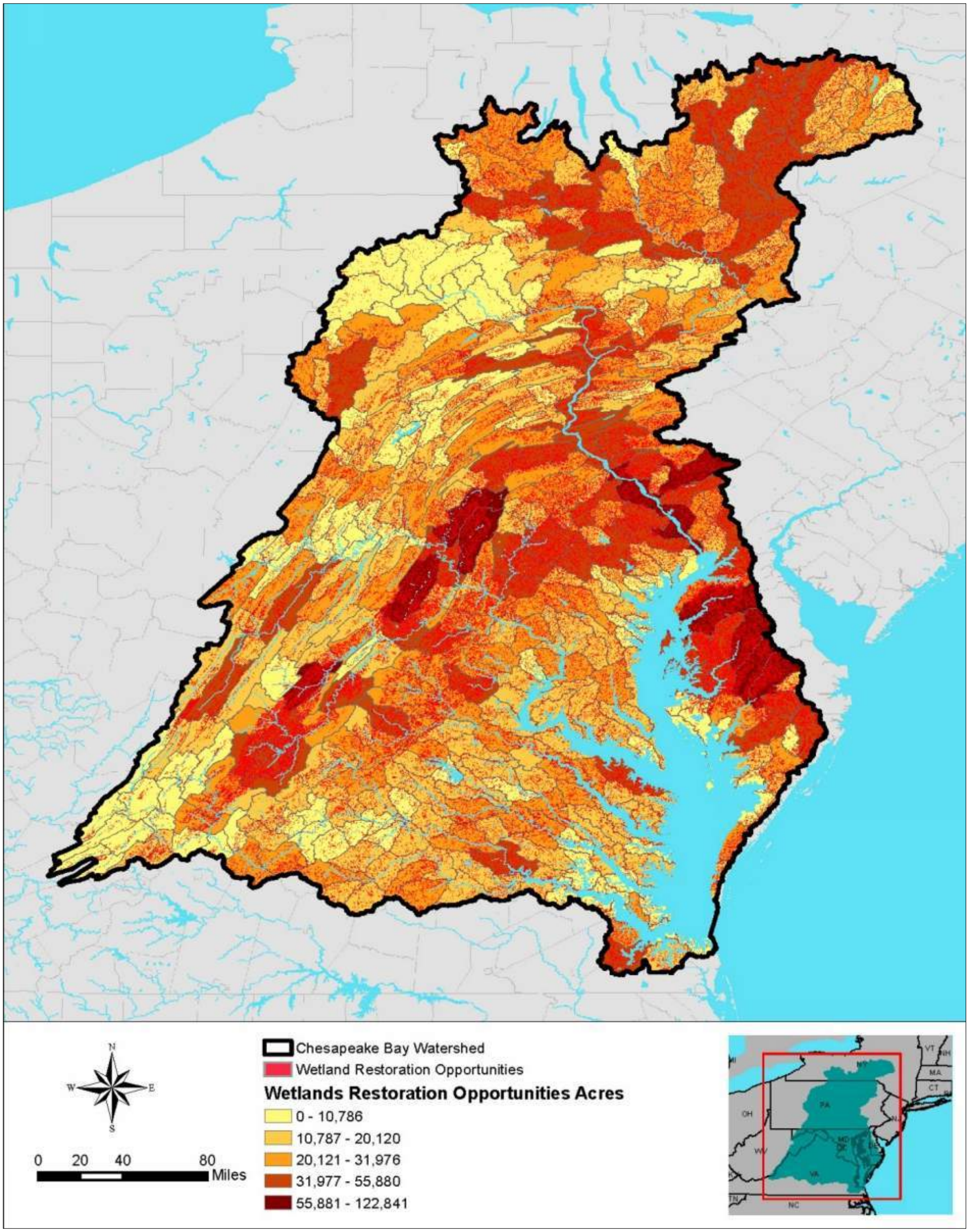


Figure 38. Combined tidal and nontidal wetlands restoration *Opportunities*: Total acres by subwatershed (2-WR-C)

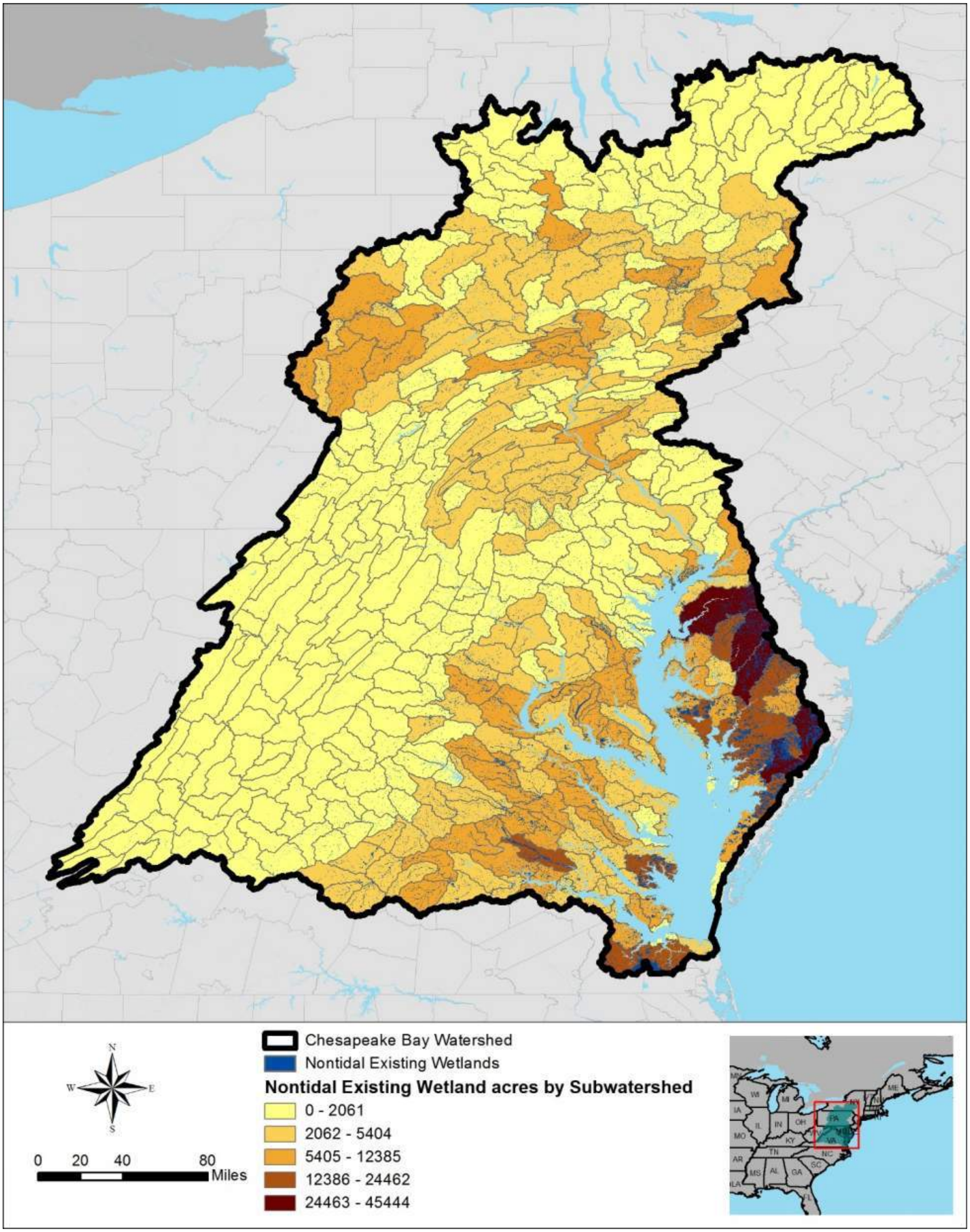


Figure 39. Nontidal wetlands enhancement *Opportunities*: Total acres by subwatershed (2-WR-D)

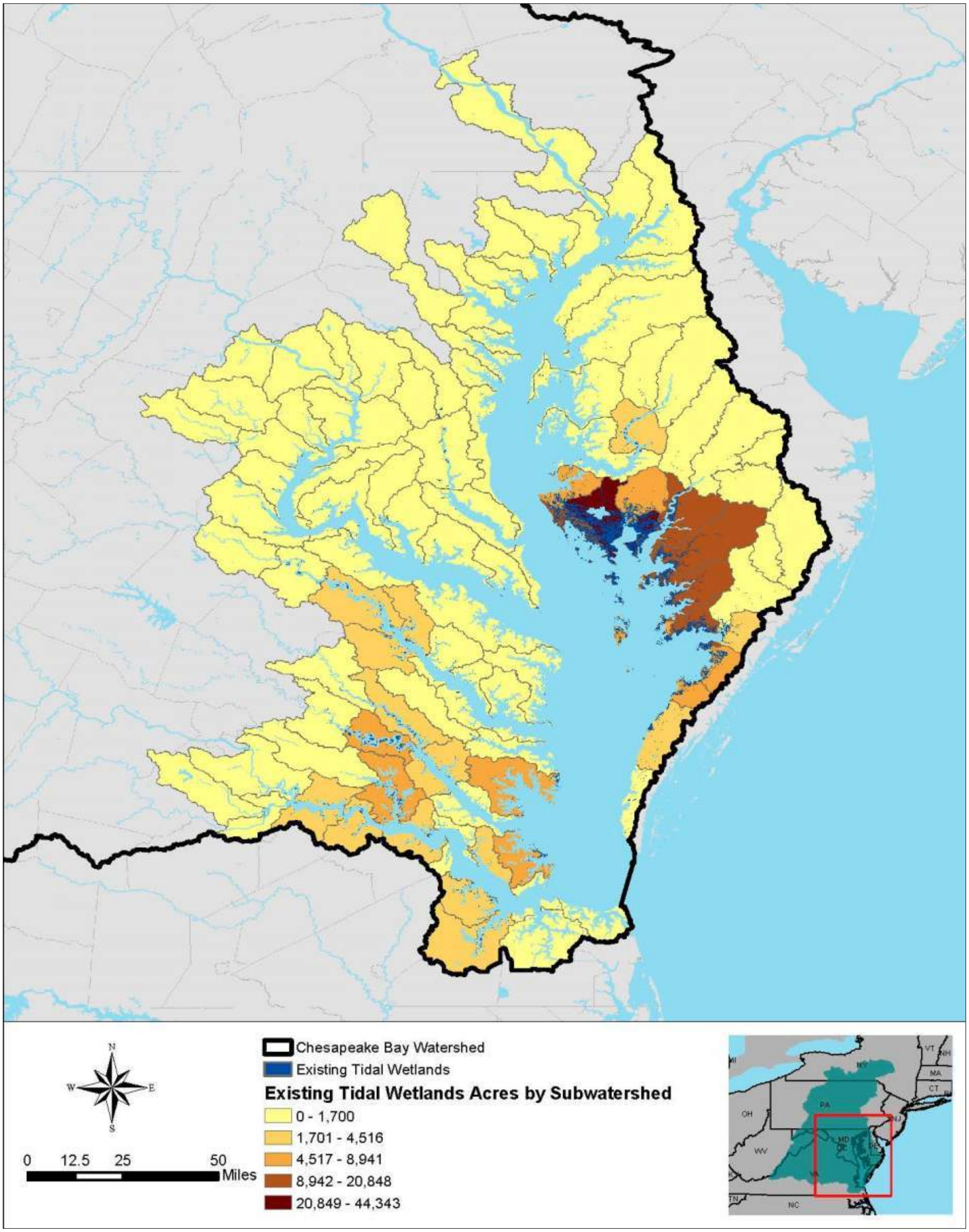


Figure 40. Tidal wetlands enhancement *Opportunities*: Total acres by subwatershed (2-WR-E)

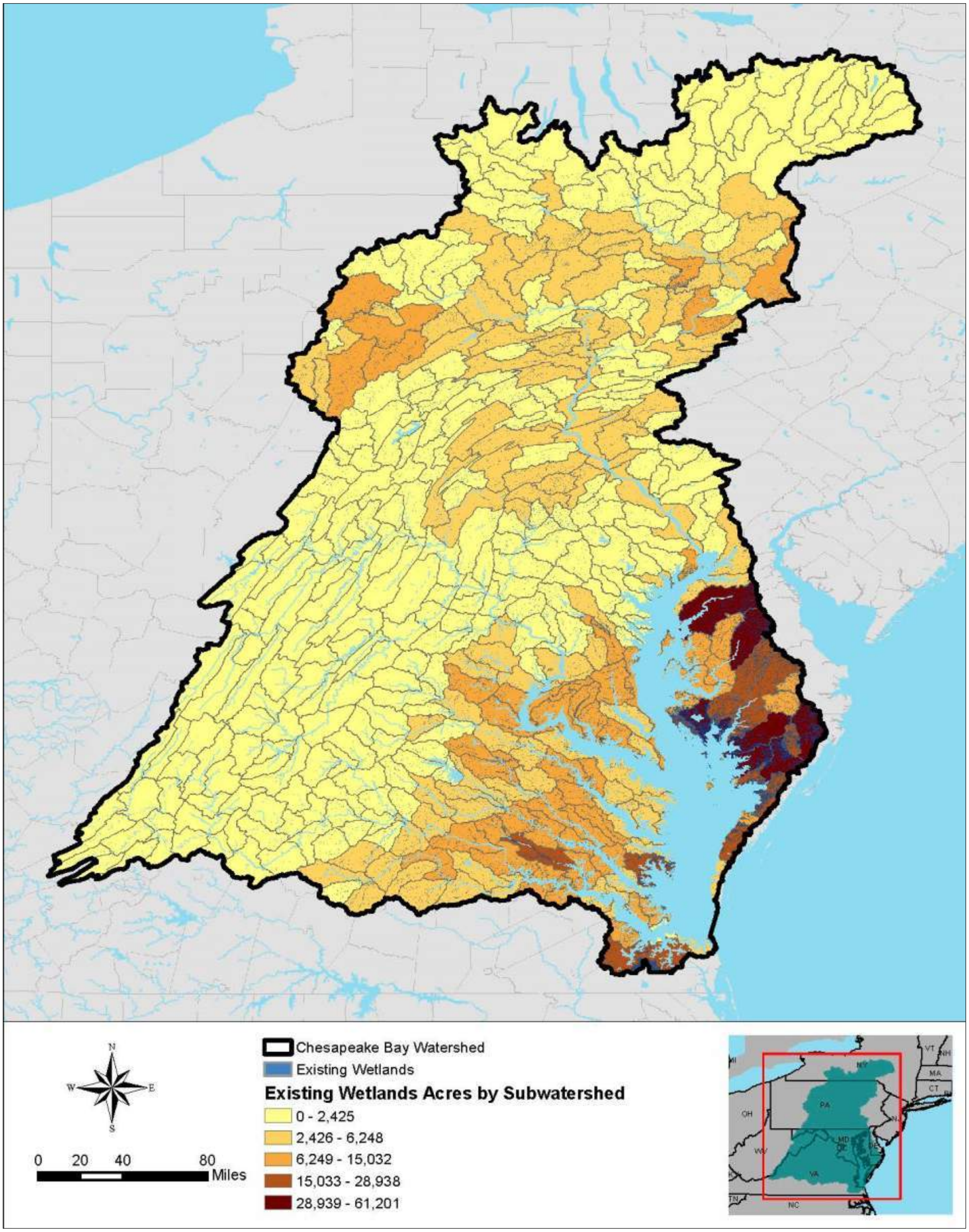


Figure 41. Combined tidal and nontidal wetlands enhancement *Opportunities*: Total acres by subwatershed (2-WR-F)

Key points:

1. The greatest nontidal wetland restoration opportunities are located in the lower Susquehanna River corridor in Pennsylvania, in subwatersheds on the upper Eastern Shore of Maryland and Delaware (Chester River, upper Choptank River, Marshyhope Creek, and upper Nanticoke River), middle Potomac River (Conococheague Creek, and Antietam Creek in Pennsylvania and Maryland, and Opequon Creek in Virginia and West Virginia), and North Fork Shenandoah in Virginia. There are broad opportunities through the upper Susquehanna River in New York and Pennsylvania, lower Susquehanna Watershed and upper Chesapeake Bay in Pennsylvania and Maryland, and scattered throughout western Virginia and into West Virginia.
2. The greatest tidal wetland restoration opportunities are located in the middle Eastern Shore of Maryland: Little Choptank River, Honga River, Blackwater River, and Transquaking River, followed by the lower Choptank River, Manokin River, and lower Tangier Bay in Maryland; Mobjack Bay and Back River in the lower Chesapeake Bay; and Pungoteague Creek in Virginia.
3. The combined wetland restoration opportunities analysis largely mimics the nontidal wetland restoration analysis.
4. The greatest magnitude of nontidal wetland enhancement opportunities (existing nontidal wetlands) is located on the Delmarva Peninsula in Maryland, Delaware, and Virginia. There are also opportunities to enhance wetlands in southern Virginia (middle Chickahominy River, Mobjack Bay, Nansemond River, and Elizabeth River).
5. Tidal wetland enhancement opportunities are centered in the Tangier Sound/Blackwater/Fishing Bay region of the Eastern Shore of Maryland extending to the northern subwatershed of Pocomoke Sound in Maryland and Virginia.
6. The combined wetland enhancement opportunity analysis largely mimics the nontidal wetland enhancement analysis.

2.7 Identify those wetland restoration opportunities that can benefit avian wildlife (2-WR-AV)

Overview: Identify wetland restoration opportunities that are important avian wildlife habitats and important toward efforts to meet the black duck outcome.

Data layers: Use the following data layers:

- Tidal and nontidal wetlands restoration opportunities – See previous section for description
- Nesting locations for wading birds and water birds – Description provided in Healthy/High-value Habitats Analysis (Center for Conservation Biology)
- CBP Black Duck Focus Areas – Description provided in Healthy/High-value Habitats Analysis

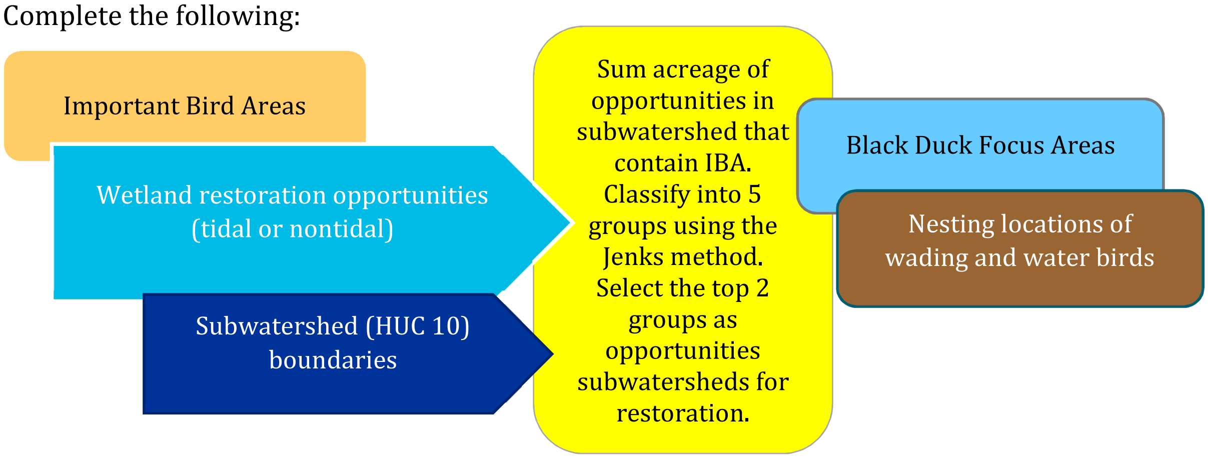
- Audubon Important Bird Areas – Description provided in Healthy/High-value Habitats Analysis

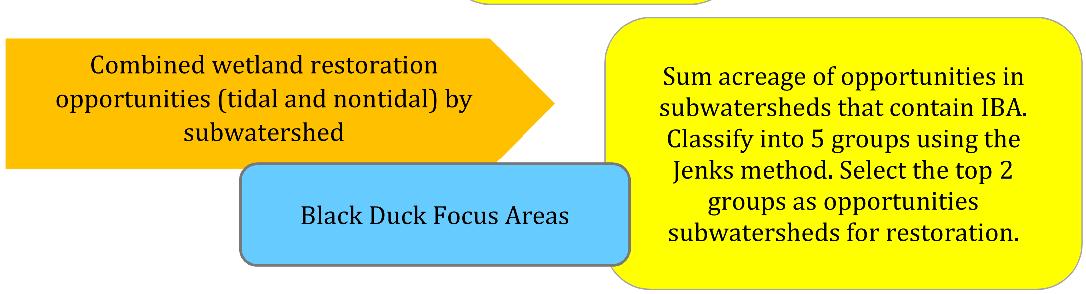
Conceptual diagram, computations, and opportunities selection: Two analyses were completed to evaluate potential benefits to avian wildlife through wetland restoration. The first considered how wetland restoration could be undertaken to provide broad avian benefits, and the second was focused on Black Duck habitat.

(1) Data that capture existing areas important to avian wildlife will be overlaid with wetland restoration opportunities to identify those opportunities that could be undertaken to benefit avian wildlife. Tidal and nontidal wetland restoration opportunities are considered independently (**Figures 42 and 43, respectively**). Initially, subwatersheds that contained IBA were selected. The acreage of wetland restoration (either tidal or nontidal) opportunities was summed for each of the selected subwatersheds, and the subwatersheds were classified using the Jenks method into five categories. The subwatersheds that contain Black Duck Focus Areas were overlaid in GIS on the IBA analysis. The point locations of nesting habitats for wading and water birds was inserted as a final layer. The final maps depict recognized avian wildlife resources in the watershed and the magnitude of wetland restoration opportunities in those subwatersheds for tidal and nontidal wetlands, respectively.

(2) Black Duck Focus Areas were overlaid with wetland restoration opportunities to identify where opportunities exist to increase wetland acreage to benefit black duck restoration efforts (**Figure 44**). Tidal and nontidal wetland restoration opportunities are combined in this analysis. The acreage of combined wetland restoration opportunities that overlapped with Black Duck Focus Areas was summed for each of the selected subwatershed, and the subwatershed were classified using the Jenks method into five categories. The highest two categories were defined as opportunities.

Complete the following:





Map product:

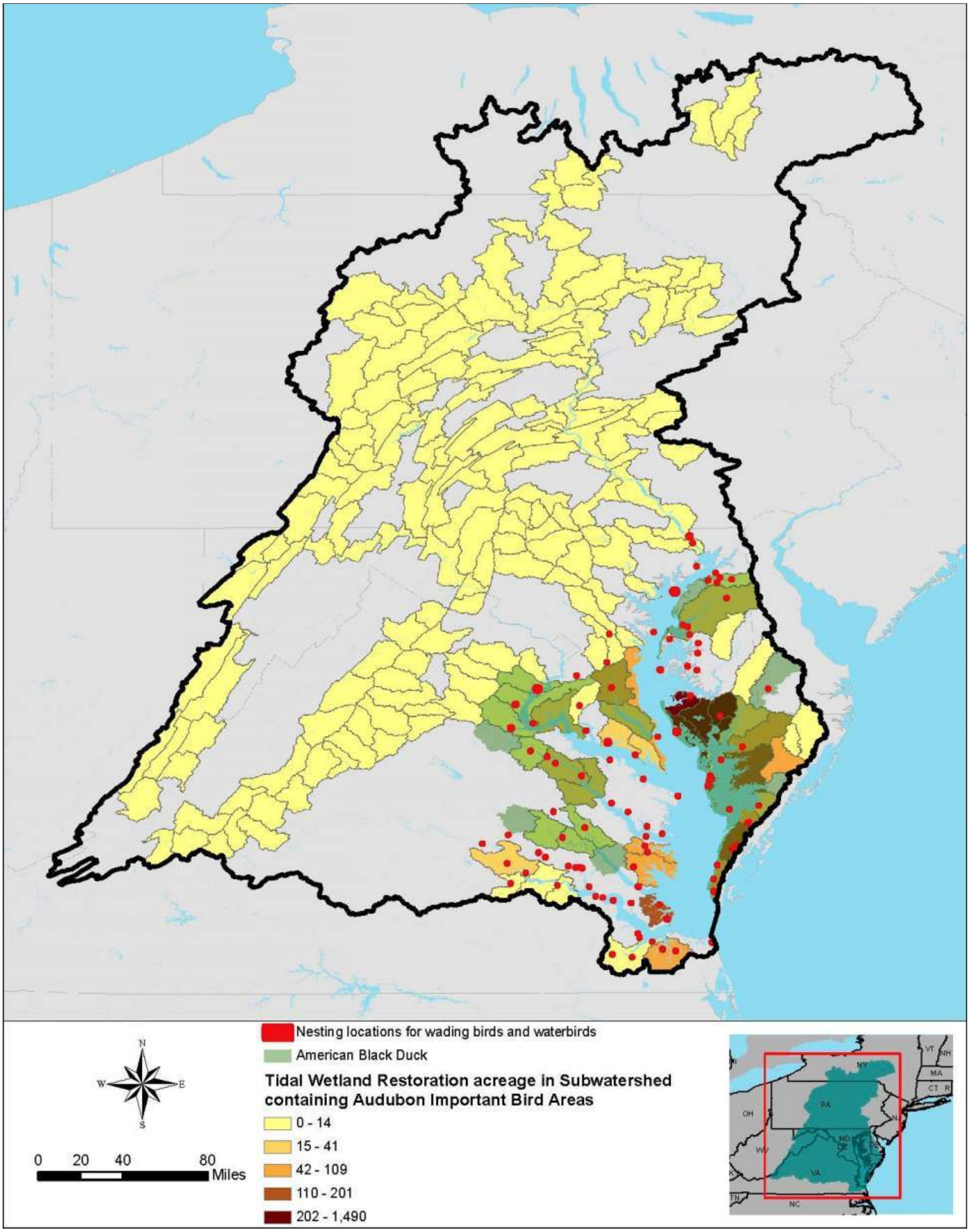


Figure 42. Tidal wetland restoration *Opportunities* to benefit avian wildlife analysis (2-WR-AV-A)

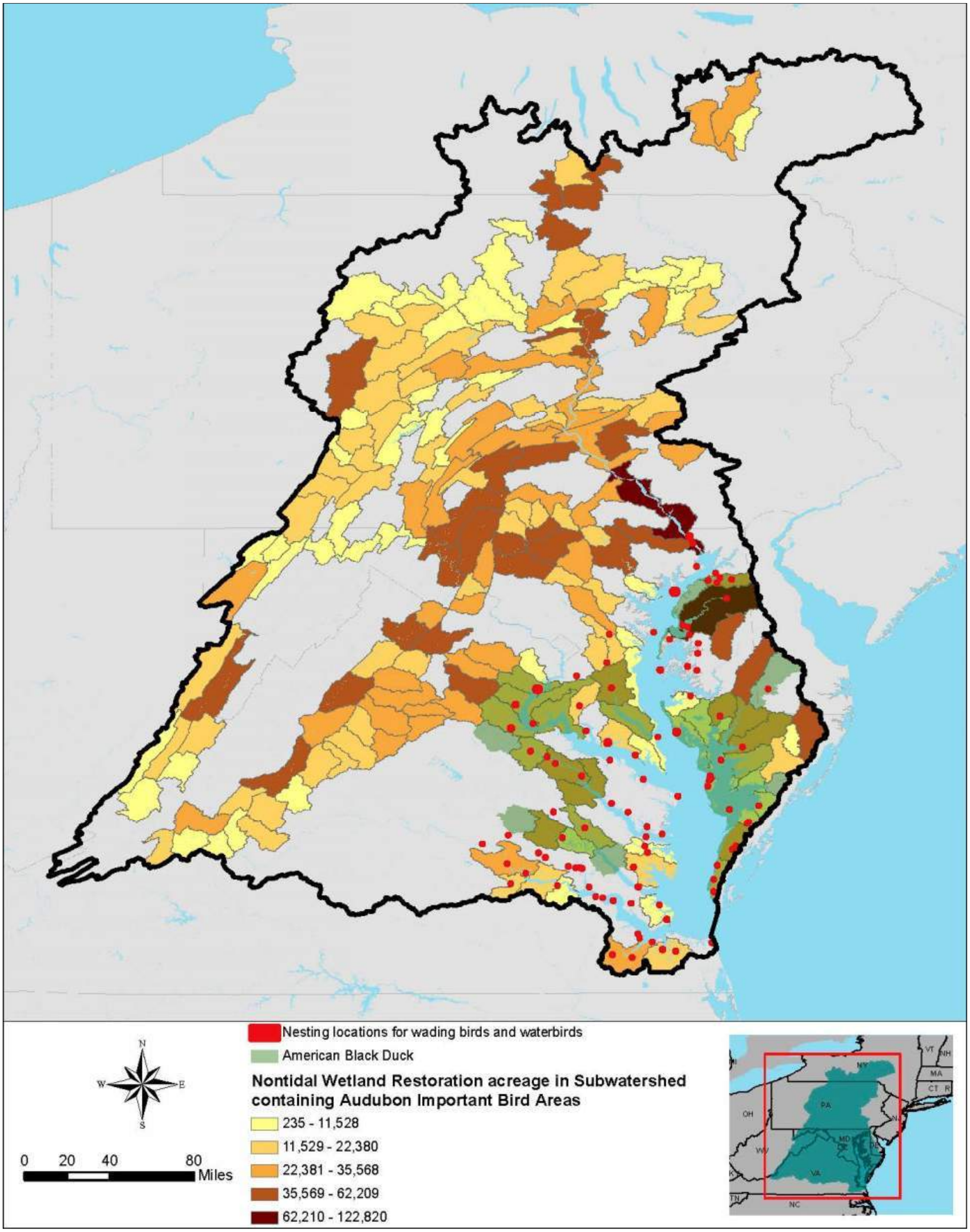


Figure 43. Nontidal wetland restoration *Opportunities* that benefit avian wildlife within subwatersheds (2-WR-AV-B)

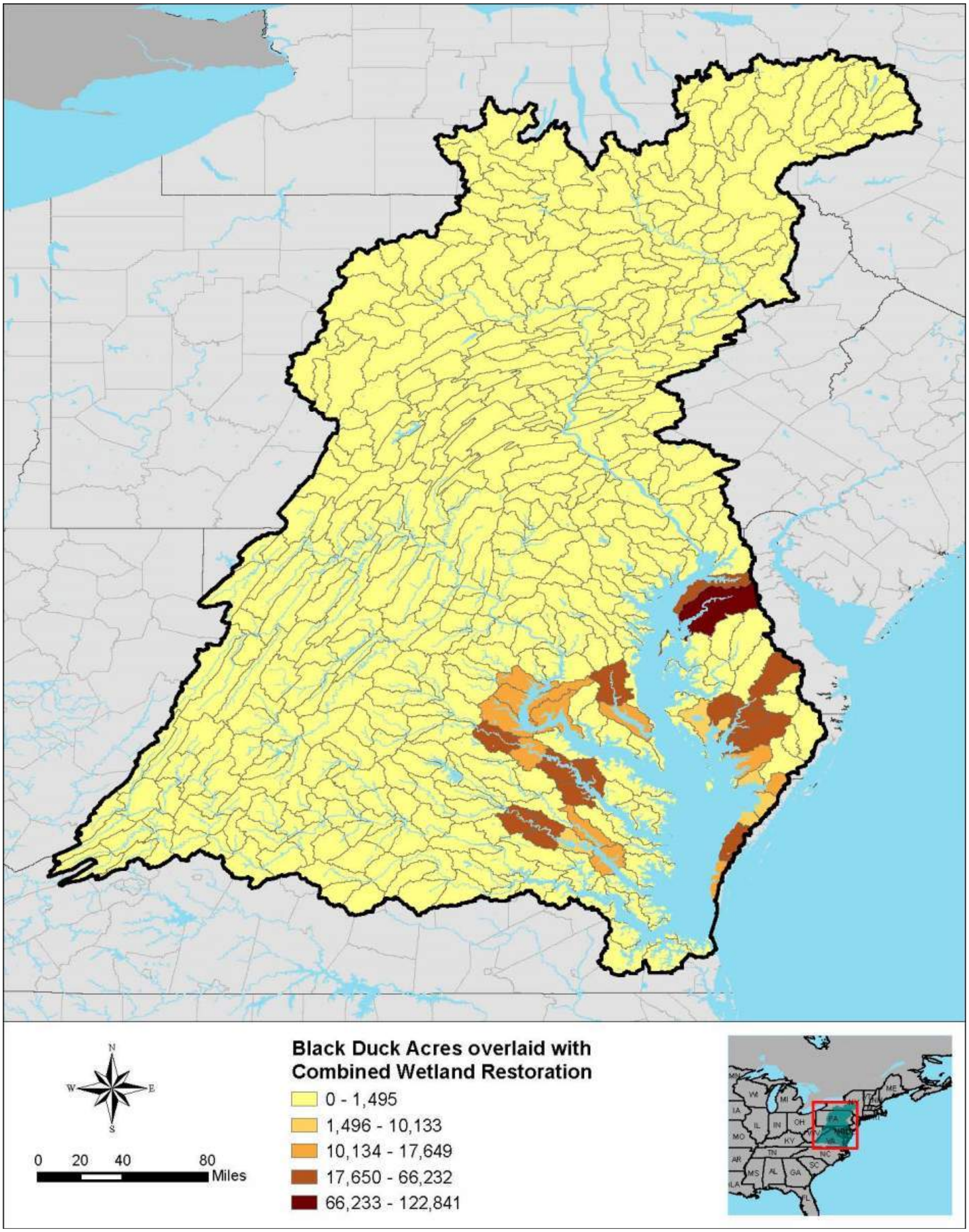


Figure 44. Wetland restoration *Opportunities* (tidal and nontidal combined) targeting Black Duck Focus Areas within subwatersheds (2-WR-AV-C)

There is a designation in the roadmap table for those subwatersheds that provide the opportunity to undertake wetland restoration to benefit avian species.

Key points:

1. The areas flanking the mainstem of Chesapeake Bay, and notably Delmarva Peninsula, provide subwatersheds with wetland restoration opportunities that overlap with the nesting water bird sites and potential black duck habitat.
2. There is a concentration of high opportunity for tidal wetland restoration to benefit avian wildlife on the central Eastern Shore of Maryland—Honga River, Blackwater River, Transquaking River, and Little Choptank River subwatersheds.
3. The Chester River and Susquehanna River subwatersheds provide the greatest overlap of nontidal wetland restoration opportunities with avian habitat resources.
4. There are nontidal wetland restoration opportunities in subwatersheds that contain only IBA in the middle Potomac along the Pennsylvania and Maryland border, throughout the lower Susquehanna River (PA), in the upper Chesapeake Bay and Tuckahoe Creek (MD), in Bald Cypress Branch – Pocomoke River and Marshyhope Creek (MD and DE), in the Chemung and Tioga River subwatersheds (NY and PA), and subwatersheds in the Potomac River Watershed (VA and WV).
5. If looking only at black duck benefits, there are areas of high opportunity in the upstream portions of the York and Rappahannock rivers (VA), Chester River (MD), Nanticoke River (MD), Wicomico River (MD), Transquaking River (MD), and Pungoteague Creek (lower Chesapeake Bay [VA]).

2.8 Identify those wetland restoration opportunities that can benefit imperiled species (2-WR-IMP)

Overview: Identify wetland restoration opportunities that are important habitats for imperiled species.

Data layers: Use the following data layers:

- Tidal and nontidal wetlands restoration and enhancement compilation – Product of previous section.
- Nature's Network imperiled species dataset – The imperiled species dataset identifies important, moderately important, and less important habitat for imperiled species.

Conceptual diagram, and computations, and opportunities selection: Data that capture habitats important to imperiled species will be overlaid with tidal and nontidal wetland restoration and enhancement opportunities to depict where those opportunities could be undertaken to benefit imperiled species. This analysis generated four maps: (1) tidal restoration (**Figure 45**), (2) tidal enhancement (existing wetlands) (**Figure 46**), (3) nontidal restoration (**Figure 47**), and (4) nontidal enhancement (existing wetlands) (**Figure 48**). The imperiled species habitat data was not available in a format that could be manipulated. Therefore, a visual was generated that portrayed the wetlands restoration and enhancement data overlaid with the imperiled species data, but no computations were performed. Regions were visually identified and circled on the map to highlight areas of high overlap.

Complete the following for both tidal and nontidal:

Map product:

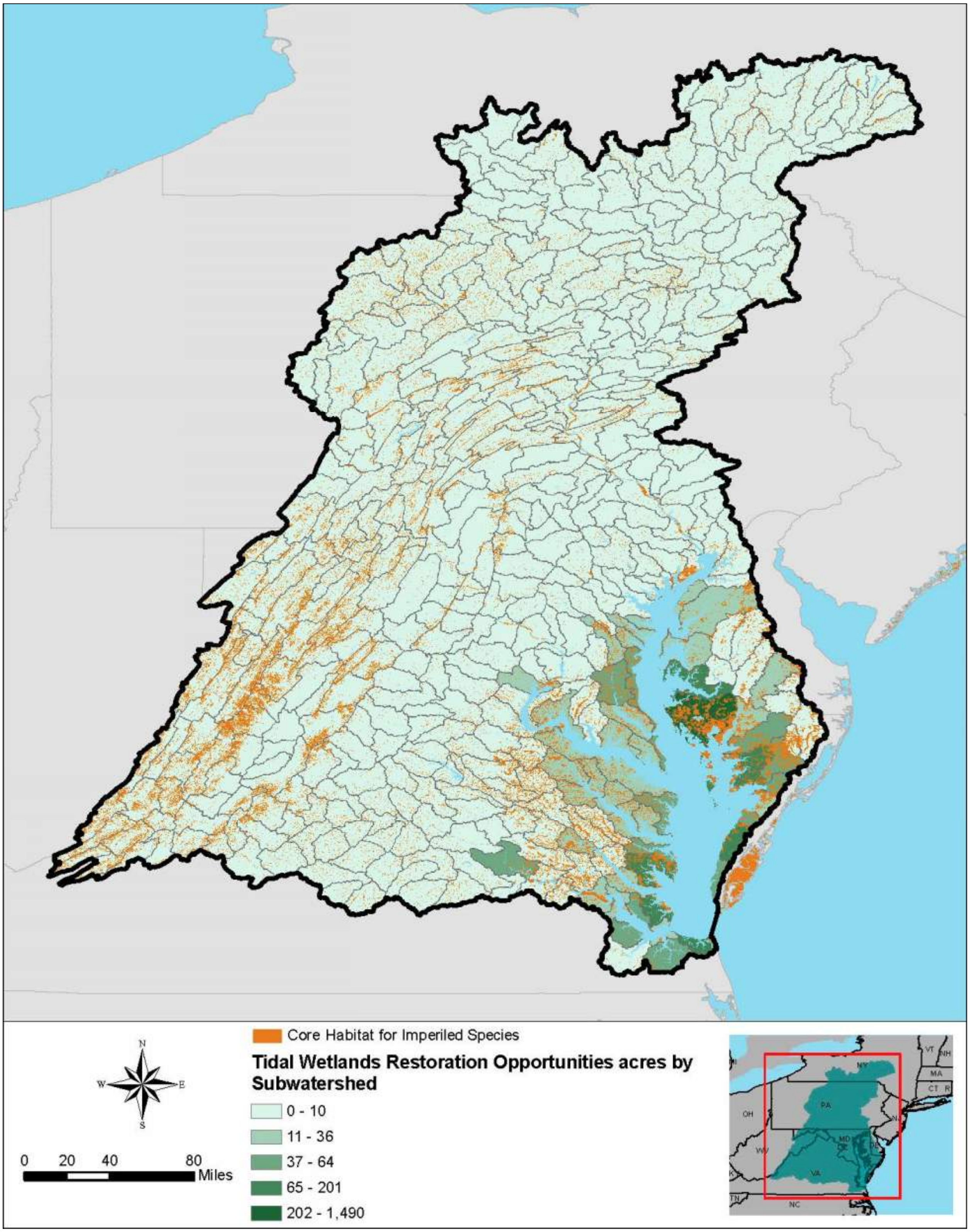


Figure 45. Overlap of imperiled species habitat and tidal wetland restoration *Opportunities* (2-WR-IMP-A)

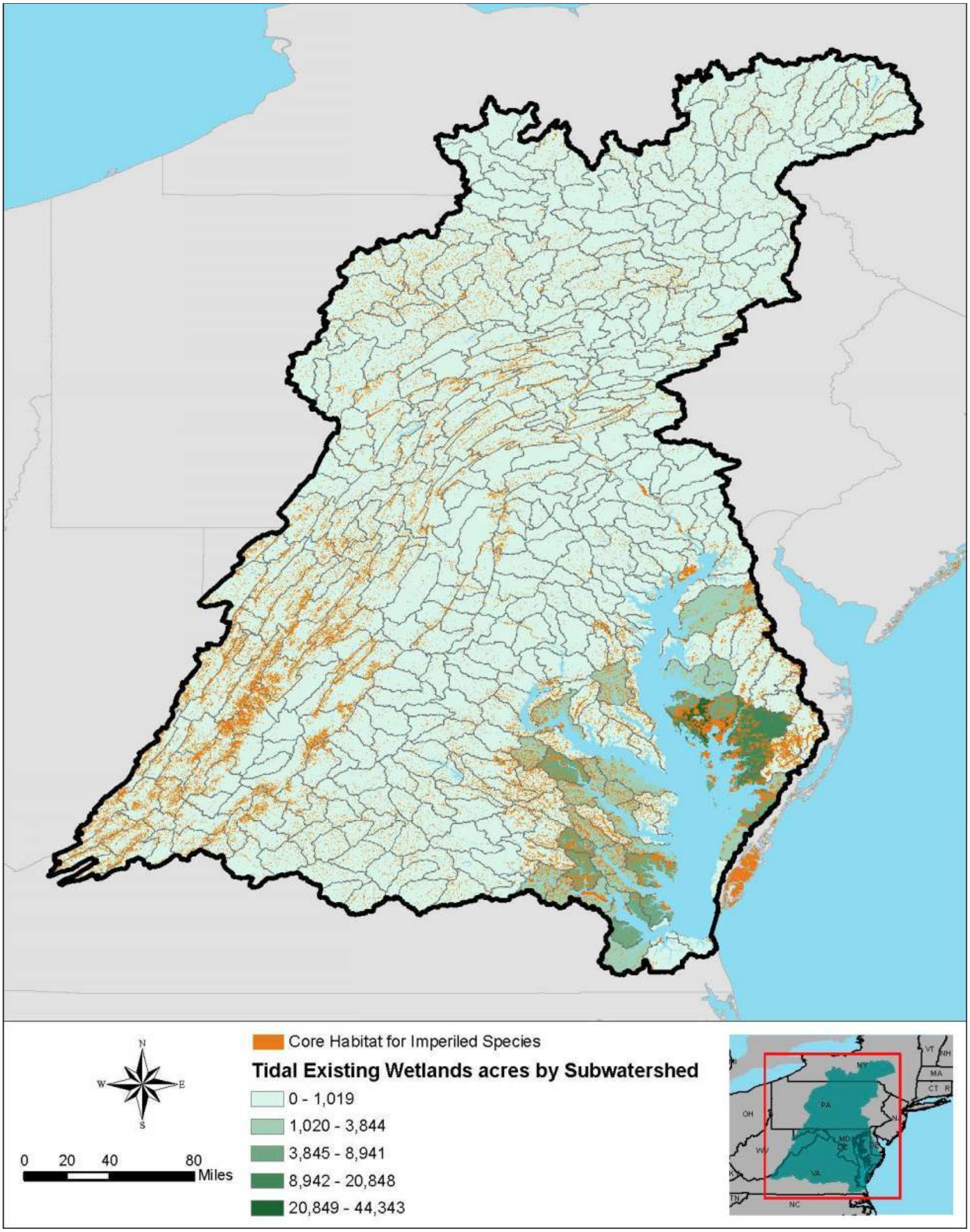


Figure 46. Overlap of imperiled species habitat and tidal wetland enhancement *Opportunities* (2-WR-IMP-B)

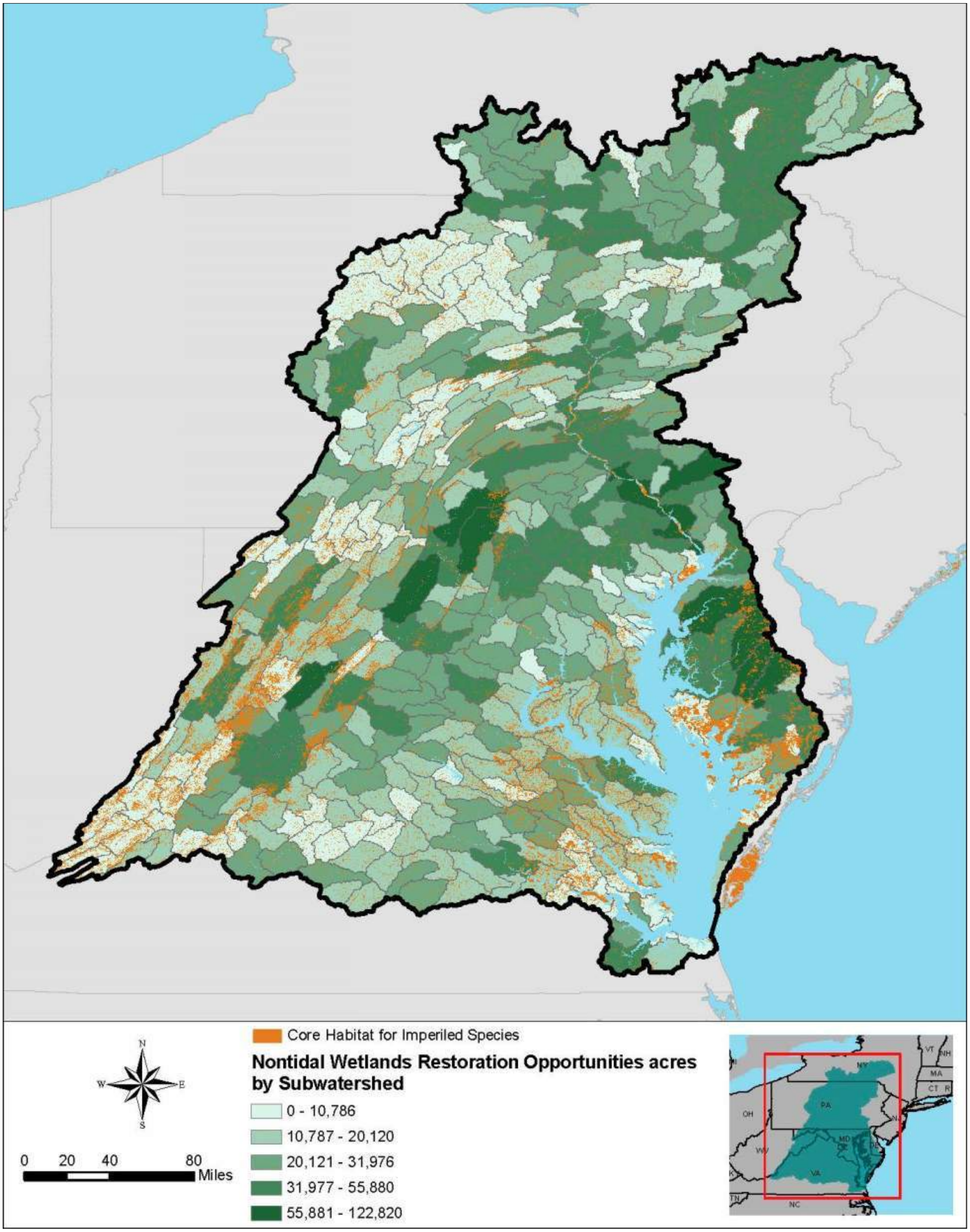


Figure 47. Overlap of imperiled species habitat and nontidal wetland restoration *Opportunities* (2-WR-IMP-C)

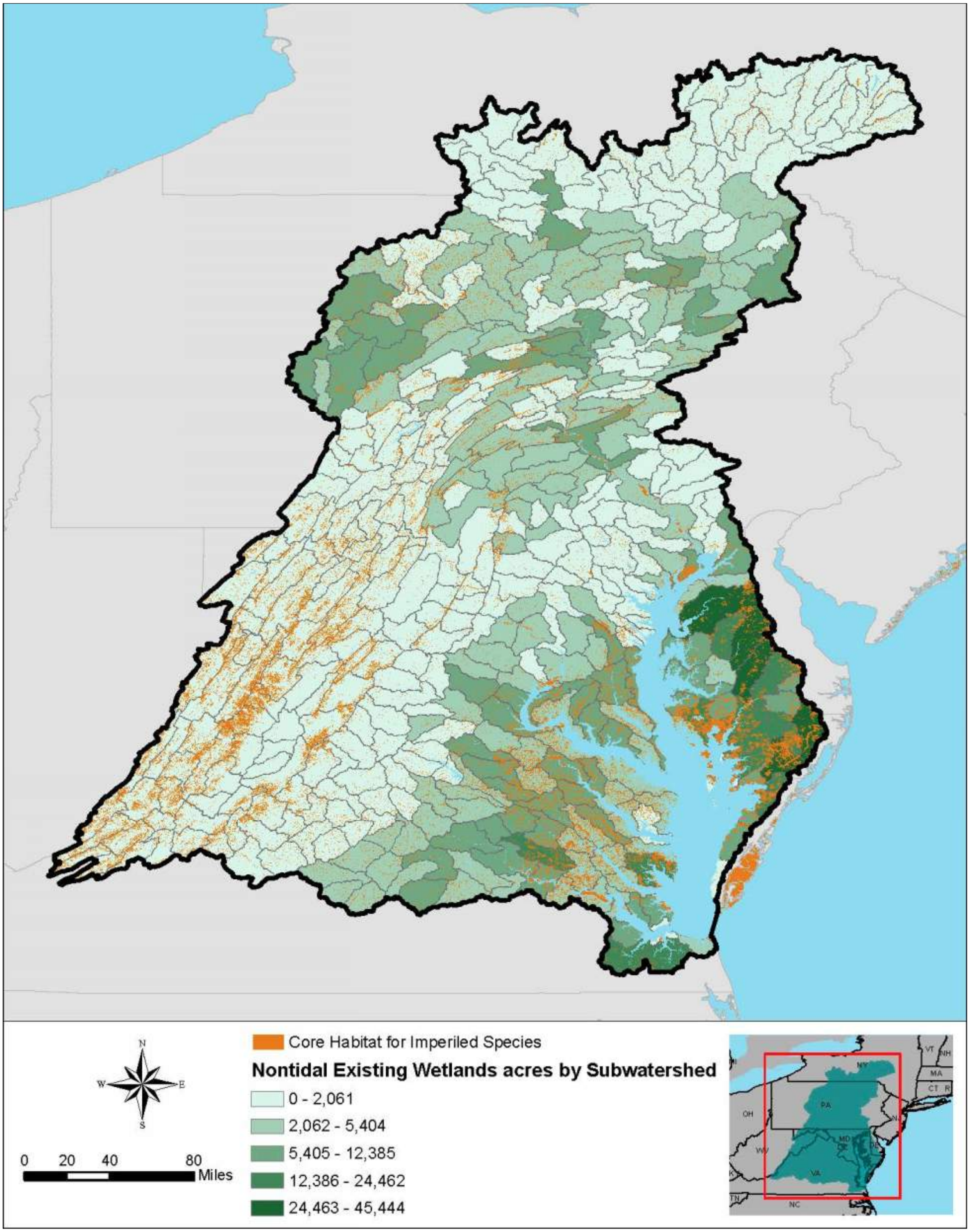


Figure 48. Overlap of imperiled species habitat and nontidal wetland enhancement *Opportunities* (2-WR-IMP-D)

Key points:

1. Tidal opportunities to address wetland restoration or enhancement with considerations for imperiled species habitat are concentrated (1) on the middle to lower Eastern Shore on Maryland from Little Choptank River through the subwatershed bounding Tangier Sound and (2) in Virginia in the subwatershed bounding Chesapeake Bay near its mouth, particularly in the James River and York River Watersheds.

2. Nontidal opportunities to address wetland restoration or enhancement with considerations of imperiled species habitat can be found throughout the watershed. There are some concentrated areas on the Delmarva Peninsula, upper and lower Susquehanna River Watersheds, and some subwatersheds in the western portions of the Potomac River.

2.9 Identify where potential wetland restoration projects exist that provide an opportunity to beneficially use dredged material (2-WR-NAV)

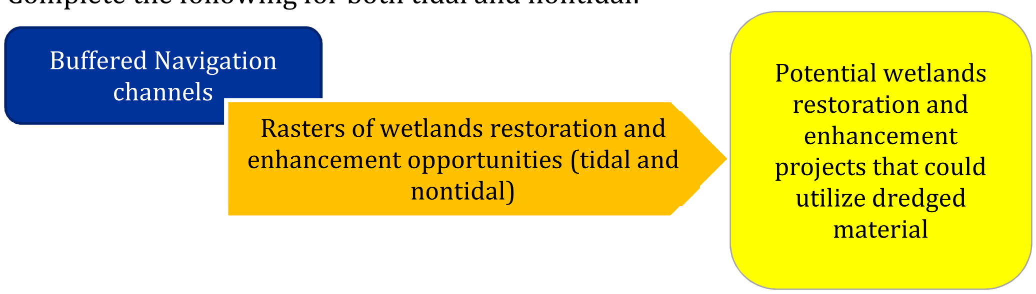
Overview: Evaluate where USACE navigation projects are located with respect to wetland restoration and enhancement opportunities in order to identify wetland restoration and enhancement opportunities that could incorporate dredged material.

Data layers:

- *USACE navigation projects* – Dredged channels (not including the Chesapeake and Delaware Canal approach channels)
- *Tidal and nontidal wetlands restoration and enhancement opportunities* – Products of previous section

Conceptual diagram and computations: A layer was created that placed a 3 mile buffer on existing USACE federal navigation channels. This identifies areas that are located within 3 miles of a federal navigation channel. Three miles represent the limits of pumping dredged material cost-effectively. Any placement of dredged material from a channel would be confined to that 3 mile buffer. In GIS, overlay the wetlands restoration and enhancement (raster) analyses with the buffered navigation channels layer. Complete this overlay once for tidal wetlands and once for nontidal wetlands (**Figures 49 and 50, respectively**). This identifies potential restoration projects that could utilize beneficial dredged material for each navigation project.

Complete the following for both tidal and nontidal:



Map product:

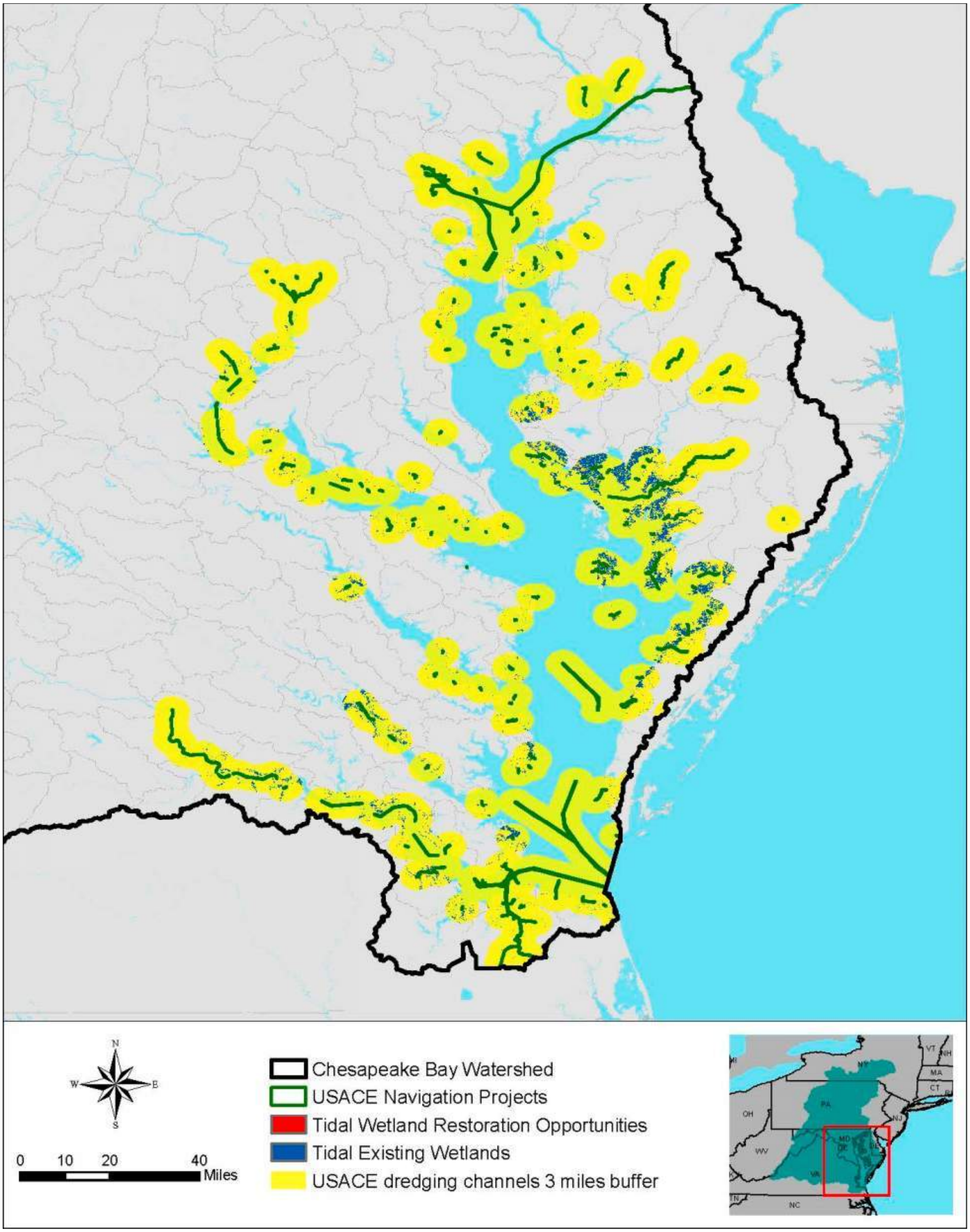


Figure 49. *Opportunities* for using dredged material to restore and enhance tidal wetlands (2-WR-NAV-A)

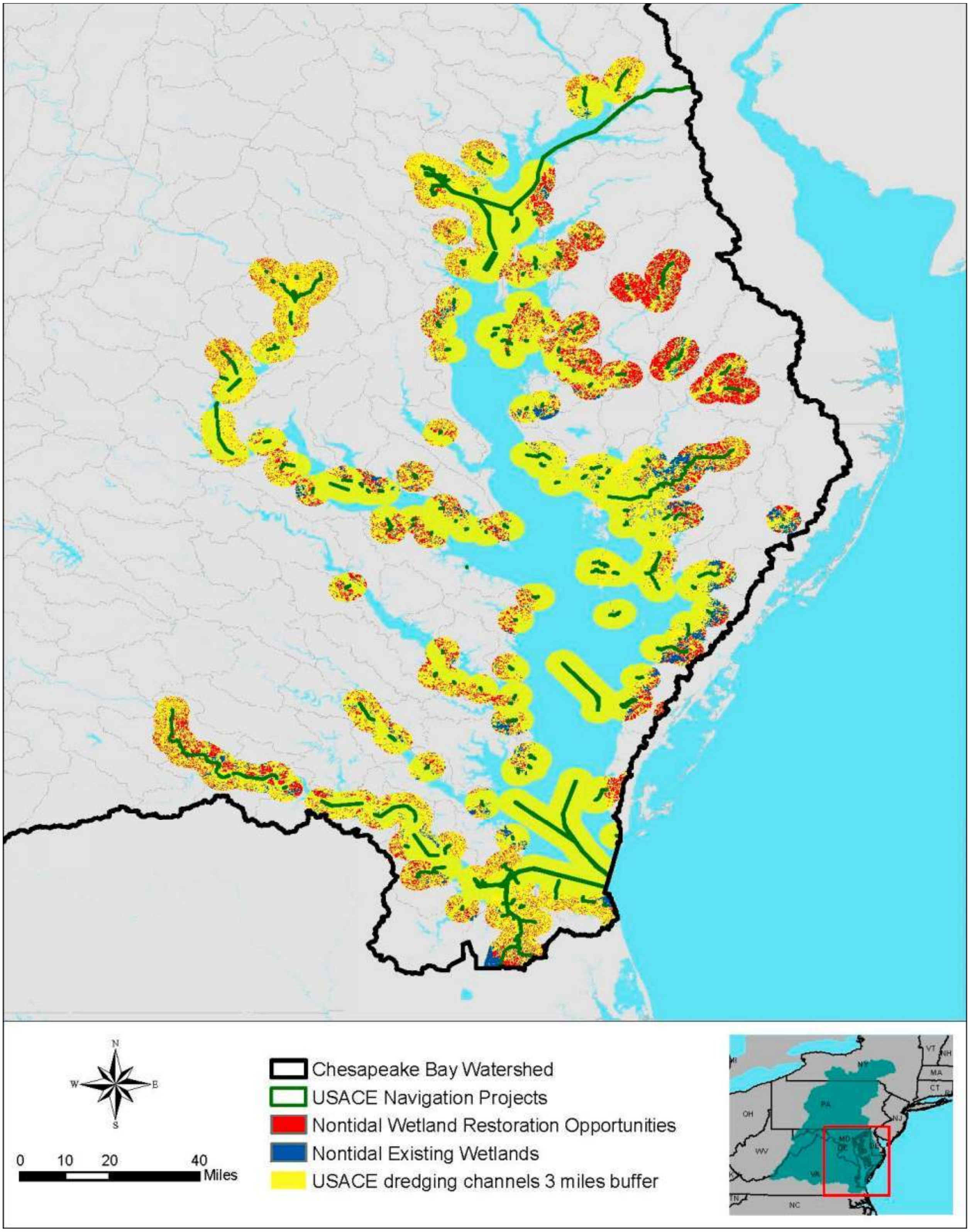


Figure 50. ***Opportunities*** **for utilizing dredged material to restore and enhance nontidal wetlands. (2-WR-NAV-B)**

Key points:

1. There are broad opportunities to use dredged material for wetland restoration and enhancement.
2. The Tangier Sound/Blackwater region on the lower Eastern Shore of Maryland is a prime area to incorporate dredged material into tidal and nontidal wetland restoration projects.
3. Channels dredged at the head of rivers provide significant opportunities to use dredged material to restore nontidal wetlands, particularly in the Potomac, James, Choptank, Wicomico, and Nanticoke river systems.

2.10 Threats analysis of wetlands (2-WR-TH)

Overview: Investigate whether the proposed wetland restoration opportunities are at risk to climate change, anticipated increases in flooding and coastal storms, and projected development in the watershed. Incorporate the Threats Analysis results with restoration opportunities and existing wetlands to understand habitats that may be lost or impaired by future threats.

Data layers:

- *Threats Analysis*
- *Wetlands restoration and enhancement compilation* – Product of previous section

Conceptual diagram and computations: Analyses are completed on the pixel scale as raster data is used.

Nontidal Threats

To identify those areas where potential wetland restoration and enhancement sites would be at risk of flooding, future projected development, and degradation, wetland restoration and enhancement opportunities were overlaid with the nontidal flooding risk layer, NACCS future projected development layer, and national fish habitat assessment layer.

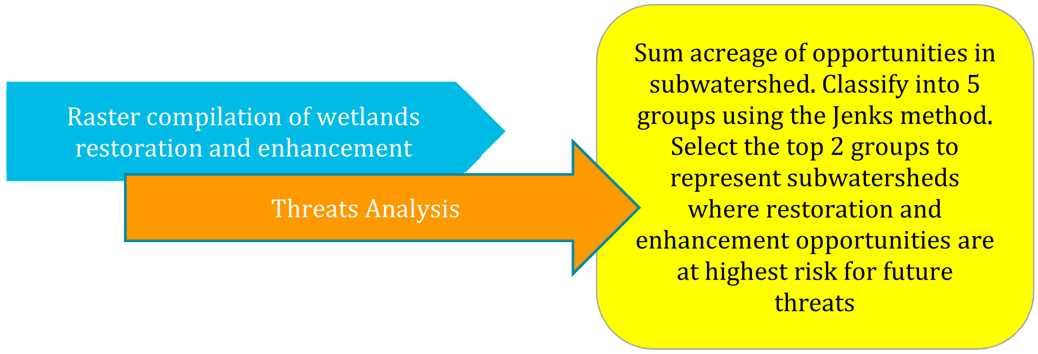
Tidal Threats

To identify those areas where potential tidal wetland restoration and enhancement sites would be threatened by urbanization and climate change including sea level rise and increased/persistent flooding in the future, wetland restoration and enhancement opportunities were overlaid with the following layers: Coastal Vulnerability Index (the Watershed Degradation Analysis that was developed for this study), USACE Sea Level Rise Curves (Year 2100), More Frequent than Normal Flooding (USGS Digital Elevation Model), Resources at Risk to Coastal Storms (NACCS Composite Risk Index), and Future Projected Development (NACCS).

For wetland restoration, overlay in GIS the compiled (nontidal and tidal) wetlands restoration analysis with (1) nontidal threats analysis and (2) tidal threat analysis. For wetland enhancement, overlay in GIS the compiled (nontidal and tidal) wetlands enhancement analysis with (1) nontidal threats analysis and (2) tidal threat analysis. The acreage where a pixel held both restoration/ enhancement opportunity and a threat were totaled for each subwatershed.

The total acreage of overlap was classified into five groups using the Jenks method in ArcGIS. The top two groups of watersheds based on acreage are identified as *Opportunities*.

Complete the following for nontidal and tidal:



This analysis generated four maps: (1) nontidal restoration (**Figure 51**), (2) nontidal enhancement (**Figure 52**), (3) tidal restoration (**Figure 53**), and (4) tidal enhancement (**Figure 54**). **Tables 5 - 8** summarize the *Opportunities* depicted in each map.

Map products:

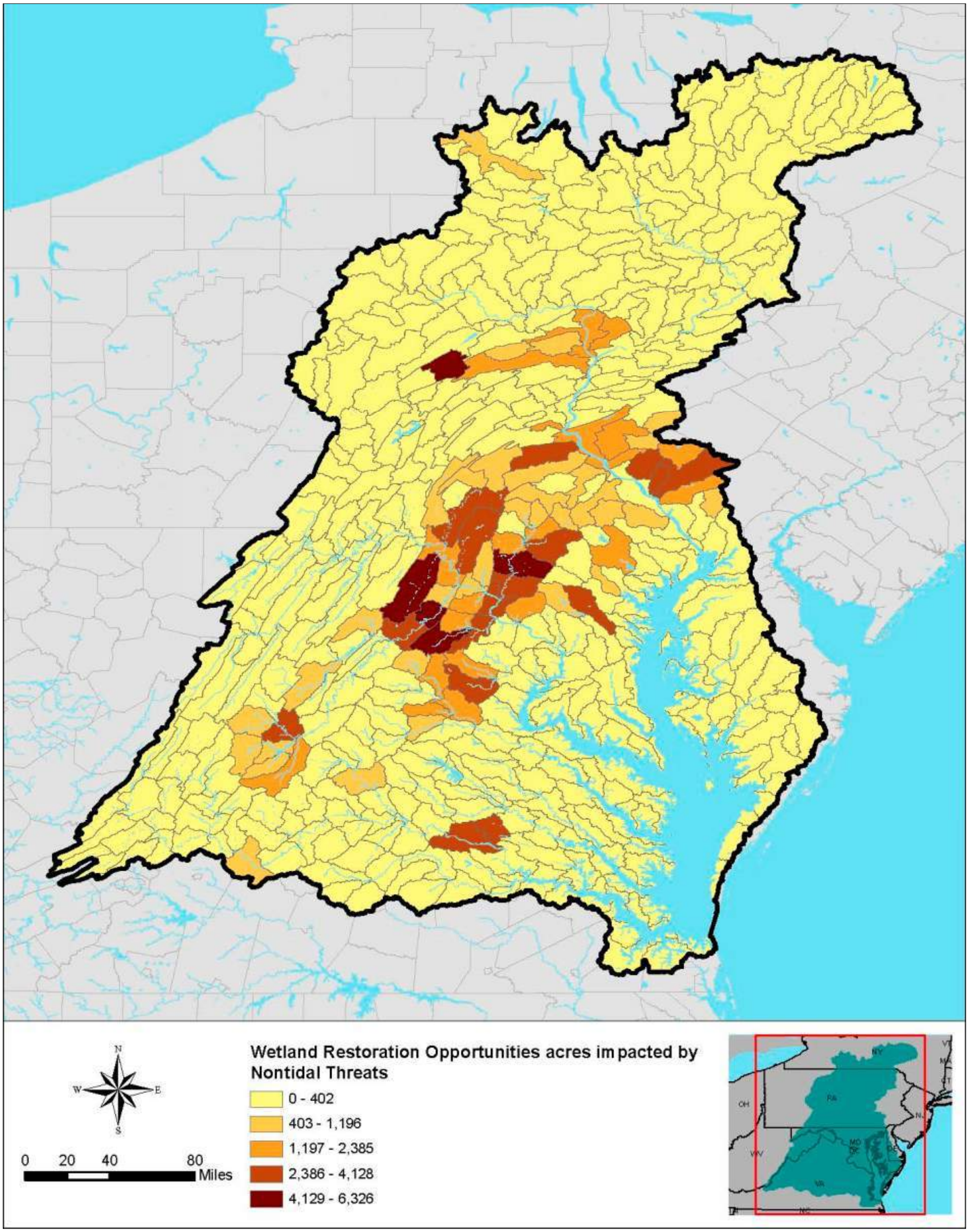


Figure 51. Wetland restoration *Opportunities* at risk to nontidal threats (2-WR-TH-A)

Table 5. *Opportunities* identified for wetland restoration opportunities at risk to nontidal threats.

NAME	TOTAL HUC ACRES	STATES	RESTORATION OPPORTUNITIES ACRES AT RISK TO FUTURE THREATS
Spring Creek	93,415	PA	6,326
Opequon Creek	185,005	VA, WV	5,442
Middle Monocacy River	132,401	MD	5,206
Upper Goose Creek	107,841	VA	5,151
Long Marsh Run-Shenandoah River	53,385	VA	4,604
Little Patuxent River	103,420	MD	4,128
Conestoga River	172,279	PA	4,049
Lower North River	96,346	VA	3,928
Tuckahoe Creek-James River	149,173	VA	3,481
Lower Monocacy River	98,502	MD	3,384
Lower Goose Creek	76,691	VA	3,350
Upper Chickahominy River	68,064	VA	3,320
Double Pipe Creek	123,438	MD	3,081
Crooked Run-Shenandoah River	105,208	VA	3,055
Tuscarora Creek-Potomac River	76,876	MD	2,974
Chiques Creek	80,666	PA	2,943
Antietam Creek	186,136	MD, PA	2,912
Cedar Run	125,378	VA	2,819
Little Conestoga Creek	41,939	PA	2,769
Conococheague Creek	178,126	MD, PA	2,677
Lower Conodoguinet Creek	122,556	PA	2,488

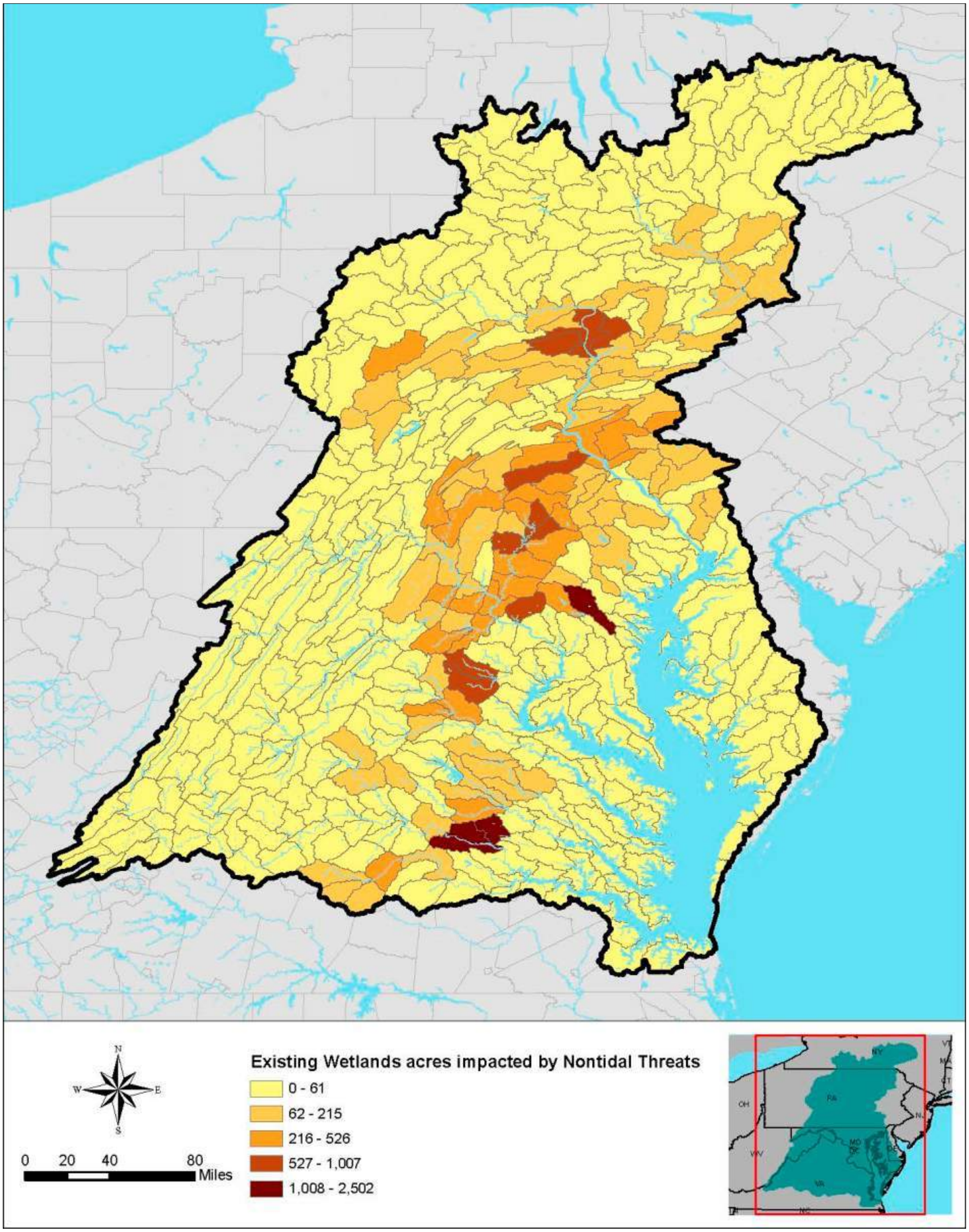


Figure 52. Wetland enhancement *Opportunities* at risk to nontidal threats (2-WR-TH-B)

Table 6. *Opportunities* identified for wetland enhancement opportunities at risk to nontidal threats.

NAME	TOTAL SUBWATERSHED ACRES	STATES	ENHANCEMENT OPPORTUNITIES ACRES AT RISK TO FUTURE THREATS
Upper Chickahominy River	68,064	VA	2,502
Little Patuxent River	103,420	MD	1,806
Tuckahoe Creek-James River	149,173	VA	1,787
Chillisquaque Creek	71,548	PA	1,007
Seneca Creek	82,919	MD	926
West Branch Susquehanna River	143,037	PA	917
Cedar Run	125,378	VA	692
Buffalo Creek	85,470	PA	680
Rock Creek	40,620	MD, PA	629
Broad Run	88,697	VA	620
Yellow Breeches Creek	139,522	PA	606
Upper Monocacy River	117,333	MD	598

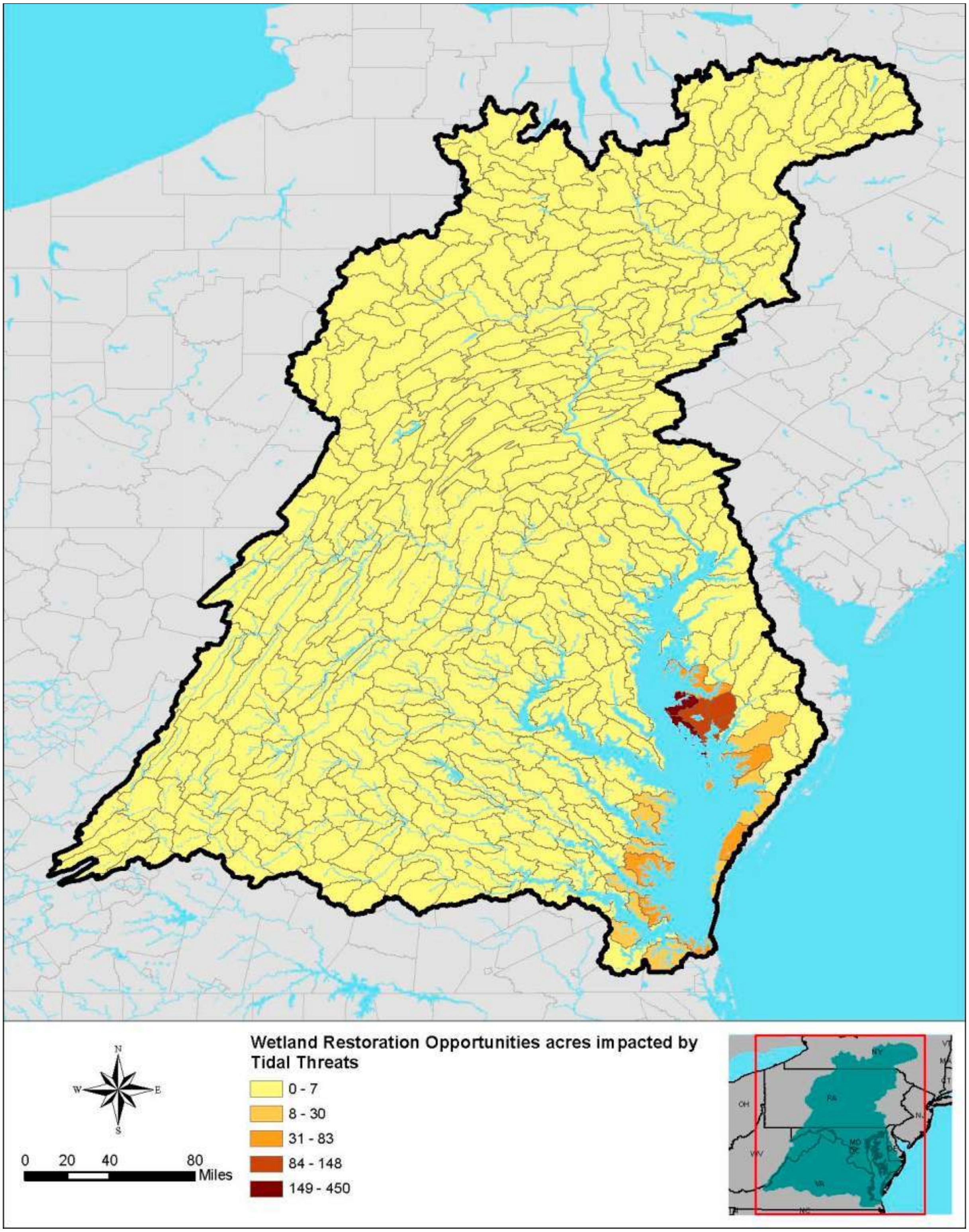


Figure 53. Wetland restoration *Opportunities* at risk to tidal threats (2-WR-TH-C)

Table 7. *Opportunities* identified for wetland restoration opportunities at risk to tidal threats

NAME	TOTAL HUC ACRES	STATES	RESTORATION OPPORTUNITIES ACRES AT RISK TO FUTURE THREATS
Honga River-Chesapeake Bay	107,814	MD	450
Little Choptank River	60,756	MD	326
Blackwater River	123,617	MD	148
Transquaking River	72,680	MD	108

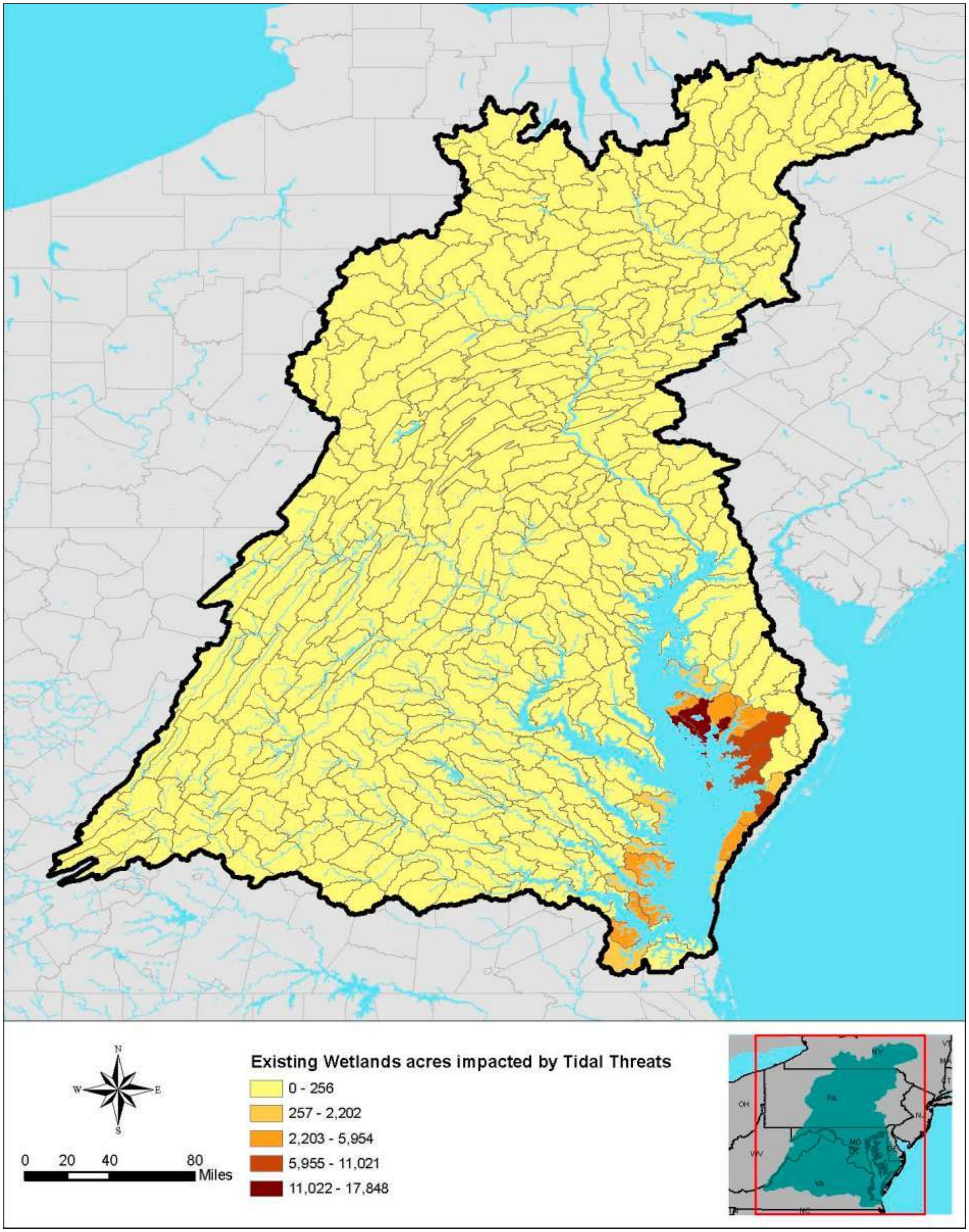


Figure 54. Wetland enhancement *Opportunities* at risk to tidal threats (2-WR-TH-D)

Table 8. *Opportunities* identified for wetland enhancement opportunities at risk to tidal threats.

NAME	TOTAL HUC ACRES	STATES	ENHANCEMENT OPPORTUNITIES ACRES AT RISK TO FUTURE THREATS
Blackwater River	123,617	MD	17,848
Honga River-Chesapeake Bay	107,814	MD	16,709
Manokin River	106,542	MD	11,021
Marumsco Creek-Pocomoke Sound	12,010	MD, VA	8,407
Wicomico River	147,430	DE, MD	8,094
Lower Tangier Sound	59,201	MD, VA	7,096
Messongo Creek-Pocomoke Sound	62,512	VA	6,977

Key points:

1. Wetland restoration in the central portion of the Chesapeake Bay Watershed are at greatest risk to future nontidal threats. These subwatersheds are primarily located in the lower Susquehanna River, upper Chesapeake Bay (western shore), and middle Potomac River basins. There are also subwatersheds of concern spread across the Chesapeake Bay watershed: middle Pamunkey River, lower North River in the upper Potomac River, Middle Chickahominy River of the James River, and Spring Creek in West Branch Susquehanna River.

2. Wetland restoration opportunities along the mainstem of the bay shore in Virginia and from the Choptank River south on the eastern shore of Maryland are at greatest risk to future tidal threats.

3. Wetland enhancement opportunities at risk to future nontidal threat are positioned along the divide between tidal and nontidal threats from northern Pennsylvania south into the James River Watershed of Virginia. The subwatersheds at greatest risk are West Branch Susquehanna, Buffalo Creek (PA), Chillisquaque Creek (PA), Yellow Breeches (PA), upper Monocacy River (MD), and Rock Creek (MD), Little Patuxent (MD), Seneca Creek (MD), Cedar Run (VA), Broad Run (VA), Middle Pamunkey River (VA), and middle Chickahominy River (VA).

4. Wetland enhancement opportunities at risk to future tidal threat are indicative of where the existing wetland resources are concentrated – lower Eastern Shore of Maryland and Virginia south of the Little Choptank River and the western shore of Chesapeake Bay in Virginia.

2.10.1 Connectivity

(3) Where do opportunities exist to improve habitat connectivity and human connectivity to healthy habitats?

This series of questions is focused on identifying opportunities within the watershed to improve habitat connectivity by considering fish passage blockages, existing healthy habitat locations, and their relation to proposed restoration opportunities, as well as risks to those resource from future threats.

2.11 Where are current healthy habitats at risk to future threats (3-CNT-HHVH)

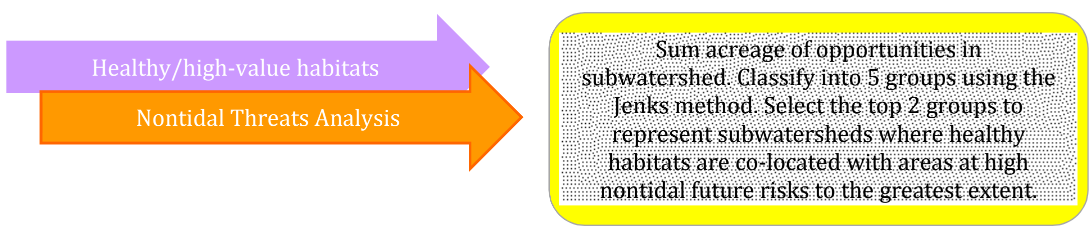
Overview: Evaluate whether existing healthy habitats analysis are at risk to future threats to climate change, anticipated increases in flooding and coastal storms, and projected development in the watershed.

Data layers:

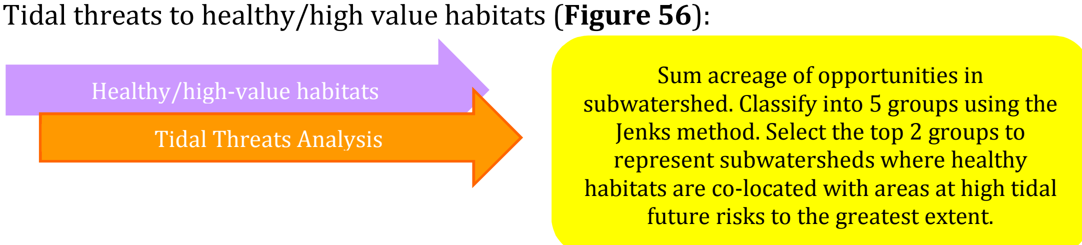
- *Healthy/High-value Habitats Analysis*
- *Threats Analysis*

Conceptual diagram, computations, and opportunities selection: Analyses are completed on the pixel scale as raster data is used. A separate analysis was completed to evaluate tidal threats and nontidal threats. For nontidal threats, overlay in GIS the healthy habitat analysis and the nontidal threat analysis. Identify if a given pixel contains a healthy habitat and is positive for a nontidal threat. For each subwatershed, sum the area covered by pixels that contain healthy habitat and a nontidal threat. Based on the total acreage in a subwatershed, classify the subwatershed into 5 categories using the Jenks method in ArcGIS. The top 2 groups of subwatersheds based on acreage are identified as *Opportunities*. Repeat this process using the tidal threats data layer rather than the nontidal threats.

Nontidal threats to healthy/high-value habitats (**Figure 55**):



Tidal threats to healthy/high value habitats (**Figure 56**):



Map products:

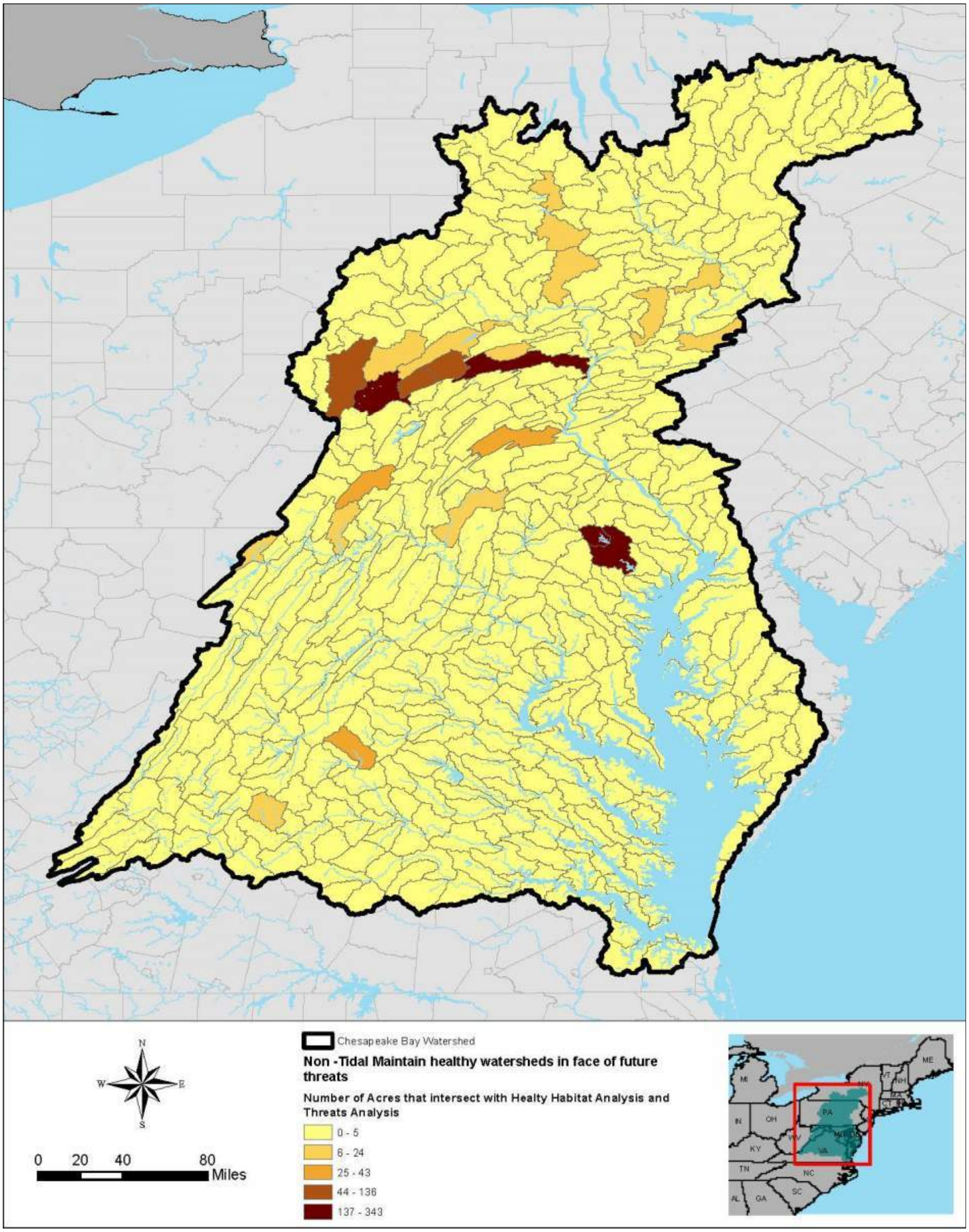


Figure 55. Healthy/high-value habitat at risk to nontidal threats (3-CNT- HHVH-A)

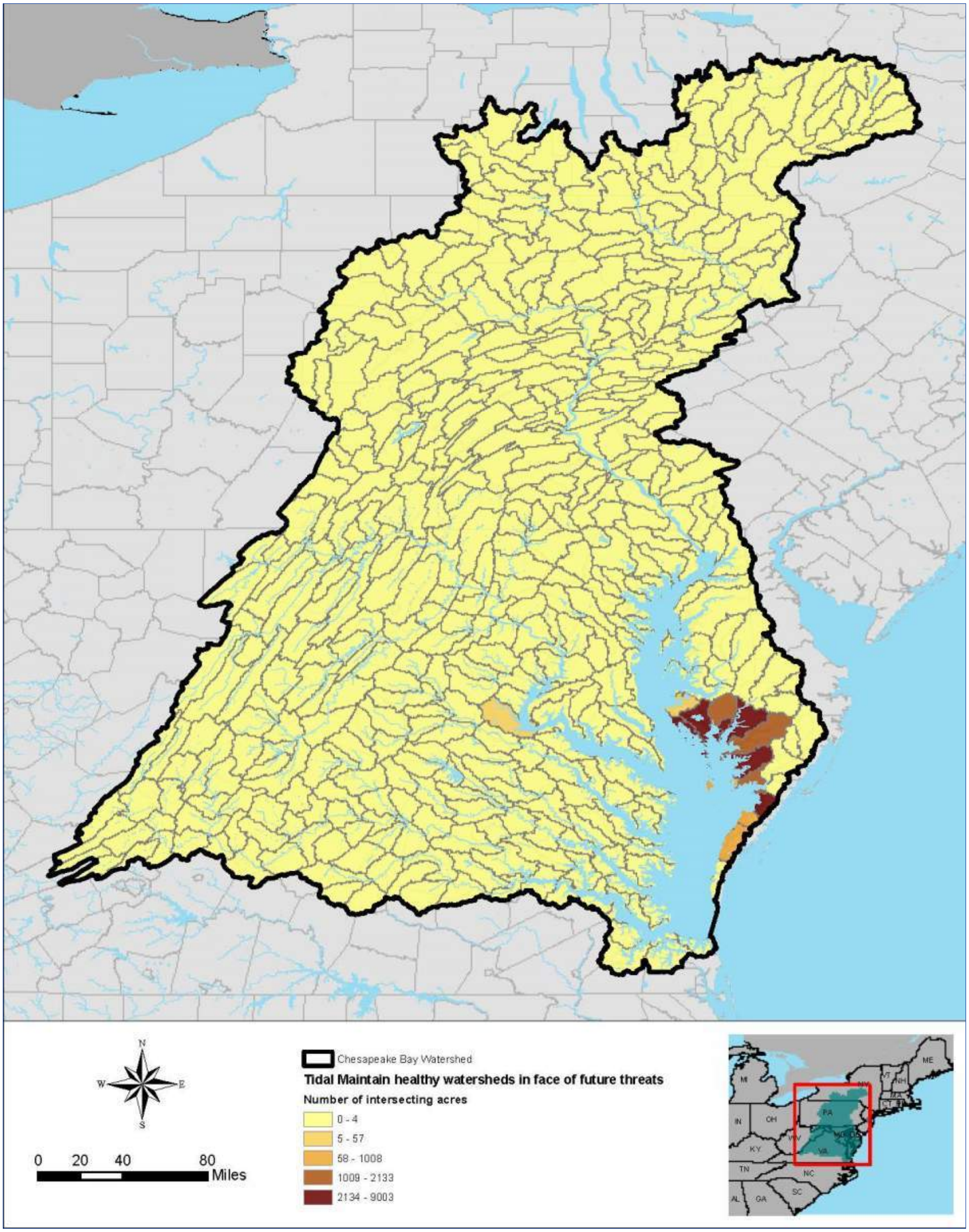


Figure 56. Healthy/high-value habitat at risk to tidal threats (3-CNT- HHVH-B)

Key points:

1. Healthy/high-value habitat facing nontidal threats are primarily in Pennsylvania:

a) Subwatersheds in the northern portion of the Juniata River sub-basin (Clearfield Creek, Little Juniata, Spruce Creek, and Spring Creek)

b) Subwatersheds in the northwestern portion of the lower Susquehanna River sub-basin (Spring Creek)

2. Healthy/high-value habitat in Maryland facing nontidal threats include the middle and upper Gunpowder River (crosses Pennsylvania and Maryland state line).

3. Healthy/high-value habitat facing moderate level nontidal threats are located in the upper James River (VA), upper Potomac River (PA, MD), Juniata River sub-basin (PA), Chemung River (PA and NY), middle Susquehanna River (PA), and West Branch Susquehanna River (PA).

4. Healthy/high-value habitat facing tidal threats are concentrated in the lower Eastern Shore of Maryland and Virginia.

2.12 Improve and maintain human connections to the natural environment (3-CNT-SOC)

Overview: This evaluation is focused on determining (1) how are restoration opportunities co-located with respect to current public access points and underserved populations, and (2) what threats exist to those access points, recreation, infrastructure, and underserved populations.

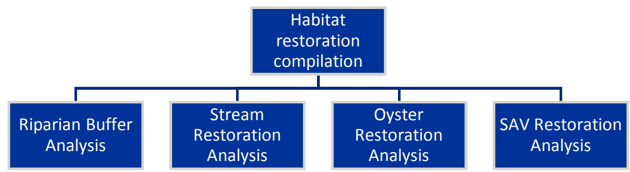
Data layers:

- *Socioeconomic analysis* (limited to public access, recreation and underserved (minority and low-income) populations)
- *Habitat restoration compilation* – Described below
- *Wetlands restoration and enhancement compilation* – Results of question 1 analyses (described in previous section)
- *Threats analysis – product of previous section*

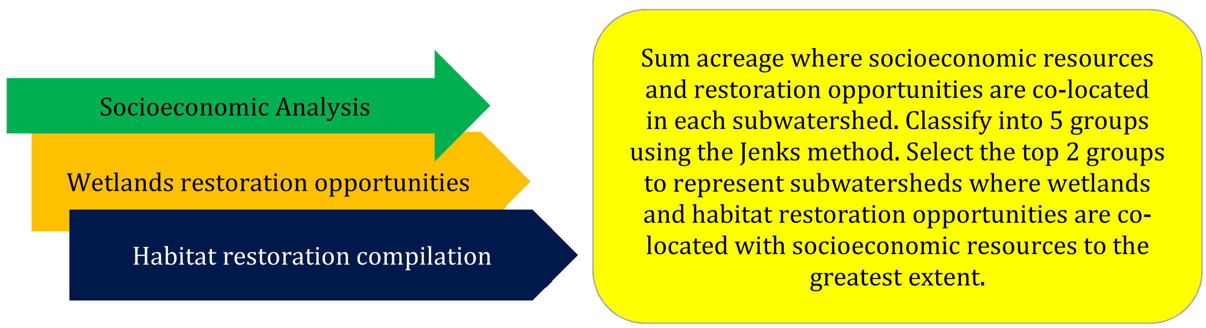
C**onceptual diagram, computations, and opportunities selection:** To evaluate the co-location of socioeconomic resources and restoration opportunities. A compilation of the various restoration opportunities identified in question 1 was developed by joining into one layer in GIS the results of (1) the riparian buffer analysis, (2) the stream restoration analysis, (3) the SAV analysis, and (4) the oyster analysis. An overly in GIS was created to depict the location of restoration opportunities from questions 1 (habitat compilation) and 2 (wetlands) with the socioeconomic resources layer. Habitat restoration opportunities data is at a subwatershed scale. First, in GIS it was determined if a given pixel contains a socioeconomic resource and a wetland restoration opportunity. For each subwatershed, sum the area covered by pixels that contain both socioeconomic resources and wetland restoration opportunity. Based on the total acreage in a subwatershed, classify the subwatershed into 5 categories using the Jenks method in ArcGIS (**Figure 57**) . Following this calculation, the habitat compilation layer was applied on top of the data layer depicting areas the co-location of wetland restoration and socioeconomic resources

(**Figure 58**). This analysis was completed a second time using the wetlands enhancement dataset (existing wetlands) to evaluate the co-location of existing wetlands, socioeconomic resources, and habitat restoration opportunities (**Figures 59 and 60**).

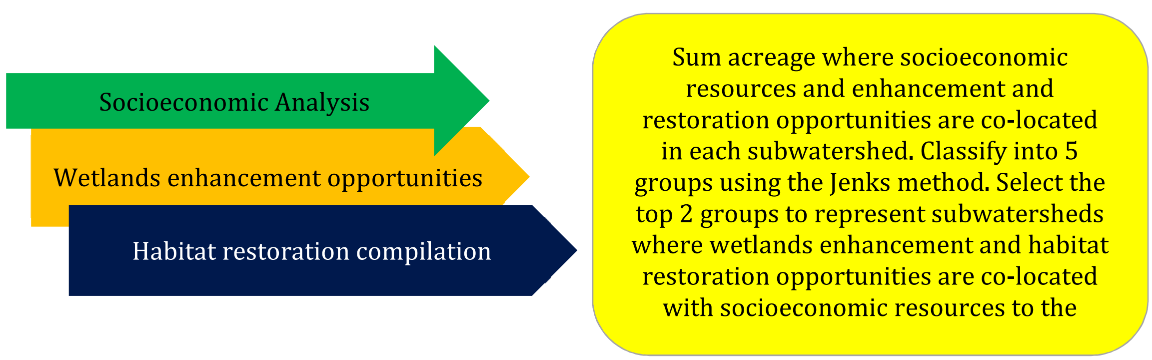
Habitat restoration compilation:



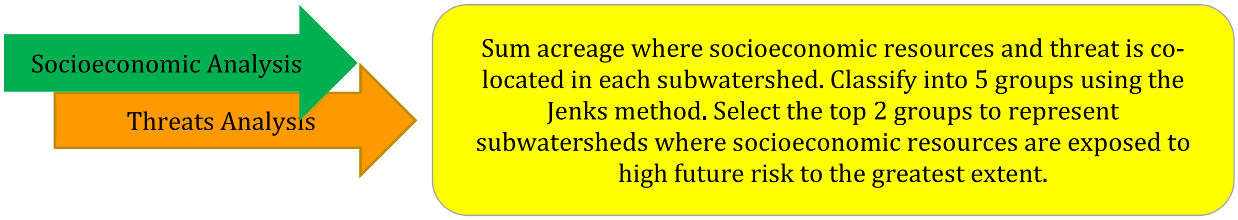
Wetlands restoration opportunities, habitat opportunities, and socioeconomic resources:



Wetlands enhancement opportunities, habitat opportunities, and socioeconomic resources:



To evaluate threats to socioeconomic resources, a separate analysis was completed to evaluate nontidal threats and tidal threats (**Figures 61 and 62**). For nontidal threats, overlay in GIS the socioeconomic resources and the nontidal threat analysis. Identify if a given pixel contains a socioeconomic resource and is positive for a nontidal threat. For each subwatershed, sum the area covered by pixels that contain a socioeconomic resource and a nontidal threat. Based on the total acreage in a subwatershed, classify the subwatershed into five categories using the Jenks method in ArcGIS. Repeat this process using the tidal threats data layer rather than the nontidal threats.


Socioeconomic Analysis
Threats Analysis
Sum acreage where socioeconomic resources and threat is co-located in each subwatershed. Classify into 5 groups using the Jenks method. Select the top 2 groups to represent subwatersheds where socioeconomic resources are exposed to high future risk to the greatest extent.

Map products:

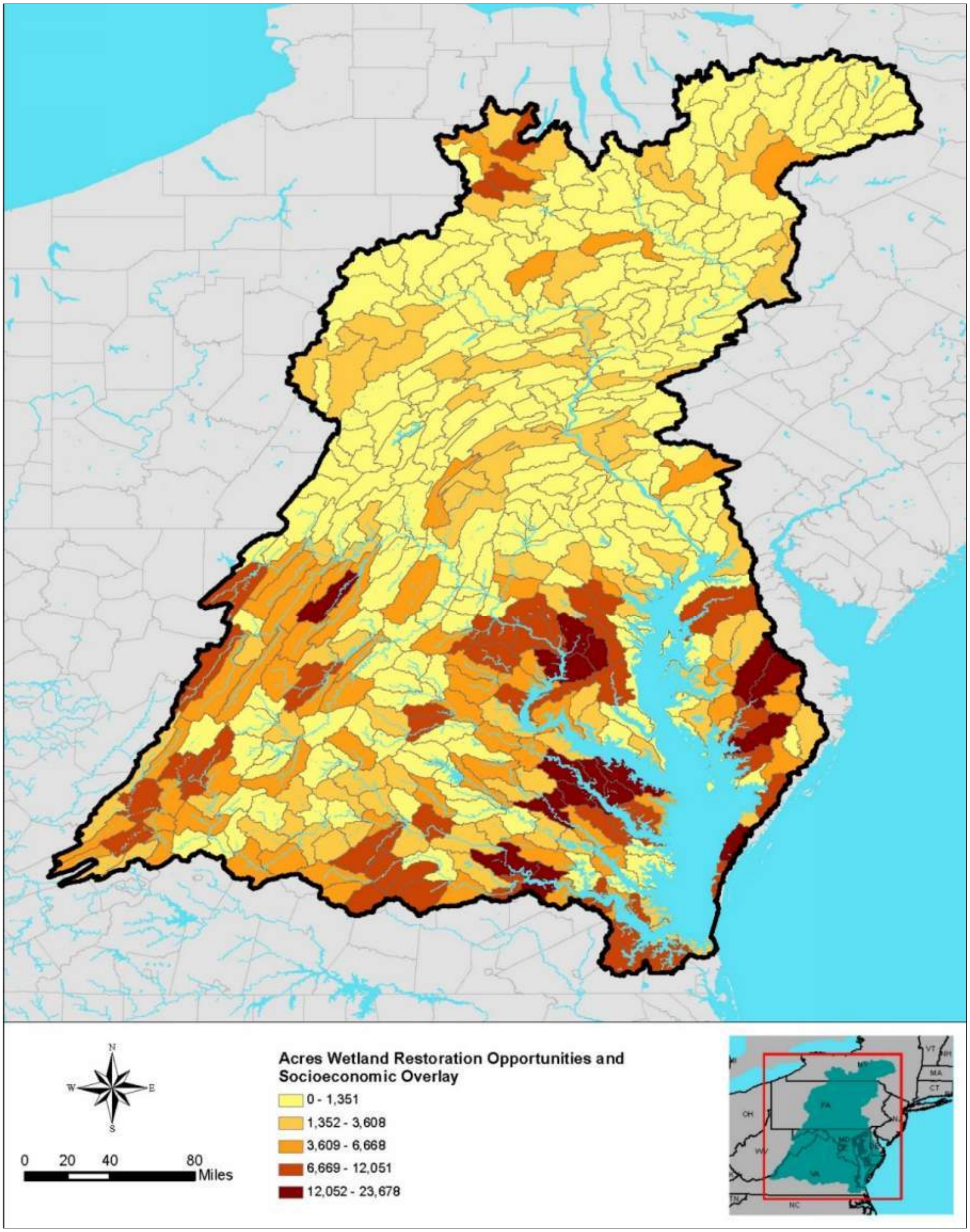


Figure 57. Wetland restoration opportunities co-located with socioeconomic resources (3-CNT-SOC-A)

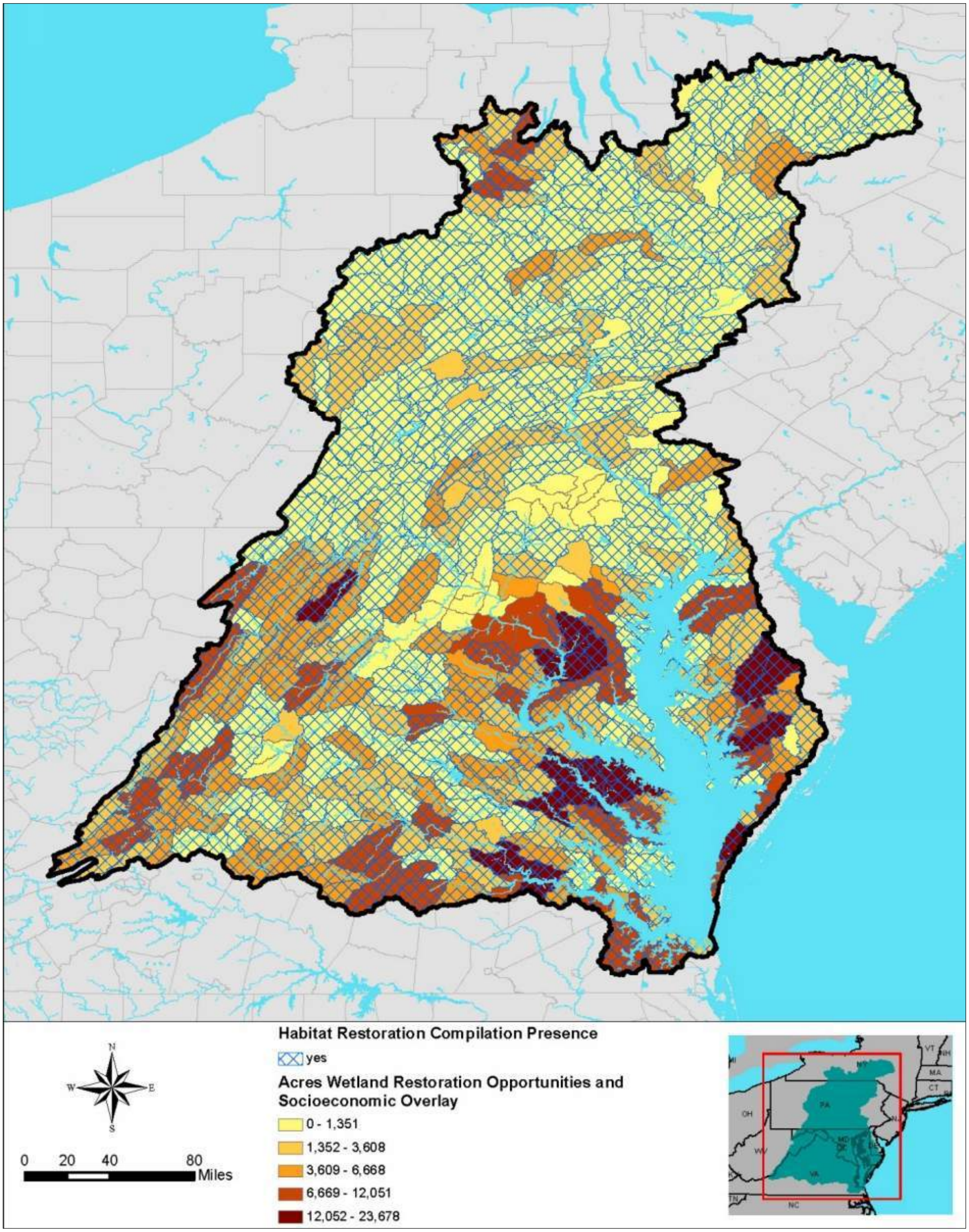


Figure 58. Wetland and habitat restoration opportunities co-located with socioeconomic resources (3-CNT-SOC-B)

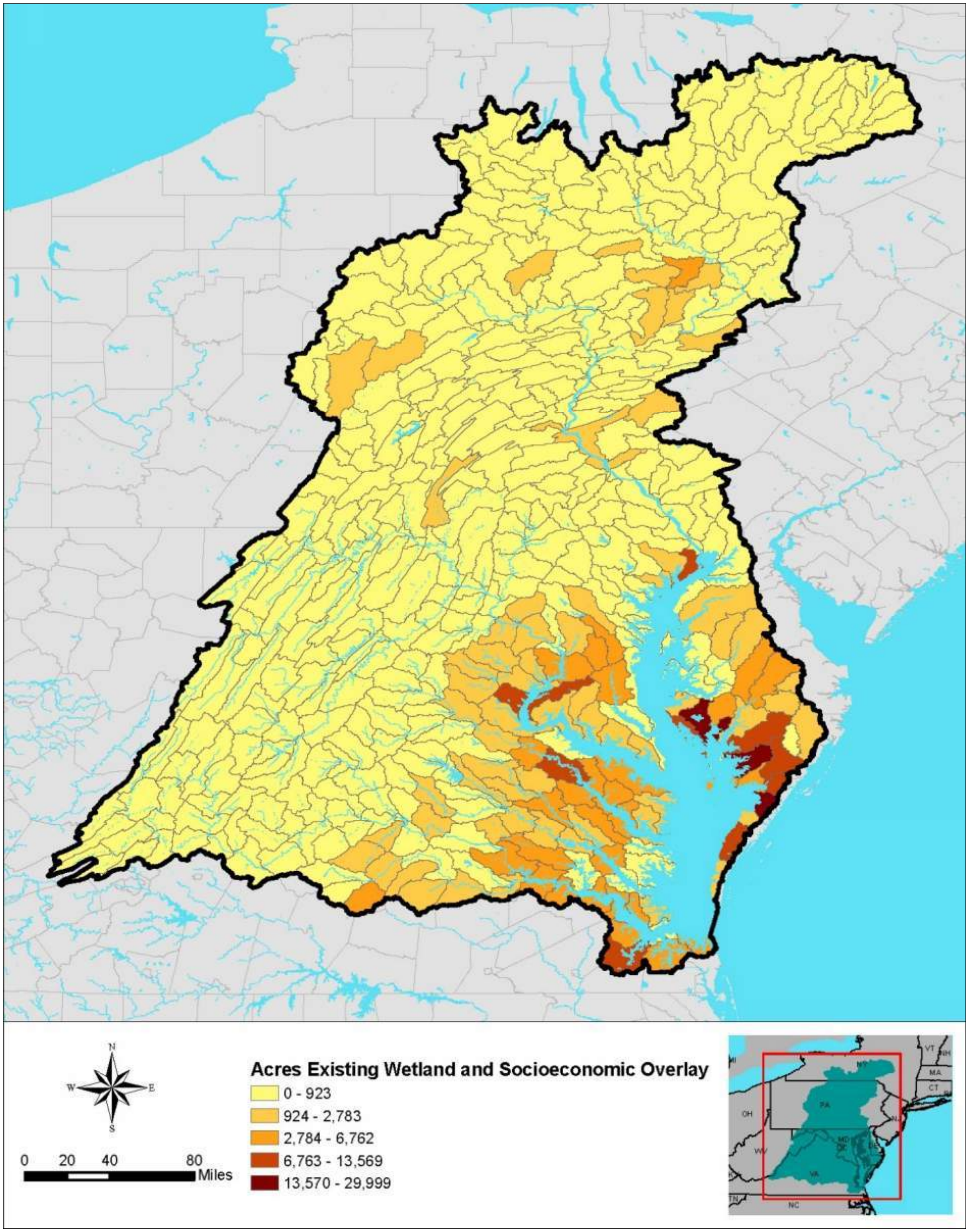


Figure 59. Wetland enhancement opportunities co-located with socioeconomic resources (3-CNT-SOC-C)

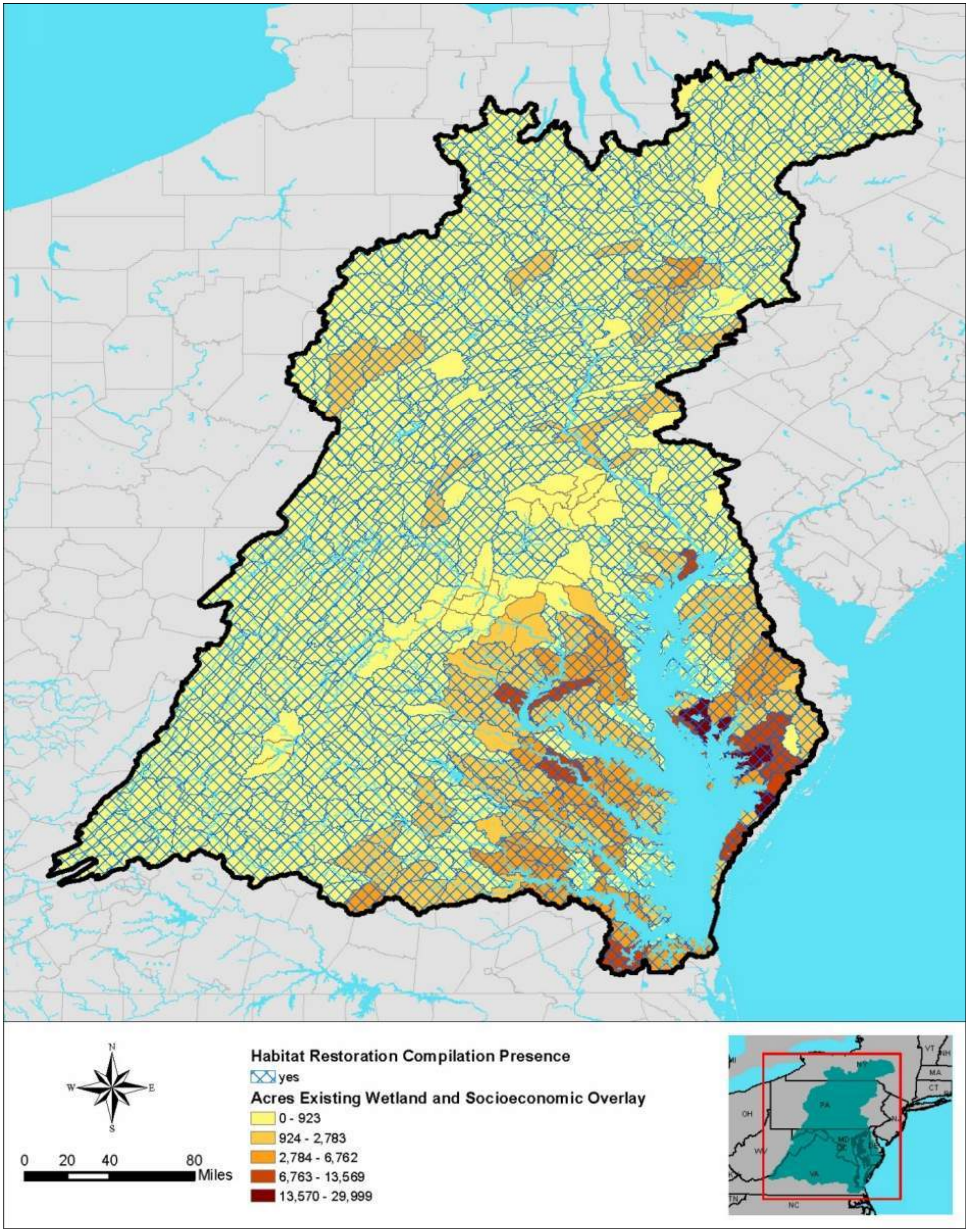


Figure 60. Wetland enhancement and habitat restoration opportunities co-located with socioeconomic resources (3-CNT-SOC-D)

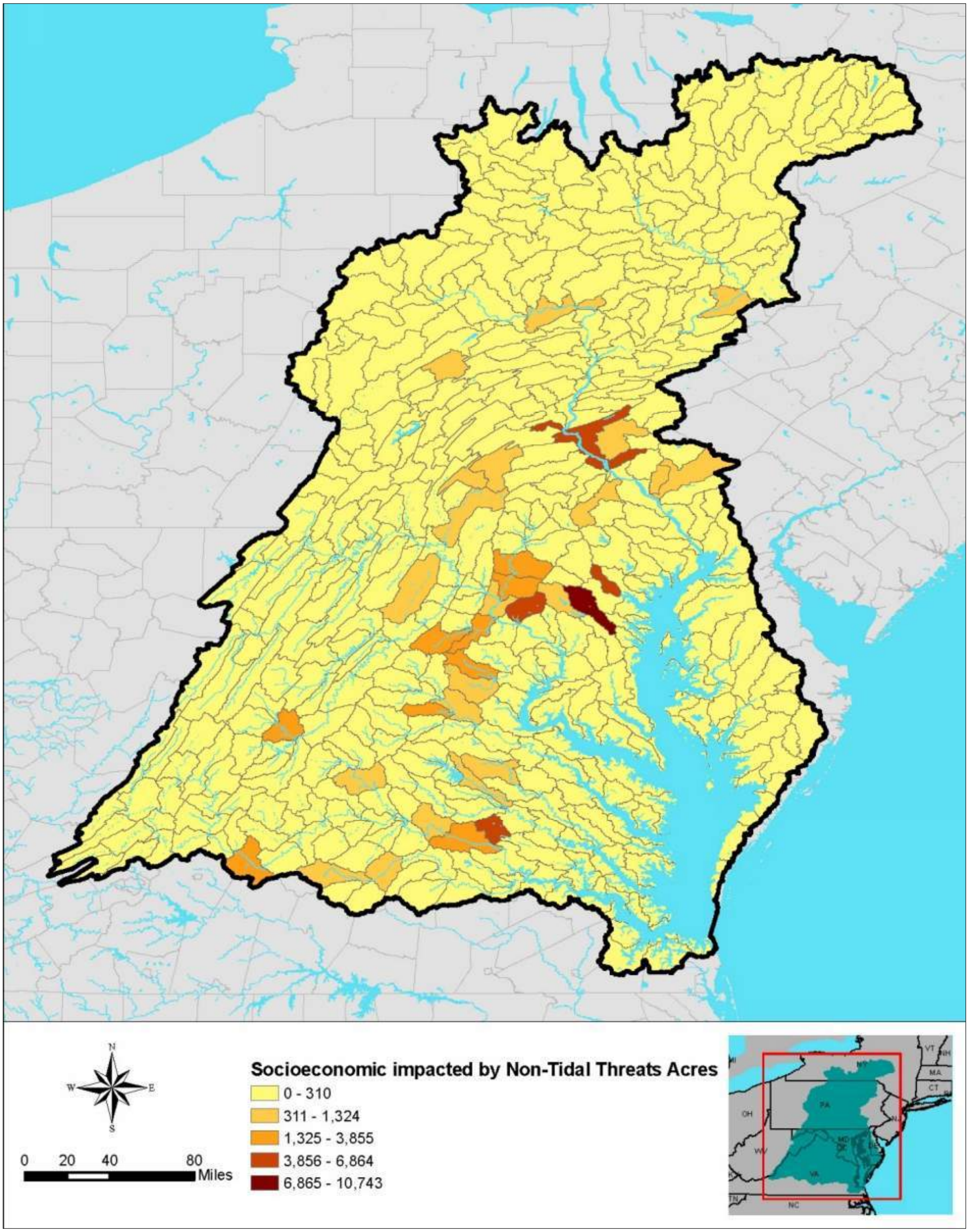


Figure 61. Socioeconomic resources facing nontidal threats (3-CNT-SOC-E)

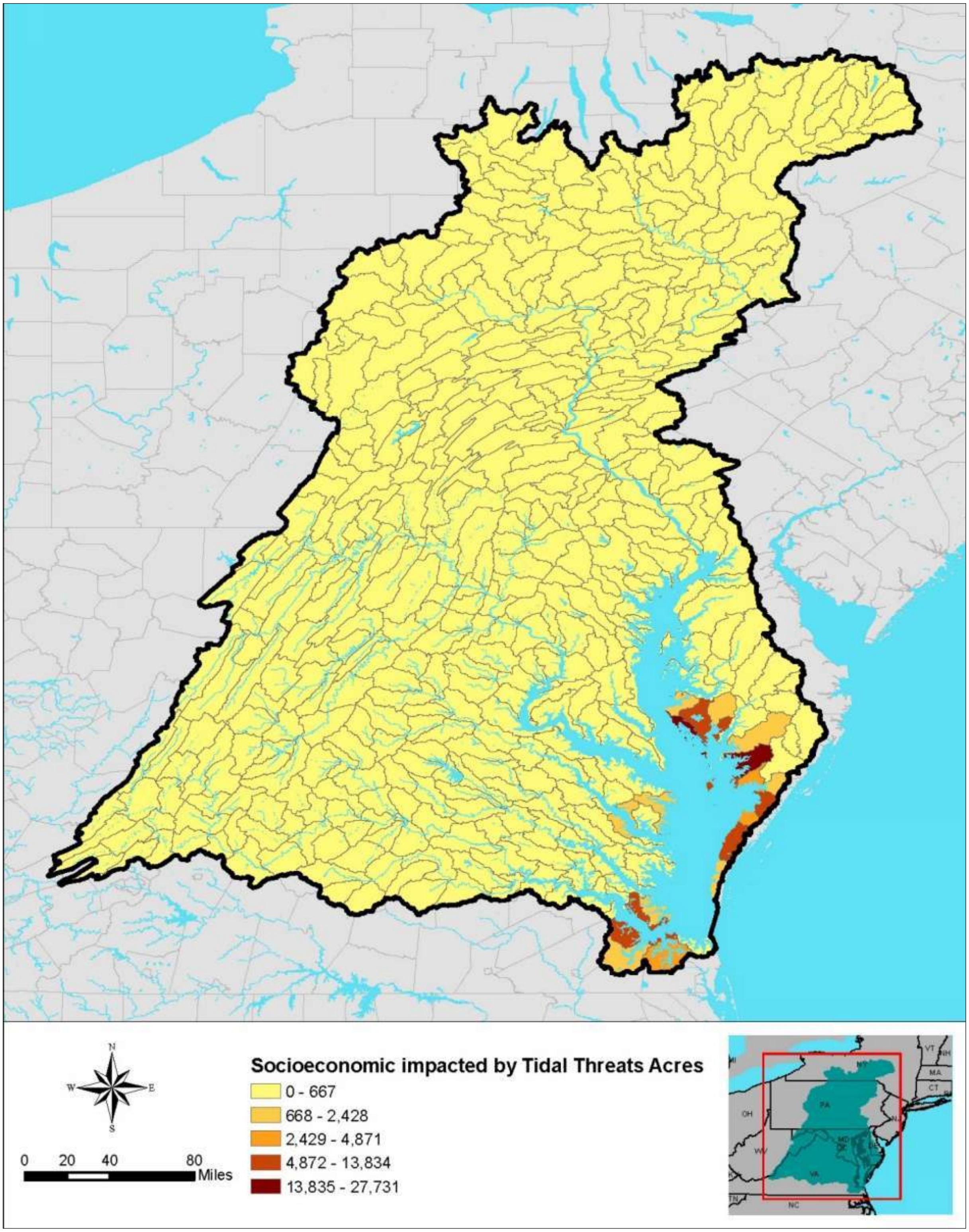


Figure 62. Socioeconomic resources facing tidal threats (3-CNT-SOC-F)

Key points:

1. The greatest overlap of wetland restoration opportunities and socioeconomic resources are in subwatersheds close to the bay mainstem:
    a) Lower James River
    b) Pamunkey River
    c) Lower Potomac River (VA)
    d) Potomac River (DC)
    e) Lower Rappahannock River
    f) Upper Nanticoke River
    g) Wicomico River
    h) North River in the upper Potomac River basin
2. There are concentrated areas of high overlap between wetland restoration opportunities and socioeconomic resources in:
    a) Subwatersheds encompassing and surrounding Washington, DC
    b) Subwatersheds in the Norfolk area
    c) Along the Eastern Shore of Maryland and Virginia
    d) Subwatersheds along the western border of the bay watershed in West Virginia and western Virginia
    e) Subwatersheds in the middle James River basin in Virginia
3. Those areas identified in #1 and 2 above also are co-located with habitat restoration opportunities.
4. The greatest overlap of wetland enhancement opportunities and socioeconomic resources are in subwatersheds on the Eastern Shore of Delmarva Peninsula including:
    a) Blackwater River (MD)
    b) Manokin River (MD)
    c) Messongo Creek-Pocomoke Sound (VA)
5. There are other high levels of overlap of wetland enhancement opportunities and socioeconomic resources in:
    a) Romney Creek (MD) at the head of the bay

b) Potomac River subwatershed below Washington, DC

c) Lower half of the Eastern Shore of Maryland and Virginia—Wicomico River (MD), Dividing Creek (MD), Pitts Creek (MD and VA), and Pungoteague Creek (VA)

6. All areas identified in #4 and 5 also are co-located with habitat restoration opportunities except for Pitts Creek at the Maryland and Virginia border on the Eastern Shore.

7. The socioeconomic resources at greatest risk to nontidal threats are in:

    a) Lower Susquehanna River basin

    b) Subwatershed in Maryland south of Baltimore (Little Patuxent and Gwynns Falls)

    c) Northwest of Washington, DC (Seneca Creek)

    d) Upper Chickahominy River in the James River basin in Virginia

8. The socioeconomic resources at greatest risk to tidal threats are in the Norfolk, VA area and along the bay on the Eastern Shore of Maryland and Virginia.

2.12.1 Conservation

(4) Where do conservation opportunities exist to increase connectivity, enhance restoration success, and address social and economic vulnerabilities?

This series of questions is focused on identifying areas adjacent to healthy habitats that are currently not preserved. Other socioeconomic benefits such as proximity to source water protection areas, etc. will be considered to provide added societal benefits.

2.13 Conservation opportunities (4-CSV)

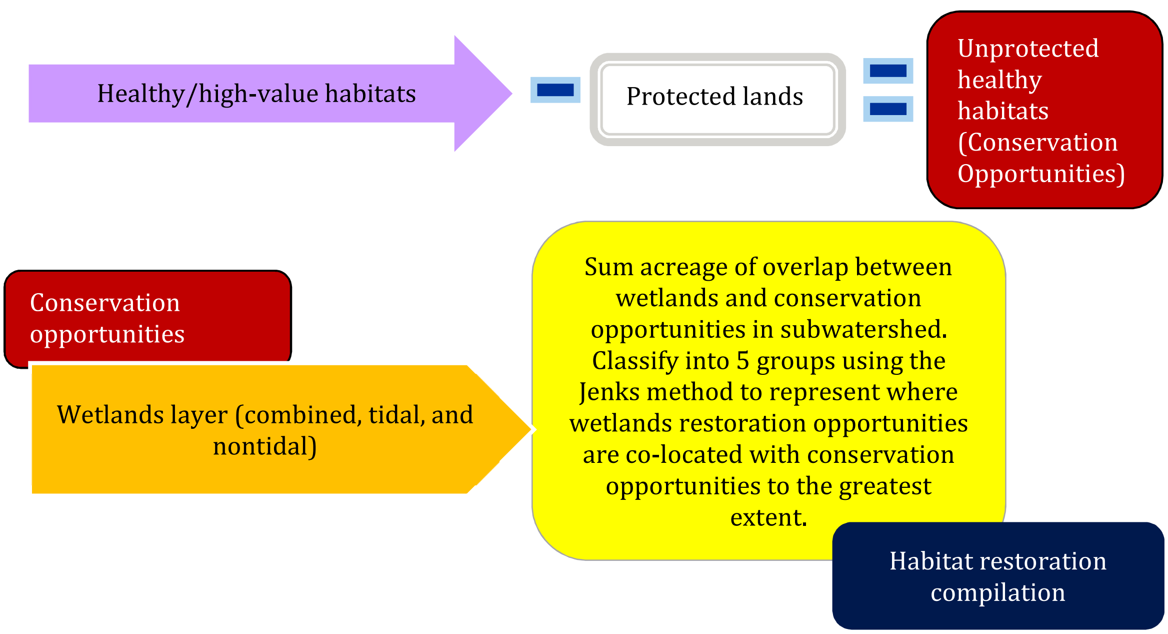
Overview: Identify healthy habitats that are currently not preserved. Consider the restoration opportunities that have been proposed and how they can be incorporated with conservation initiatives.

Data layers:

- *Healthy/high-value habitats analysis* – Generated by Healthy/High-Value Habitats Analysis
- *Protected lands layer from CBP*
- *Habitat restoration compilation* – Results of question 1 analyses (described in previous section)
- *Wetlands restoration and enhancement* – Perform analysis using the following: (1) combined wetland restoration, (2) combined wetlands enhancement, (3) tidal wetlands restoration, (4) tidal wetlands enhancement, (5) nontidal wetlands restoration, and (6) nontidal wetlands enhancement layer.

Conceptual diagram, computations, and opportunities selection: In GIS, the healthy/high-value habitats layer (raster data) was overlaid with the protected lands layer to identify those healthy/high-value habitats that are not currently protected. The acreage of healthy/high-value habitat pixels that were not also protected pixels were summed by subwatershed. The total acreage of unprotected habitat was classified into five groups utilizing the Jenks method in ArcGIS. The top two groups of watersheds based on acreage are identified as *Opportunities* for conservation (**Figure 63**).

Overlay the habitat and wetland restoration/enhancement opportunities to evaluate the areas where restoration/enhancement opportunities exist compared to unprotected lands. To facilitate this investigation, the conservation and wetlands data was initially analyzed since these layers were raster data. This was completed for each of the six wetlands layers identified above (**Figures 64-69**). Since the habitat restoration data only identified opportunities (and was not raster data), it was simply overlaid on top of the conservation/wetland analysis. For each of the six wetlands layers, the conservation opportunities and wetlands analysis were evaluated in GIS to determine those pixels where wetland opportunities are co-located with unprotected habitat. The total acreage of overlap between unprotected habitat and wetland opportunities in an individual subwatershed was calculated and then classified into five groups using the Jenks method in ArcGIS. A layer depicting the subwatershed identified as habitat restoration opportunities was overlaid, but no further computations were completed.



Map products:

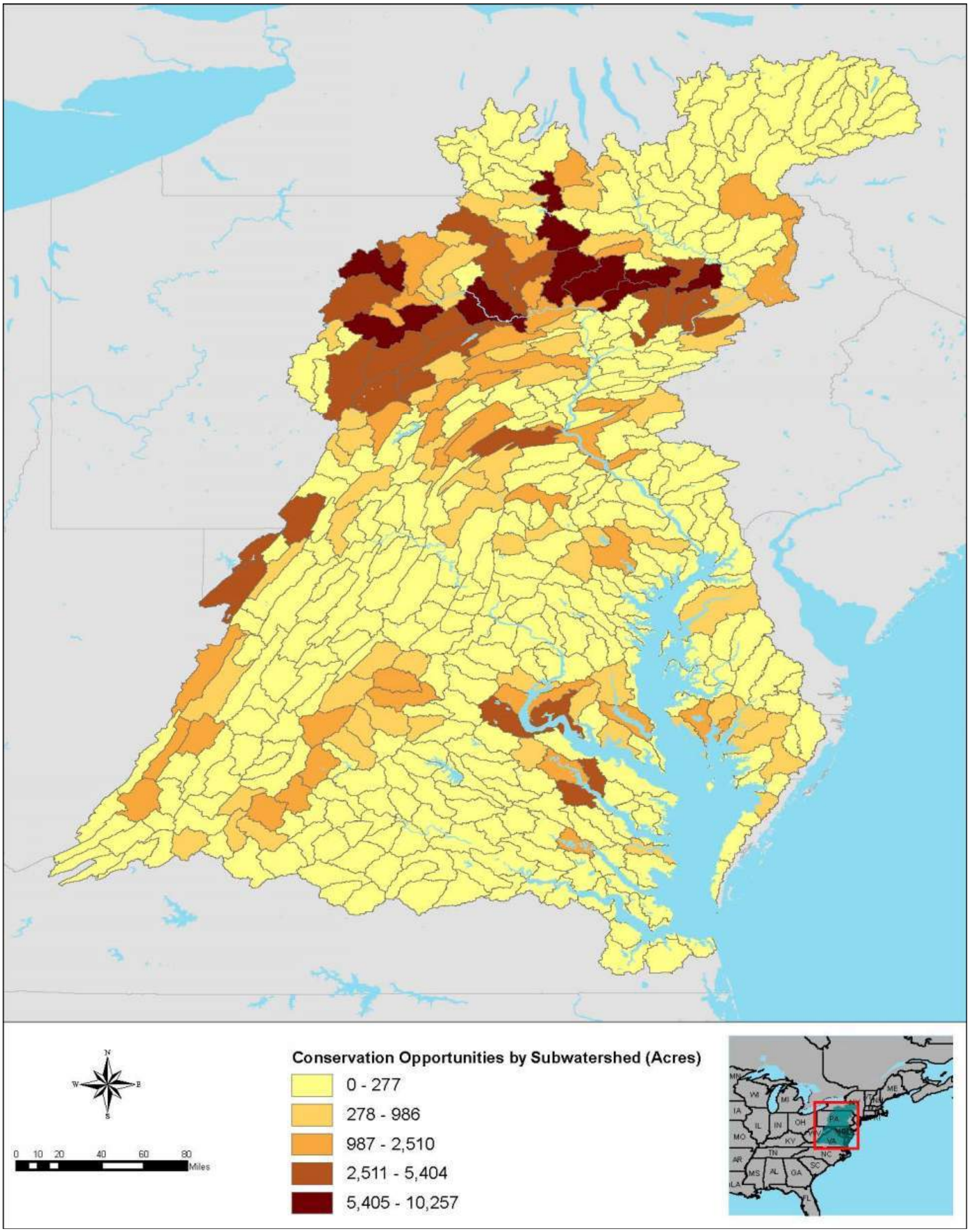


Figure 63. Conservation *Opportunities* by subwatershed (4-CSV-A)

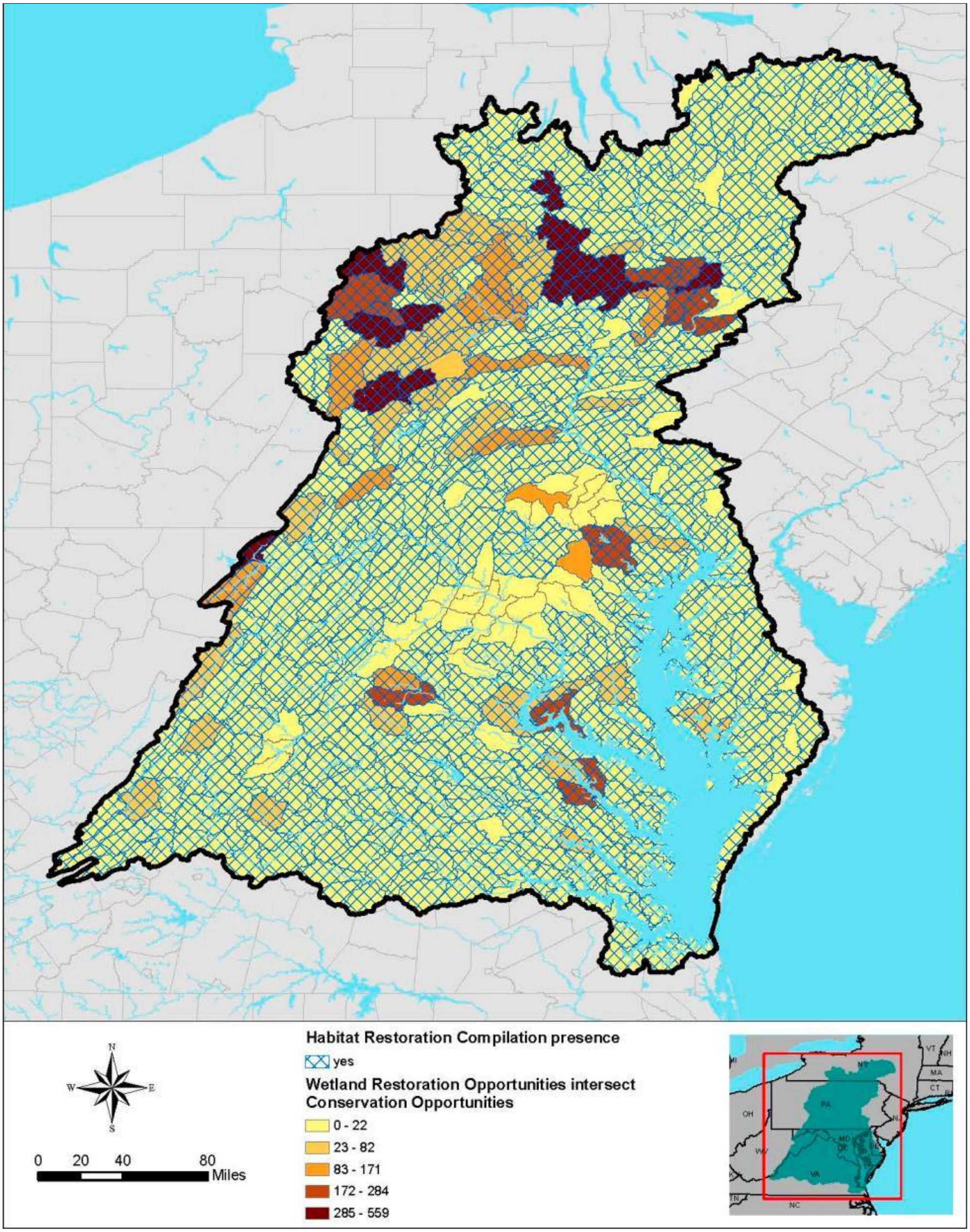


Figure 64. Conservation and combined wetland restoration (tidal and nontidal) opportunities comparison to habitat restoration opportunities (4-CSV-B)

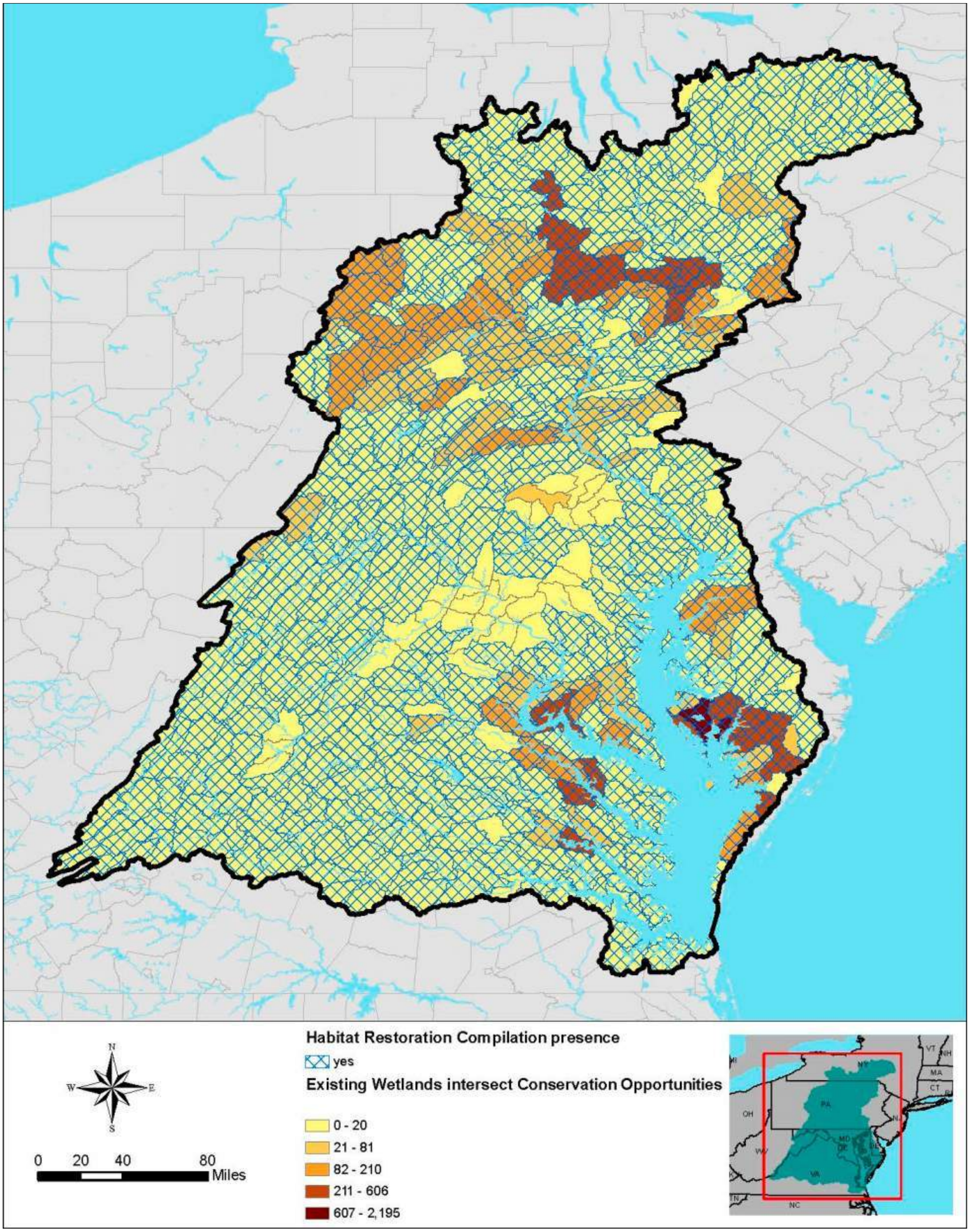


Figure 65. Conservation and combined wetland enhancement opportunities comparison to habitat restoration opportunities (4-CSV-C)

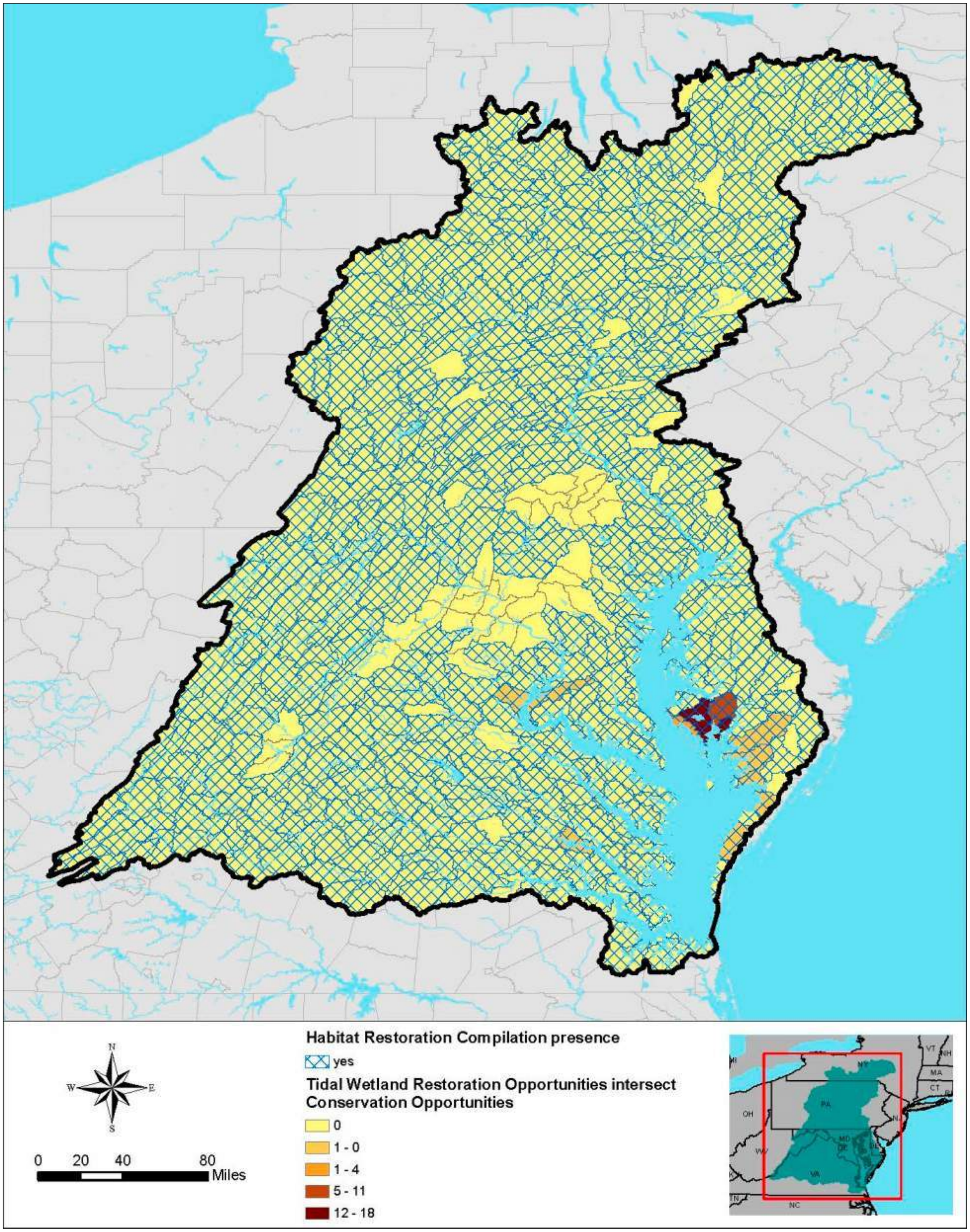


Figure 66. Conservation and tidal wetland restoration opportunities comparison to habitat restoration opportunities (4-CSV-D)

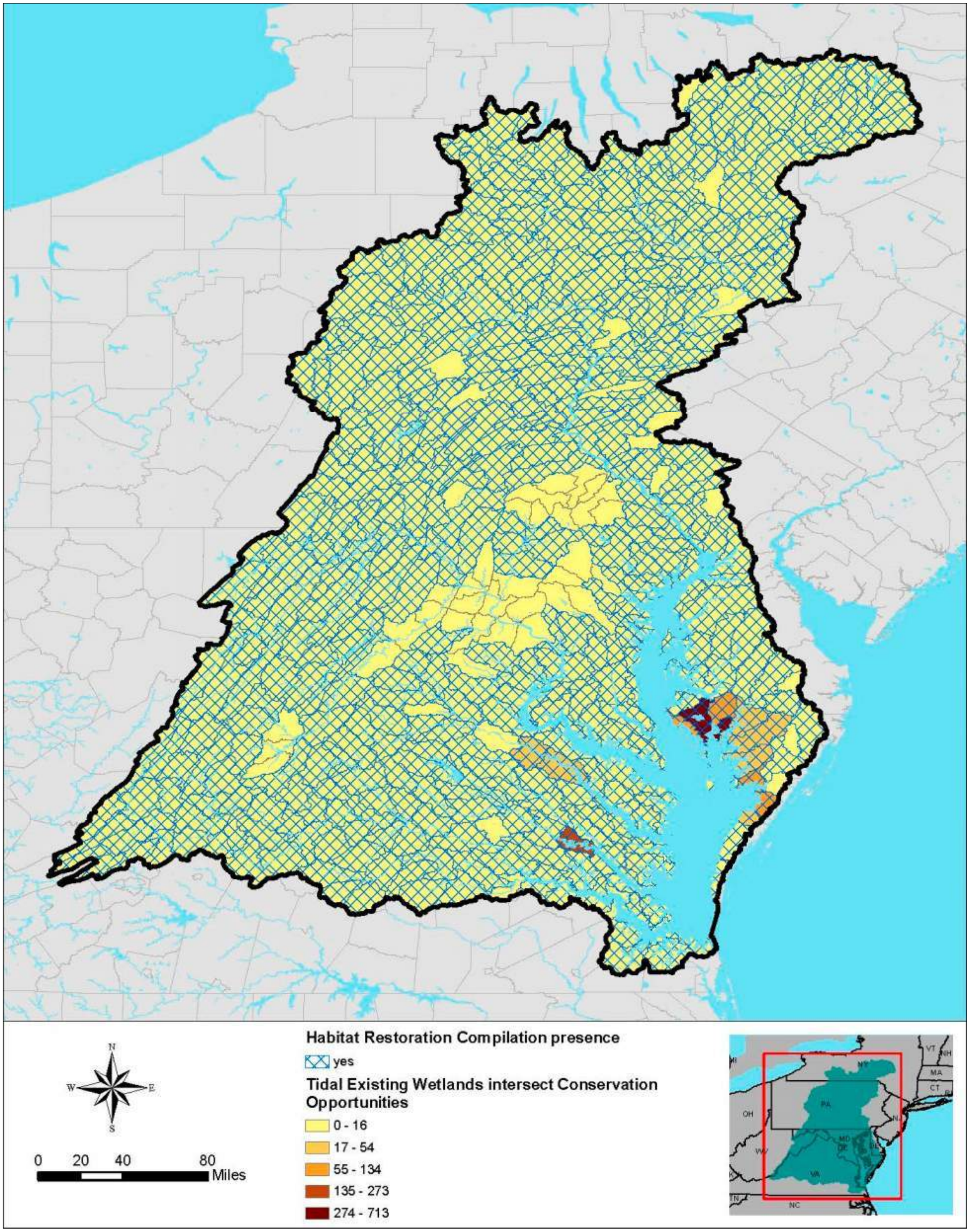


Figure 67. Conservation and tidal wetland enhancement opportunities comparison to habitat restoration opportunities subwatersheds (4-CSV-E)

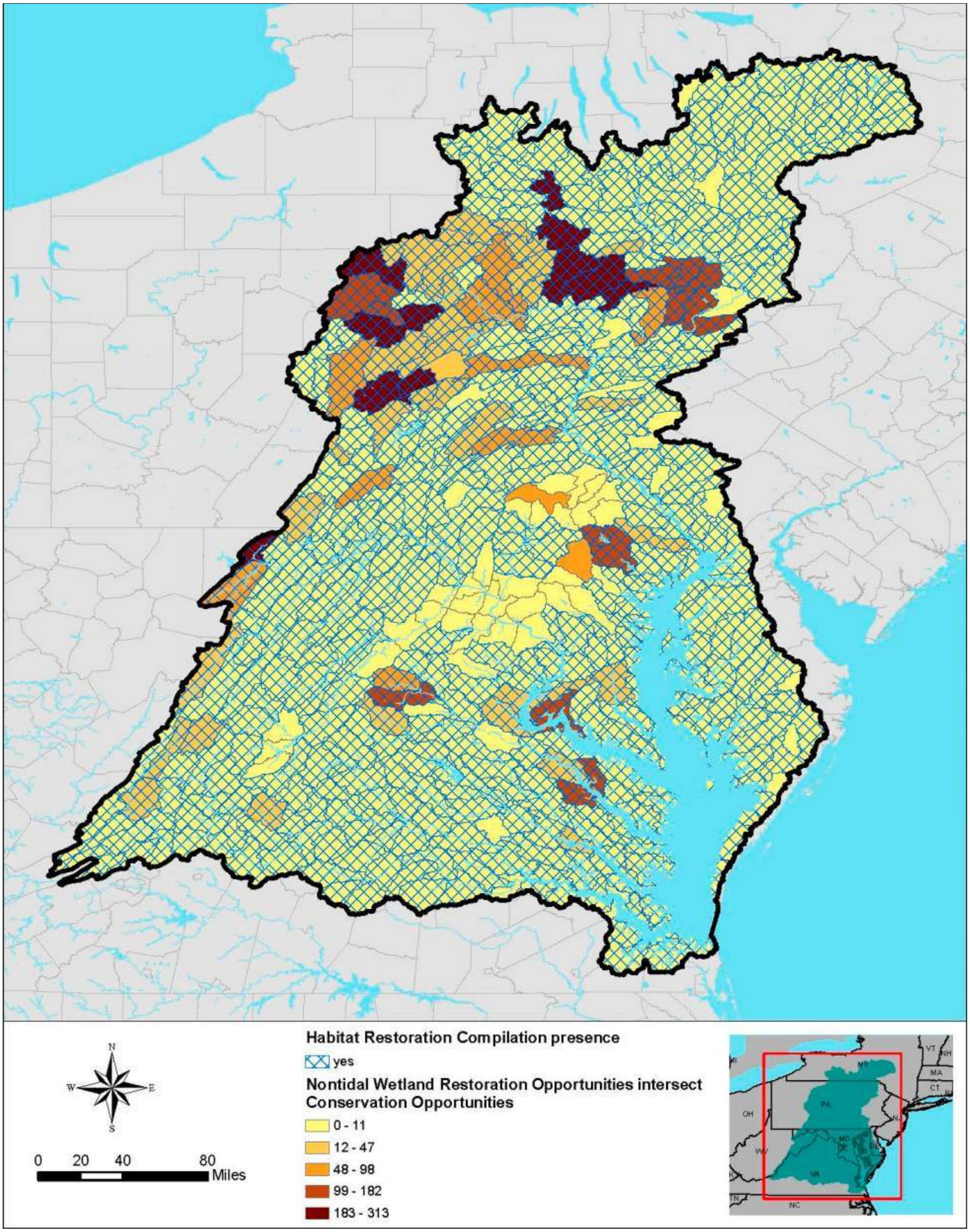


Figure 68. Conservation and nontidal wetland restoration opportunities comparison to habitat restoration opportunities (4-CSV-F)

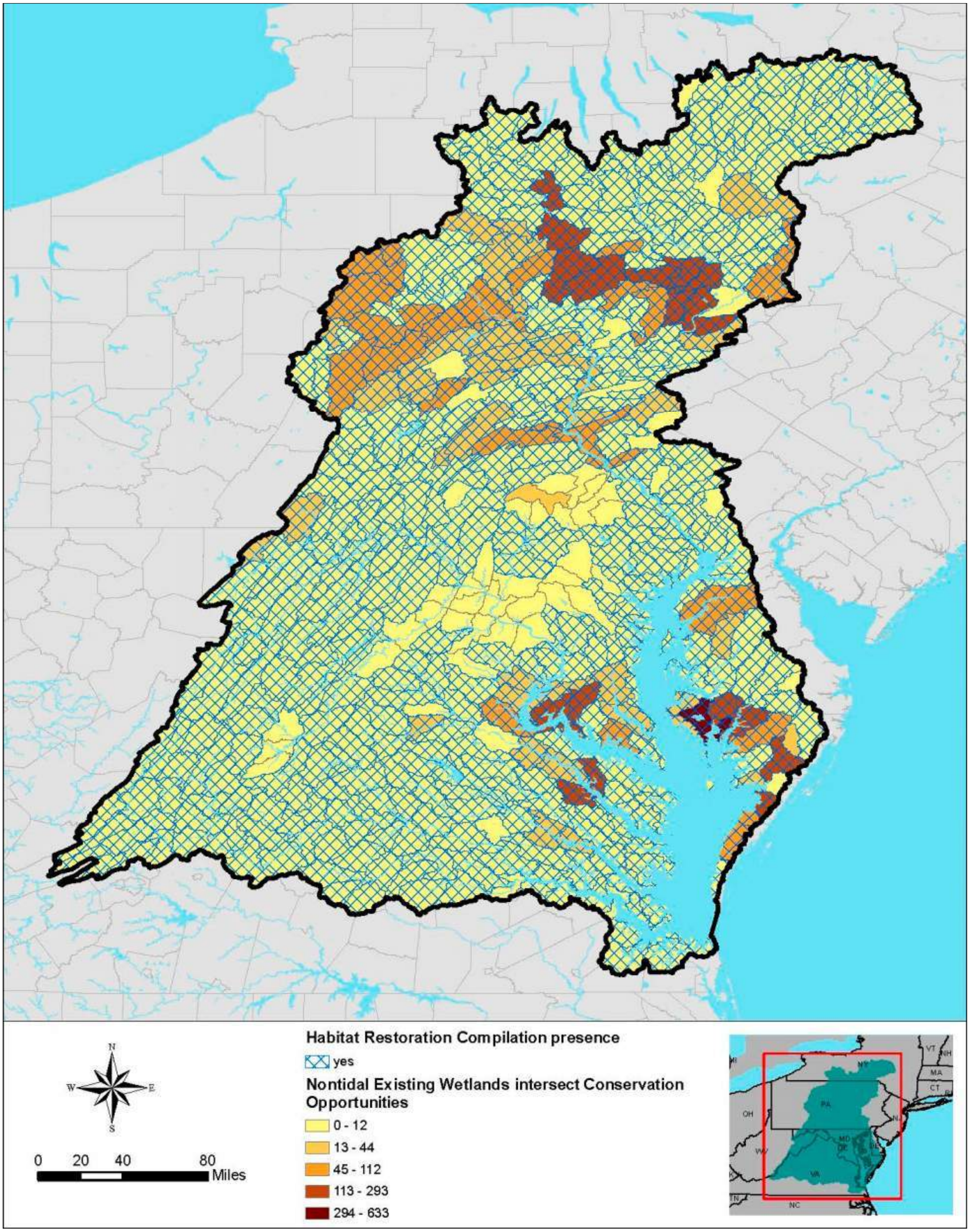


Figure 69. Conservation and nontidal wetland enhancement opportunities comparison to habitat restoration opportunities (4-CSV-G)

Key points:

1. Opportunities to conserve unprotected healthy/high-value habitats are concentrated in the upper Susquehanna River basin and the West Branch Susquehanna basin in PA. Other subwatersheds with high opportunities are:
    a) Sherman Creek in the lower Susquehanna River basin (PA)
    b) Potomac Creek (VA and MD) and Nanjemoy Creek (MD) in the Potomac River basin
    c) Cat Point Creek (VA) in the Rappahannock River basin
    d) Stony River (MD, WV), Savage River (MD), and Wills Creek (MD, PA) in the Potomac River basin
2. All subwatersheds identified with high overlap of conservation and wetland restoration opportunities also have been identified as habitat restoration opportunities. These areas are concentrated in the upper Susquehanna River and West Branch Susquehanna basins in Pennsylvania and the Savage River (MD) in the Potomac River basin.
3. All subwatersheds identified with high overlap of conservation and wetland enhancement (existing wetlands) opportunities have also been identified as habitat restoration opportunities. These areas are focused in:
    a) Upper Susquehanna River basin (PA)
    b) Lower Eastern Shore (MD), Nanjemoy Creek (MD) in the Potomac River basin
    c) Cat Point Creek (VA) in the Rappahannock River basin
    d) Lower Pamunkey River (VA)

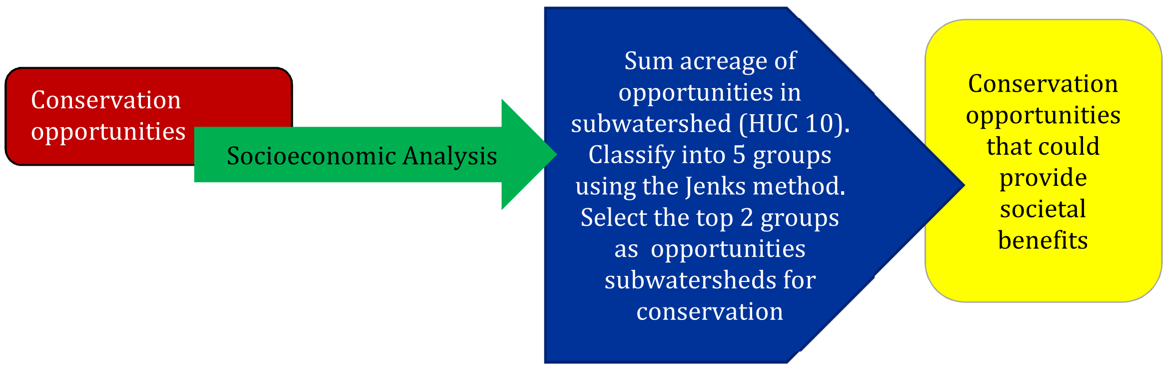
2.14 Consider opportunities to provide added societal benefits (4-CSV-SOC)

Overview: Consider if conservation opportunities are situated to add societal benefits such as recreation, source water protection, etc.

Data layers:

- *Conservation opportunities* – Generated in previous section
- *Socioeconomic analysis* – Include source water protection areas, water supply areas, recreation/access points, underserved populations, and parks

Conceptual diagram and computations: Overlay the conservation opportunities layer with our socioeconomic analysis to identify which conservation opportunities could provide added societal benefits (source water protection). As both data sources were raster data, the GIS analysis identified where an individual pixel was both unprotected (conservation opportunity) and contained a socioeconomic resource. The total acreage of overlap between unprotected habitat and socioeconomic resources in an individual subwatershed was classified into five groups using the Jenks method in ArcGIS. The top two groups of watersheds based on acreage are identified as *Opportunities* (**Figure 70)**.



Map products:

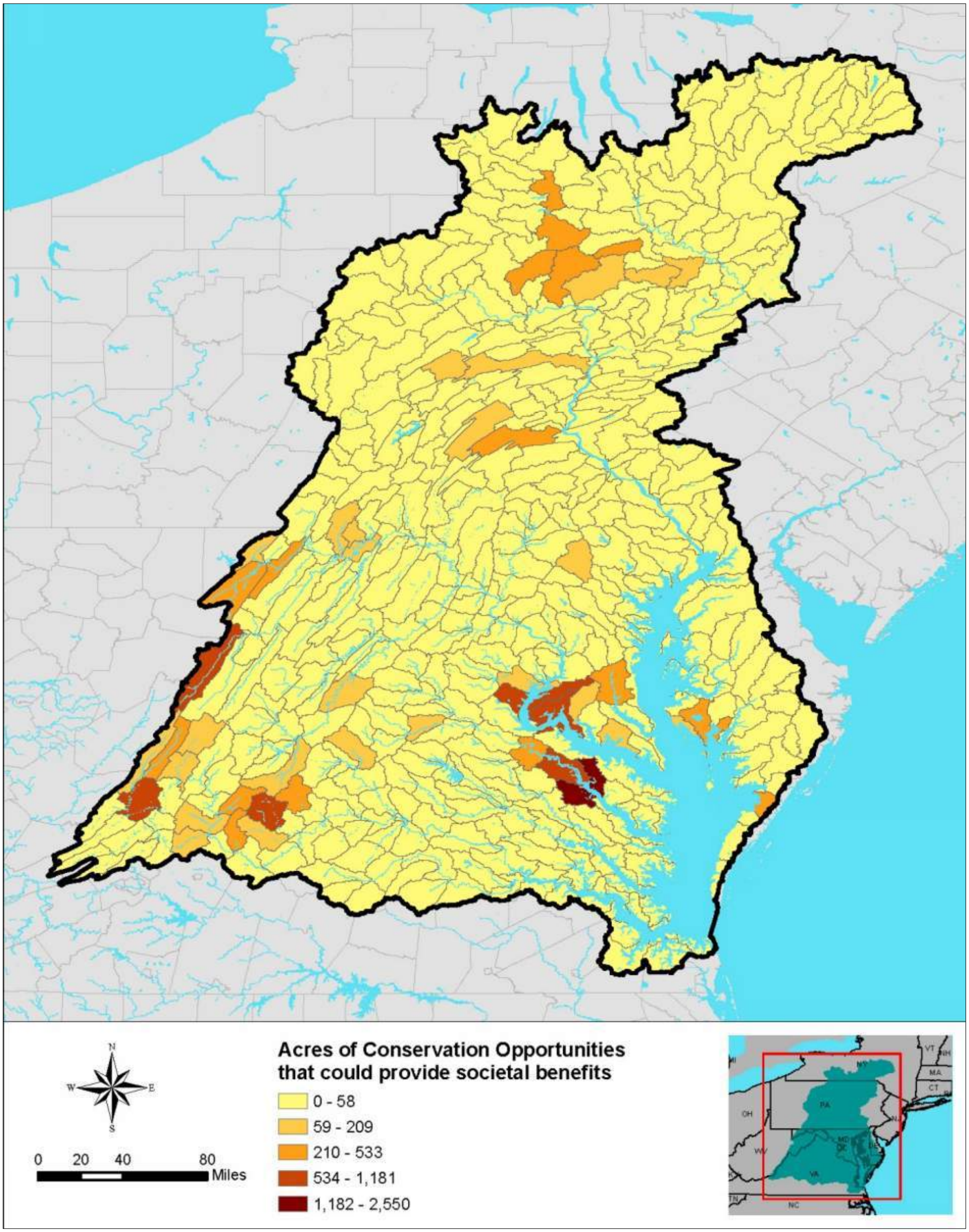


Figure 70. Analysis of conservation opportunities and socioeconomic resources (4-CSV-SOC-A)

Key points:

1. Subwatersheds that have the greatest overlap between conservation opportunities (unprotected healthy habitats) and socioeconomic resources are primarily located in Virginia:

   a) Cat Point Creek and Occupacia Creek in the Rappahannock River basin (VA)

   b) Quantico Creek and Nanjemoy Creek in the Potomac River basin (VA/MD)

   c) North Branch South Fork in the Potomac River basin (VA)

   d) Tye River and lower Jackson River in the James River basin in VA

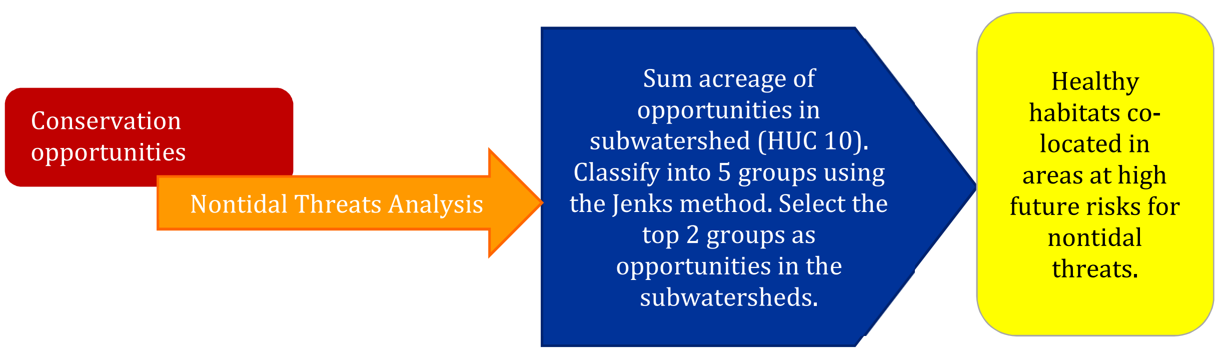
2.15 Threat reduction potential (4-CSV-TH)

Overview: Evaluate whether the identified conservation opportunities are at risk to future threats to climate change, anticipated increases in flooding and coastal storms, and projected development in the watershed. Alternatively, consider if conservation of certain areas could be undertaken as a measure to address future threats (such as flooding).

Data layers:

- *Conservation opportunities*
- *Threats analysis*

Conceptual diagram, computations, and opportunities selection: The following analysis was completed using the nontidal threats layer and the tidal threats layer separately (**Figures 71 and 72**). Overlay in GIS the conservation opportunities layer with the threats analysis. Identify if there are any conservation areas located in areas at high risk. The conservation opportunities and threats analysis were evaluated in GIS to determine those pixels where conservation opportunities are co-located with a threat. The total acreage of overlap between conservation opportunities and threats in an individual subwatershed was calculated and classified into five groups using the Jenks method in ArcGIS. Select the top two groups as *Opportunities*.



Map products:

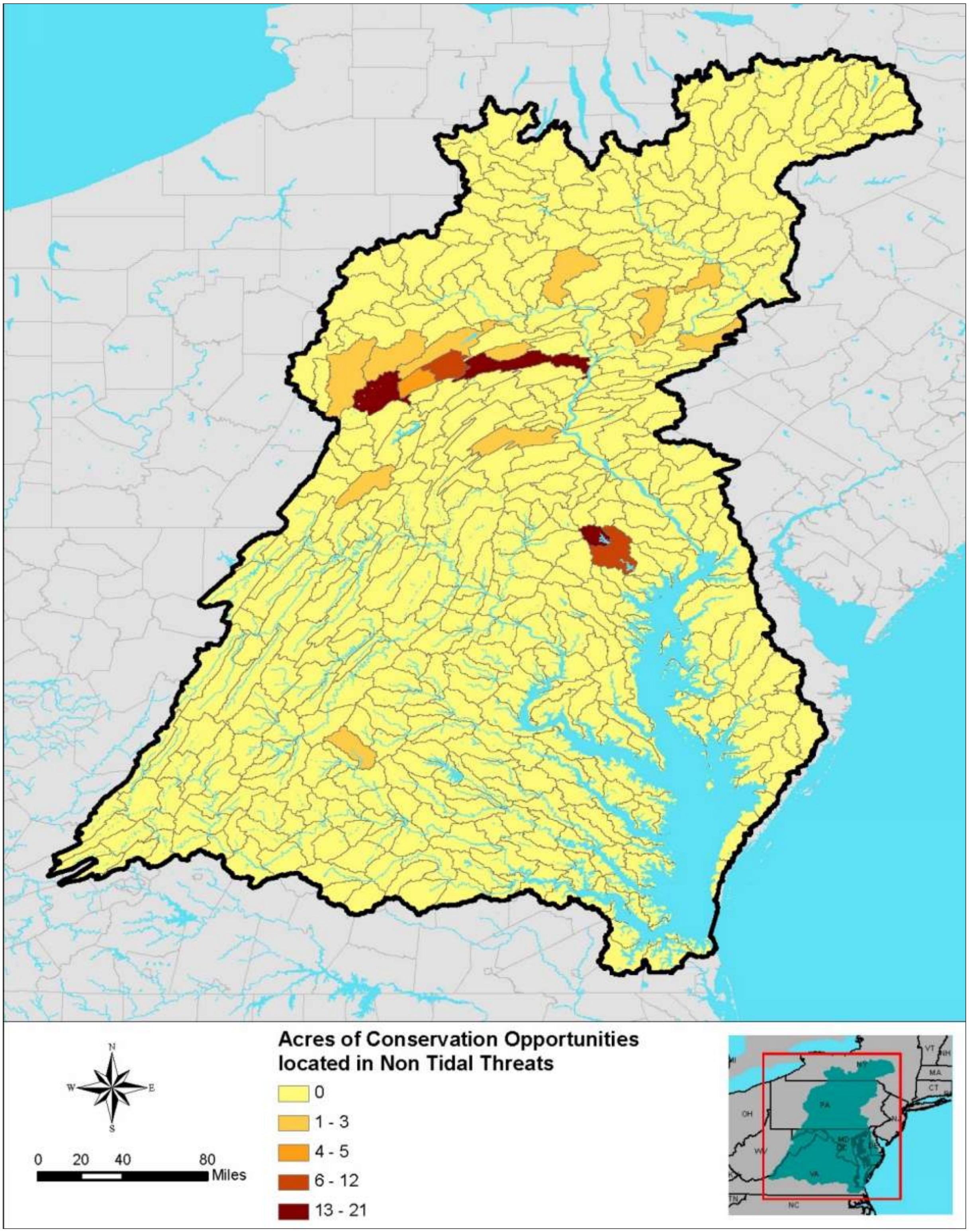


Figure 71. Conservation opportunities at risk to nontidal threats (4-CSV-TH-A)

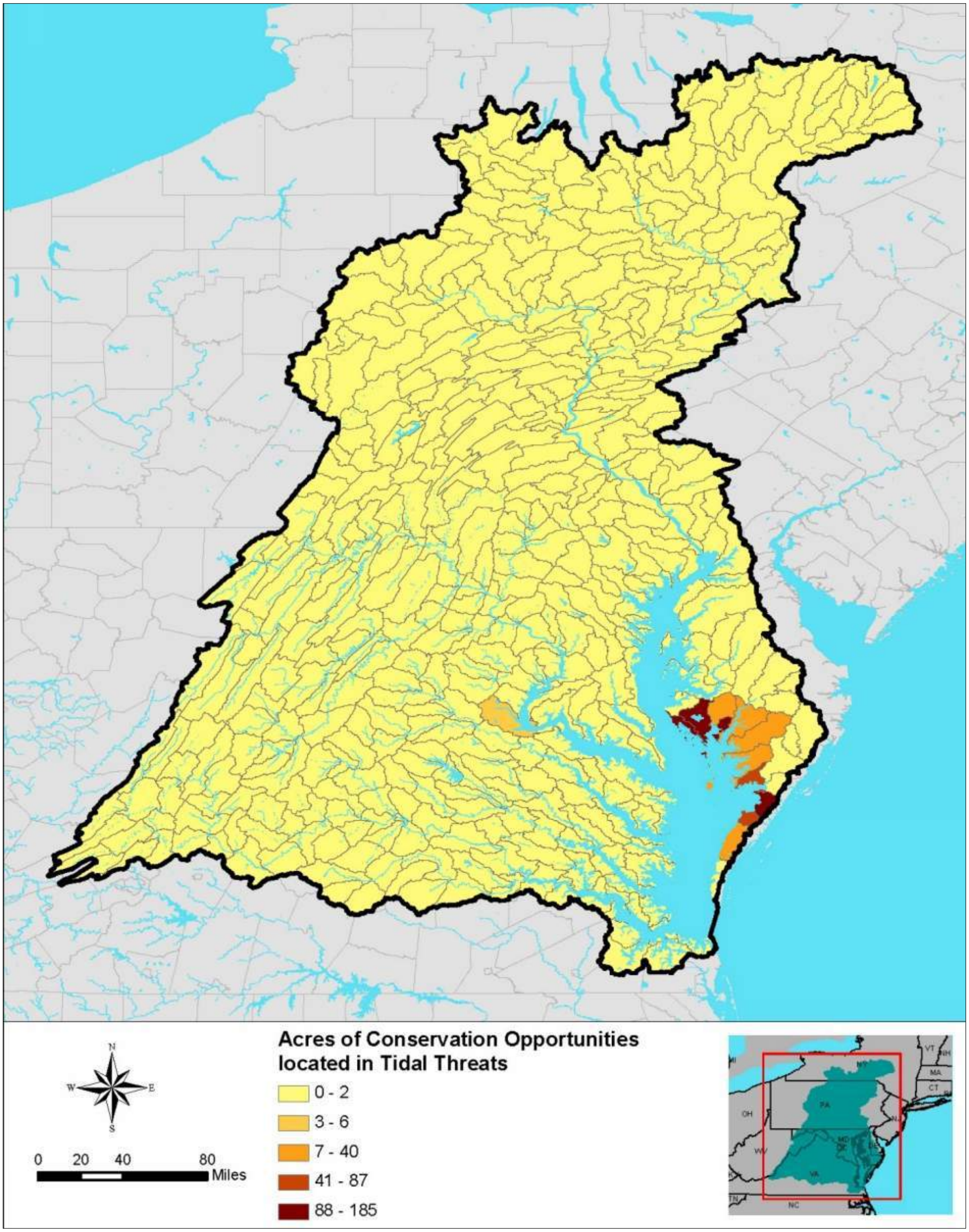


Figure 72. Conservation opportunities at risk to tidal threats (4-CSV-TH-B)

Key points:

1. Conservation opportunities in the following subwatershed are at the highest risk to future nontidal threats such as climate change impacts and development:

    a) Penns Creek, Spring Creek, and Little Juniata River in the lower Susquehanna River basin in Pennsylvania

    b) Upper Gunpowder Falls and Middle Gunpowder Falls in the upper Chesapeake Bay basin in Maryland

2. Conservation opportunities in the following subwatersheds are at the highest risk to future tidal threats:

    c) Blackwater River and Honga River on the lower Eastern Shore of Maryland

    d) Messongo Creek, Marumsco Creek, and Deep Creek in the Pocomoke Sound in Maryland and Virginia

2.15.1 Shorelines and Streambanks

(5) Where can shoreline opportunities for restoration and conservation be implemented to maximize/optimize aquatic ecosystem restoration and community resilience?

Note: Initially, the intention was to incorporate streambank erosion along with shoreline evaluations. However, no comprehensive dataset focused on eroding streambanks was identified.

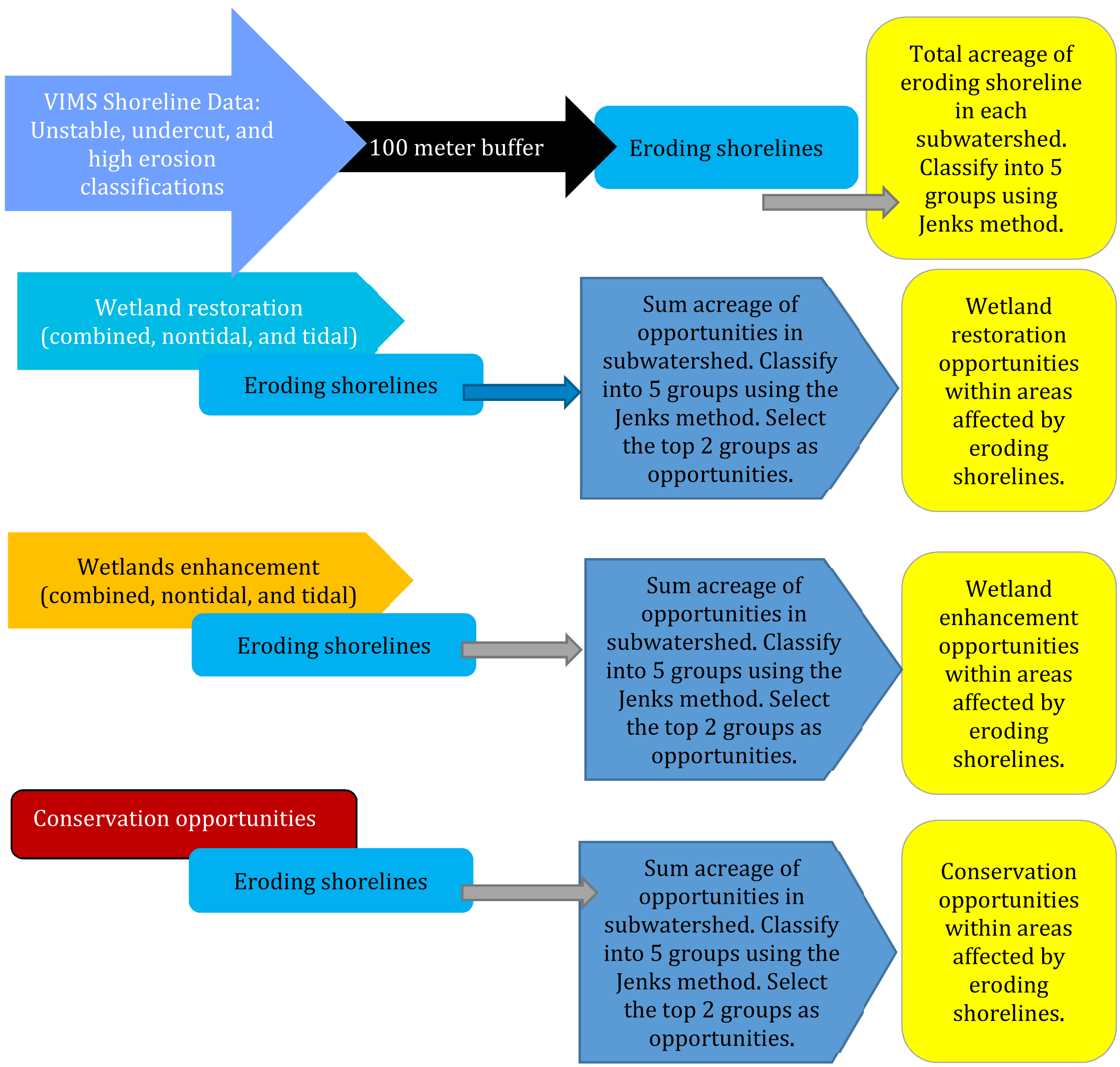
2.16 Identify opportunities where shoreline erosion projects could be undertaken to protect habitat (5-SS-ERO)

Overview: Identify where proposed habitat restoration, and wetland restoration and enhancement opportunities (results of questions 1 and 2), and conservation opportunities (results of question 4) are located adjacent to eroding shorelines to differentiate which restoration and conservation opportunities can be implemented to address erosion of shorelines and protect habitat. Alternatively, this evaluation will provide information to identify where potential projects are located in areas at risk to shoreline erosion.

Data layers: Include the following data layers in the evaluation:

- *Eroding shoreline* – VIMS Shoreline Inventory
- *Habitat restoration compilation* – Results of question 1 analyses (described in previous section)
- *Wetlands restoration and enhancement* – Perform analysis using the following: (1) combined wetland restoration, (2) combined wetlands enhancement, (3) tidal wetlands restoration, (4) tidal wetlands enhancement, (5) nontidal wetlands restoration, and (6) nontidal wetlands enhancement layer.
- *Conservation opportunities compilation* – Results from question 4

Conceptual diagram, computations, and opportunities selection: The available data from VIMS was used to create a layer that represented the location of eroding shoreline. The eroding shorelines data was categorized differently for Maryland and Virginia. From the Virginia dataset, the data defined as high and unstable was used to represent eroding shoreline. From the Maryland dataset, the data defined as high and undercut was used. A 100 m buffer was generated around those locations. The total acreage of eroding shoreline in an individual subwatershed was calculated and classified into five groups using the Jenks method in ArcGIS (**Figure 73**). The buffered eroding shoreline layer was utilized to calculate the acreage within the buffer of (1) combined, tidal, and nontidal wetland restoration opportunities (**Figures 74, 75, and 76, respectively**), (2) combined, tidal, and nontidal wetland enhancement opportunities (**Figures 77, 78, and 79, respectively**), and (3) conservation opportunities (**Figure 80**). The buffered eroding shoreline layer was overlaid individually with each of the opportunities layers (1–3 above). For each of the opportunities, the acreage of opportunity within the buffer was calculated and classified into five groups using the Jenks method in ArcGIS. Select the top two groups as shoreline *Opportunities* for each evaluation.



Map products:

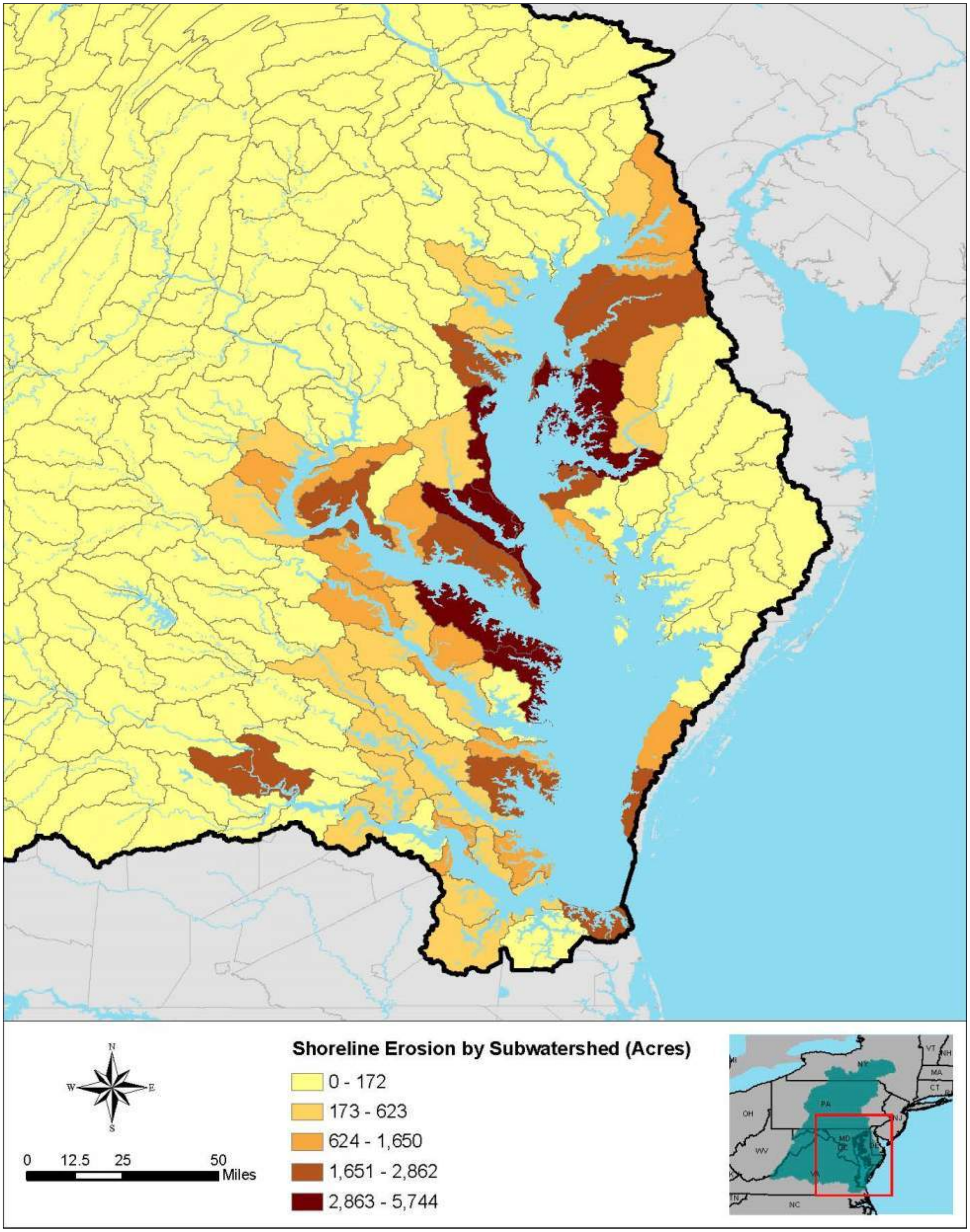


Figure 73. Acreage affected by shoreline erosion by subwatershed (5-SS-ERO-A)

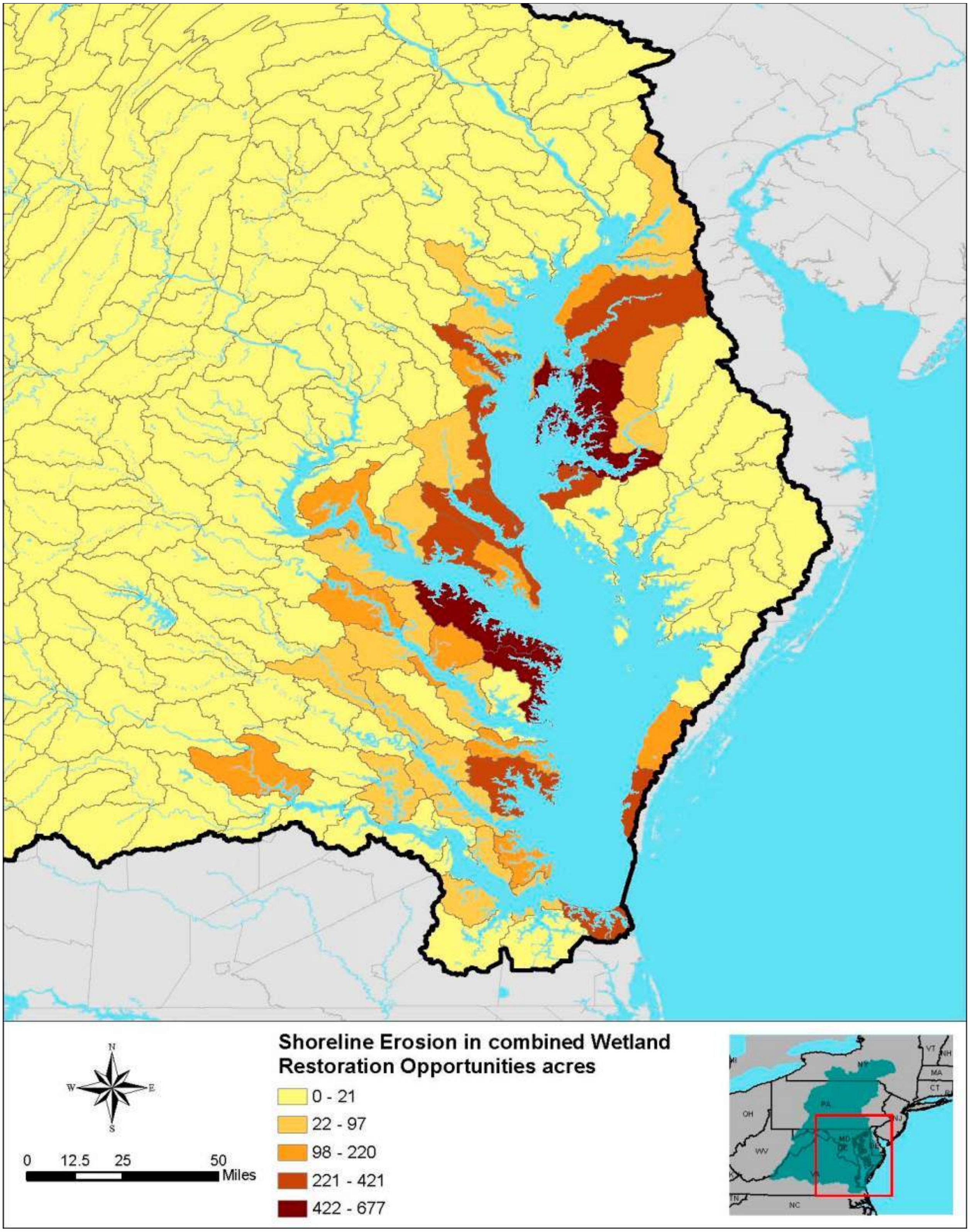


Figure 74. ***Opportunities*** **for considering shoreline erosion with wetland restoration: Acreage of combined wetland restoration opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-B)**

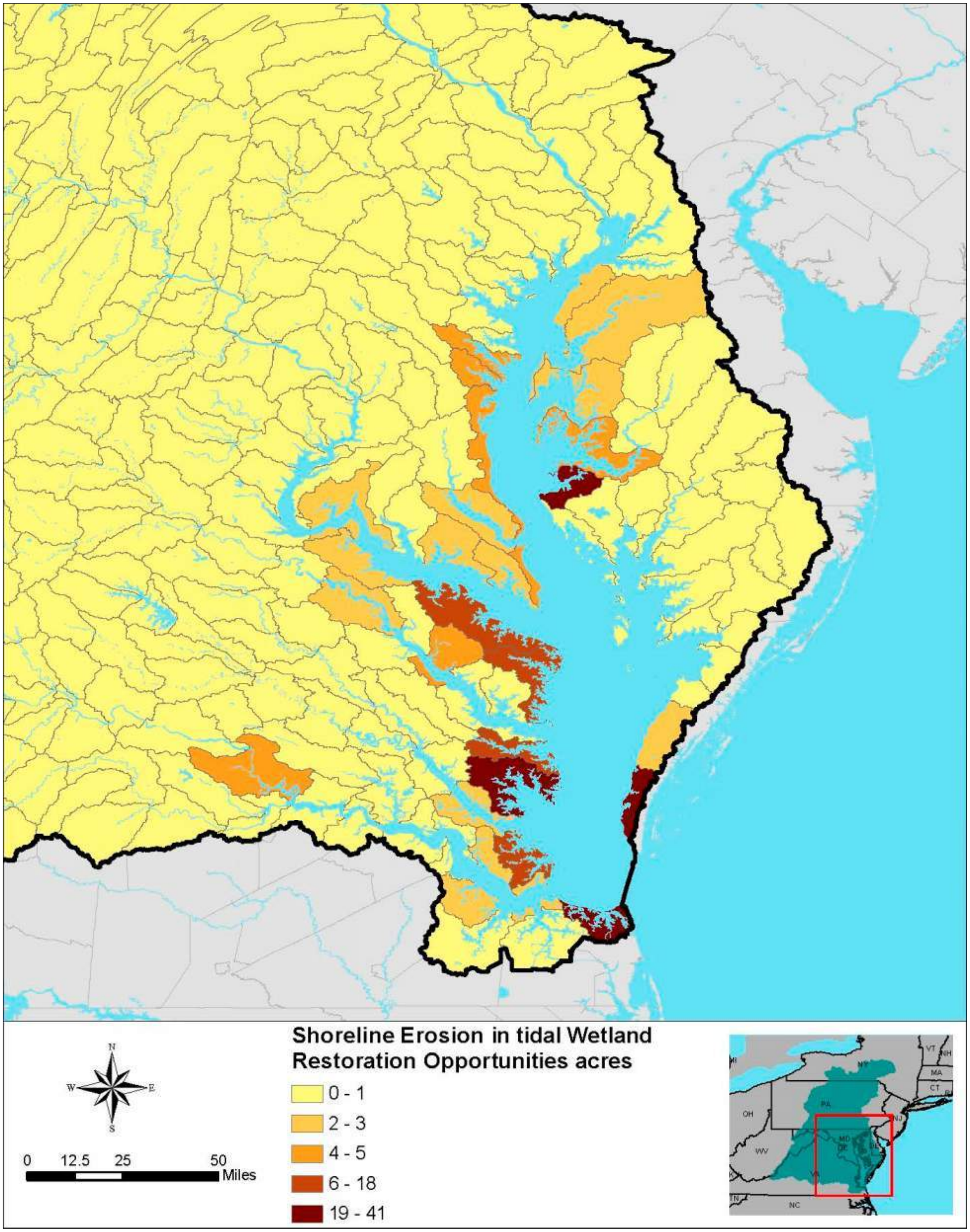


Figure 75. ***Opportunities*** **for considering shoreline erosion with tidal wetland restoration: Acreage of tidal wetland restoration opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-C)**

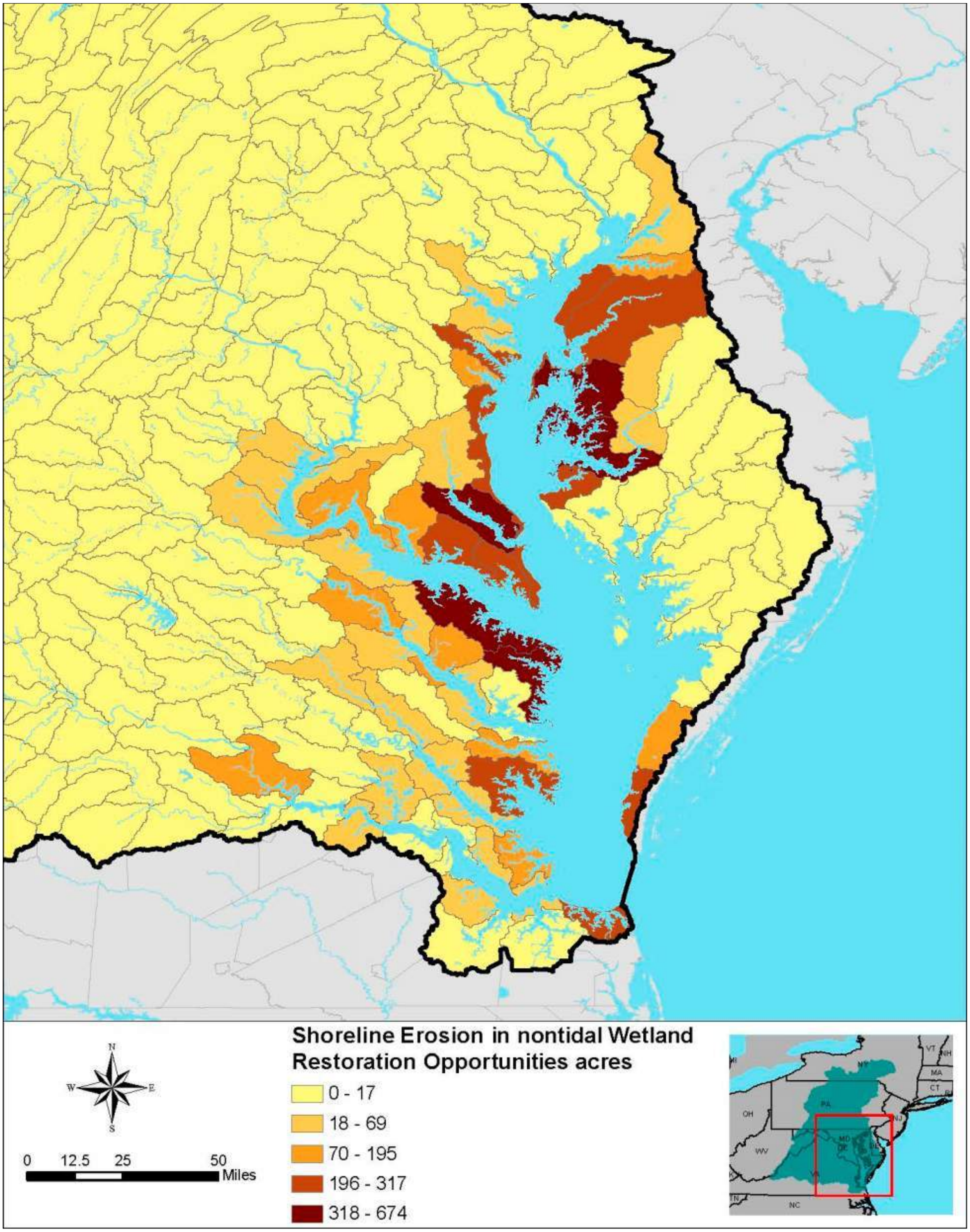


Figure 76. ***Opportunities*** **for considering shoreline erosion with nontidal wetland restoration: Acreage of nontidal wetland restoration opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-D)**

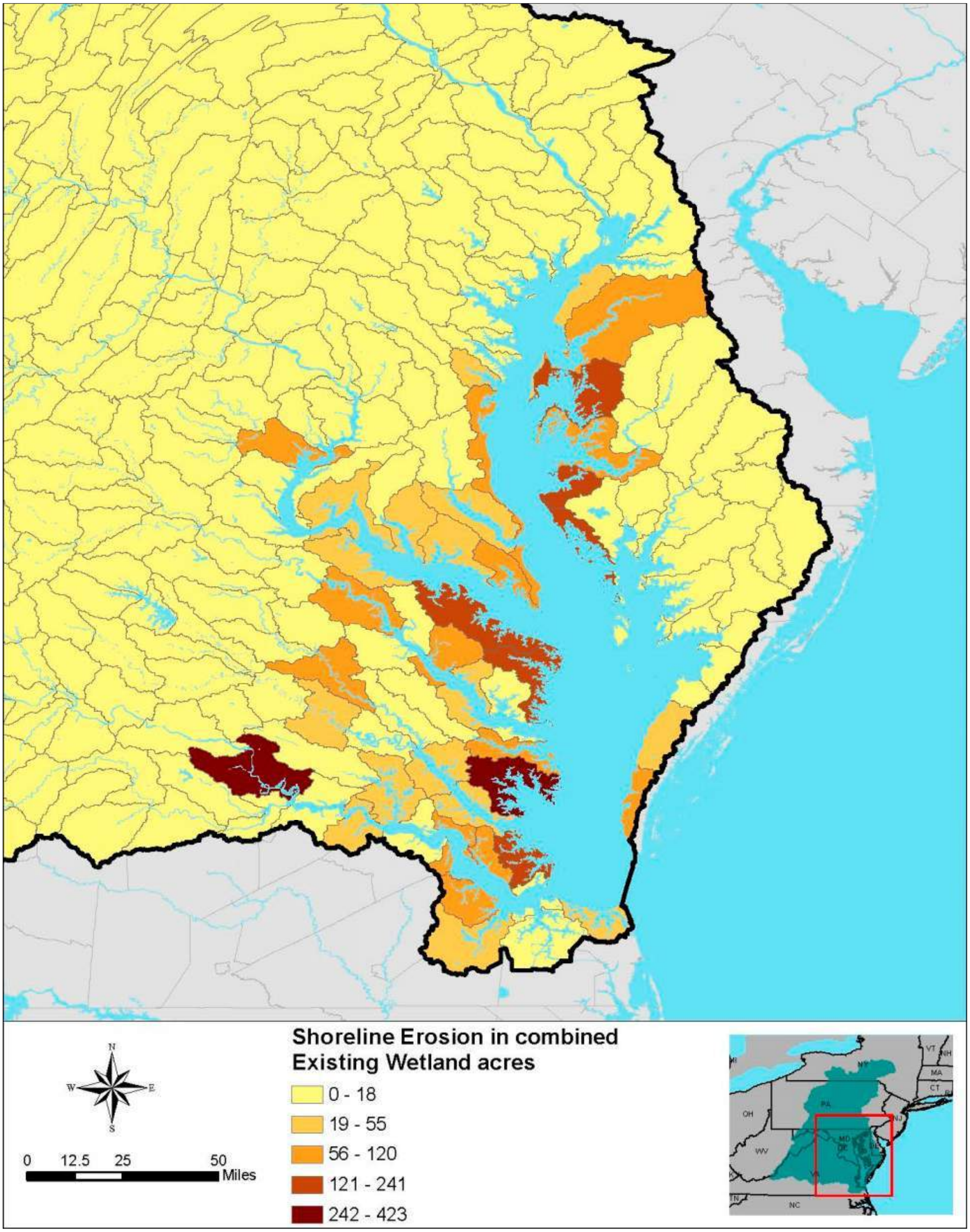


Figure 77. ***Opportunities*** **for considering shoreline erosion with wetland enhancement: Acreage of combined wetland enhancement opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-E)**

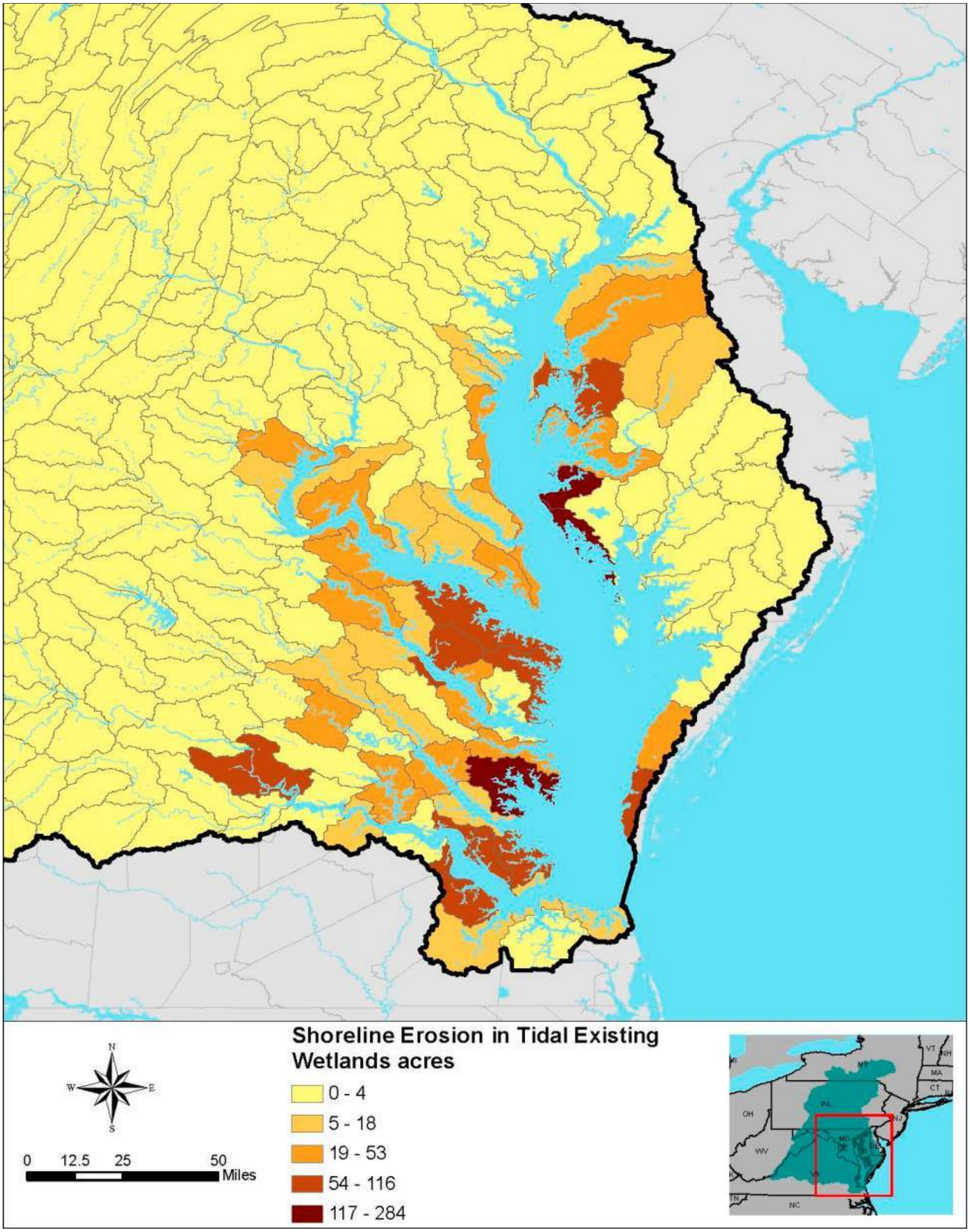


Figure 78. ***Opportunities*** **for considering shoreline erosion with tidal wetland enhancement: Acreage of tidal wetland enhancement opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-F)**

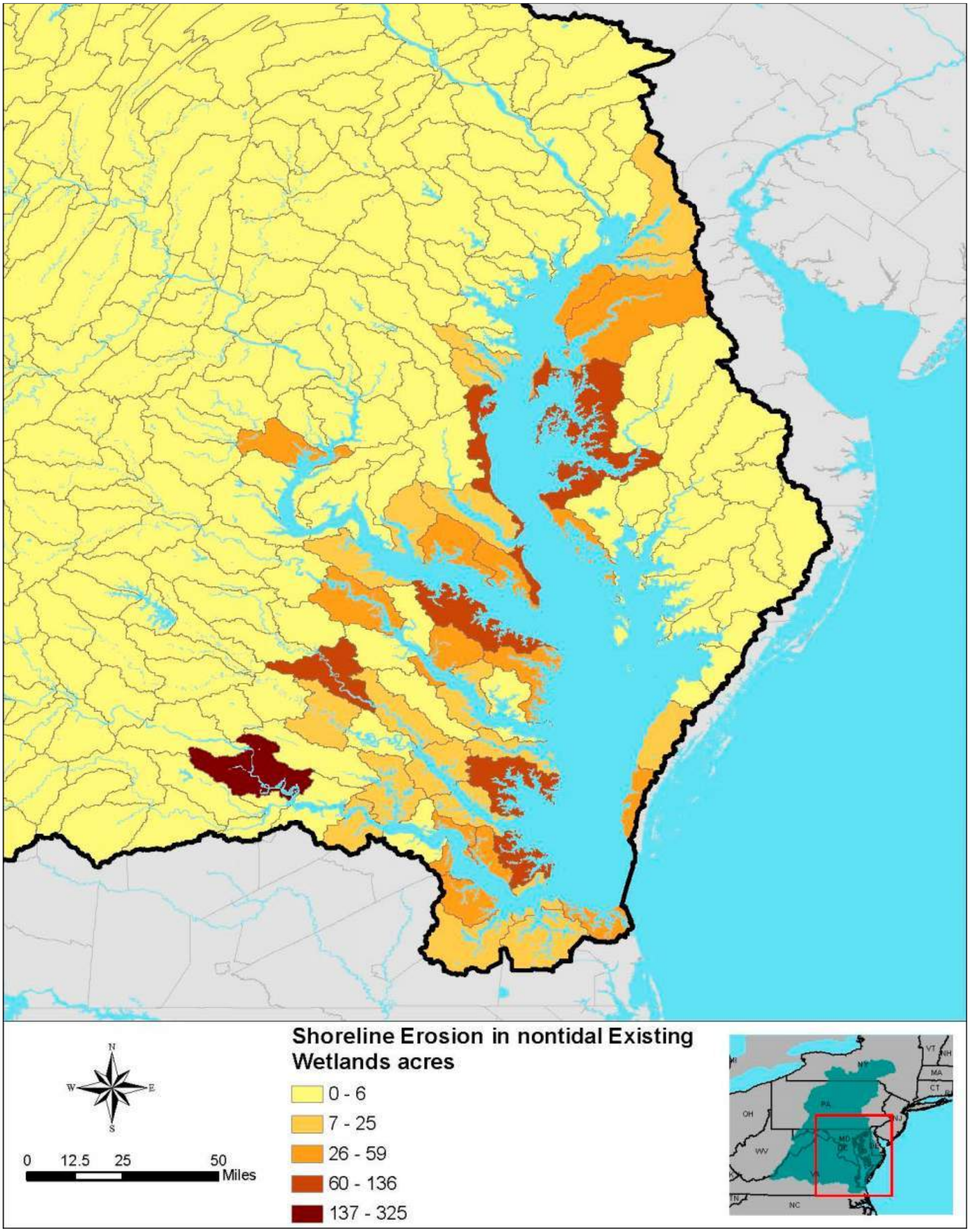


Figure 79. ***Opportunities*** **for considering shoreline erosion with nontidal wetland enhancement: Acreage of nontidal wetland enhancement opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-G)**

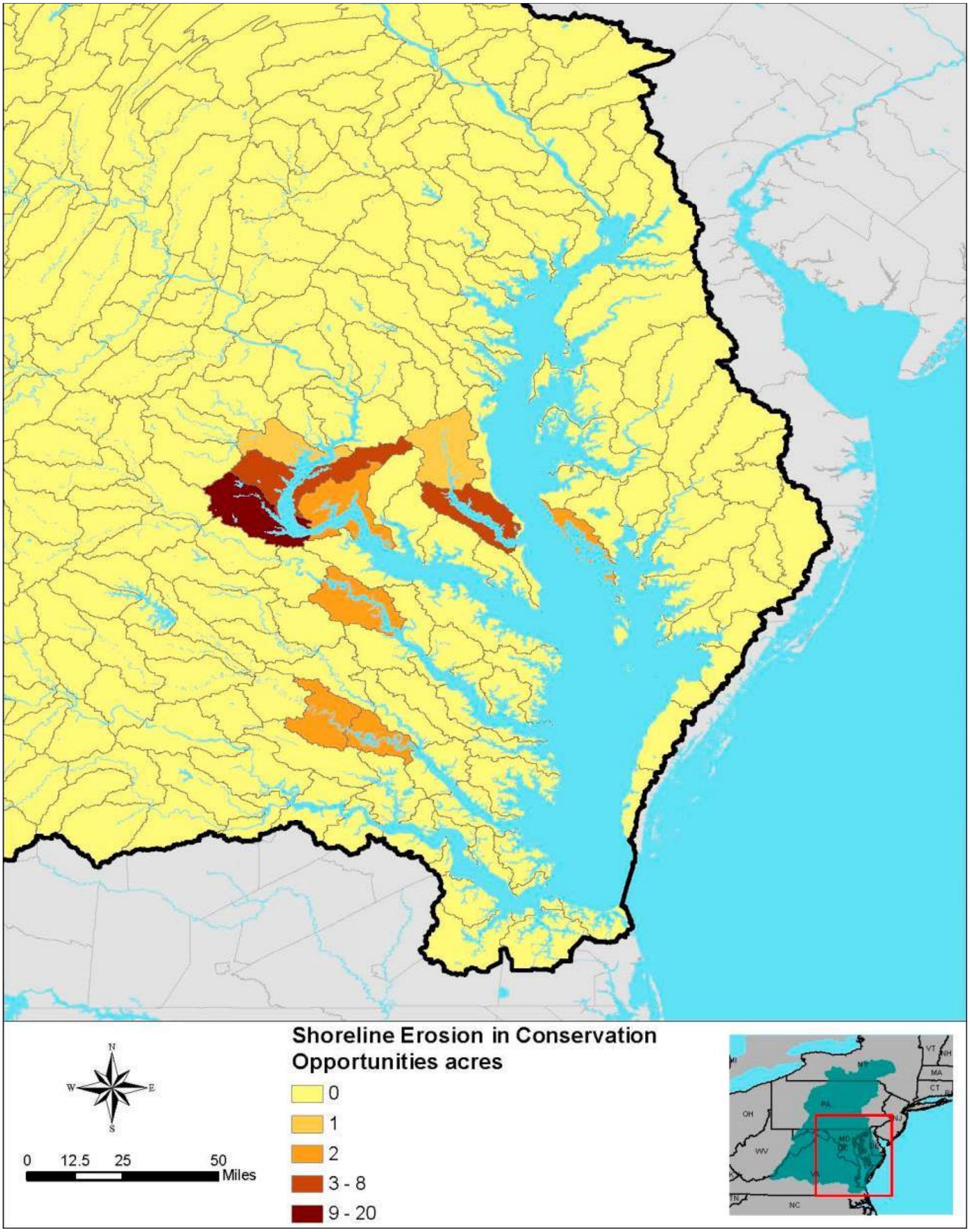


Figure 80. ***Opportunities*** **for considering shoreline erosion with conservation: Acreage of conservation opportunities affected by shoreline erosion by subwatershed (5-SS-ERO-H)**

Key points:

1. The subwatersheds with the greatest amount of acreage at risk to shoreline erosion are generally located between Eastern Bay on the mid-Eastern Shore of Maryland and the southern shore of the Potomac River in Virginia:

    a) Eastern Bay (MD)

    b) Lower Choptank River (MD)

    c) Herring Bay (MD)

    d) Lower Patuxent River (MD)

    e) Nomini Creek (VA)

    f) Great Wicomico River (VA)

2. Additional subwatersheds at high risk to impacts from shoreline erosion extend along the bay from above the Chester River south to Norfolk:

    a) Upper Chesapeake Bay (MD)

    b) Chester River (MD)

    c) Severn River (MD)

    d) South River (MD)

    e) Little Choptank River (MD)

    f) St. Mary's River (MD)

    g) St. Clements Bay (MD)

    h) Nanjemoy River (MD)

    i) Mobjack Bay (VA)

    j) Cherrystone Inlet (VA)

    k) Falling Creek in the James River (VA)

    l) Lynnhaven River (VA)

3. The subwatersheds with the greatest opportunity to use wetland restoration to address shoreline erosion are in the same general region as the subwatersheds with the greatest amount of shoreline erosion:

    a) Eastern Bay (MD)

b) Lower Choptank (MD)

c) Nomini Creek (VA)

d) Great Wicomico River (VA)

e) Severn River (MD)

f) Chester River (MD)

g) Little Choptank (MD)

h) Herring Bay (MD)

i) Lower Patuxent River (MD)

j) St. Clements Bay (MD)

k) Mobjack Bay (VA)

l) Cherrystone Inlet (VA)

m) Lynnhaven River (VA)

4. The subwatersheds with the greatest amount of existing wetlands at risk to eroding shorelines are listed below. There is also an opportunity to undertake enhancement of these wetlands to address shoreline erosion.

a) Falling Creek in the James River (VA)

b) Mobjack Bay (VA)

c) Eastern Bay (MD)

d) Little Choptank River (MD)

e) Honga River (MD)

f) Nomini Creek (VA)

g) Great Wicomico River (VA)

h) Back River – Lower Chesapeake (VA)

5. The highest acreage of conservation opportunities that could be affected by shoreline erosion are located along the Potomac River and Patuxent River systems:

a) Potomac Creek (MD/VA)

b) Quantico Creek (MD/VA)

c) Lower Patuxent River (MD)

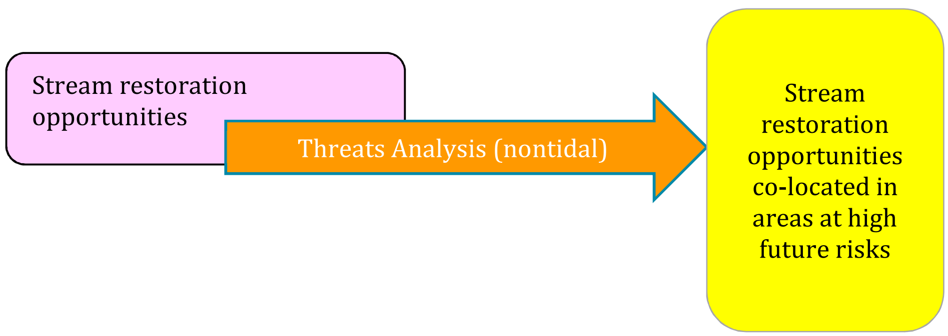
2.17 Identify if any areas targeted for stream restoration could incorporate features to reduce future risks (5-SS-SR)

Overview: Evaluate whether any opportunity areas identified for stream restoration are located in areas at high risk to future threats. Determine if the project incorporate features to address increased flooding or other future threats.

Data layers:

- *Stream restoration opportunities* – Generated in previous section
- *Threat analysis* – Nontidal component

Conceptual diagram, computations, and opportunities selection: Overlay in GIS the stream restoration opportunities layer with the nontidal component of the threats analysis. Identify those subwatersheds that have opportunities for stream restoration subwatersheds and are exposed to nontidal threats (**Figure 81**).



Map products:

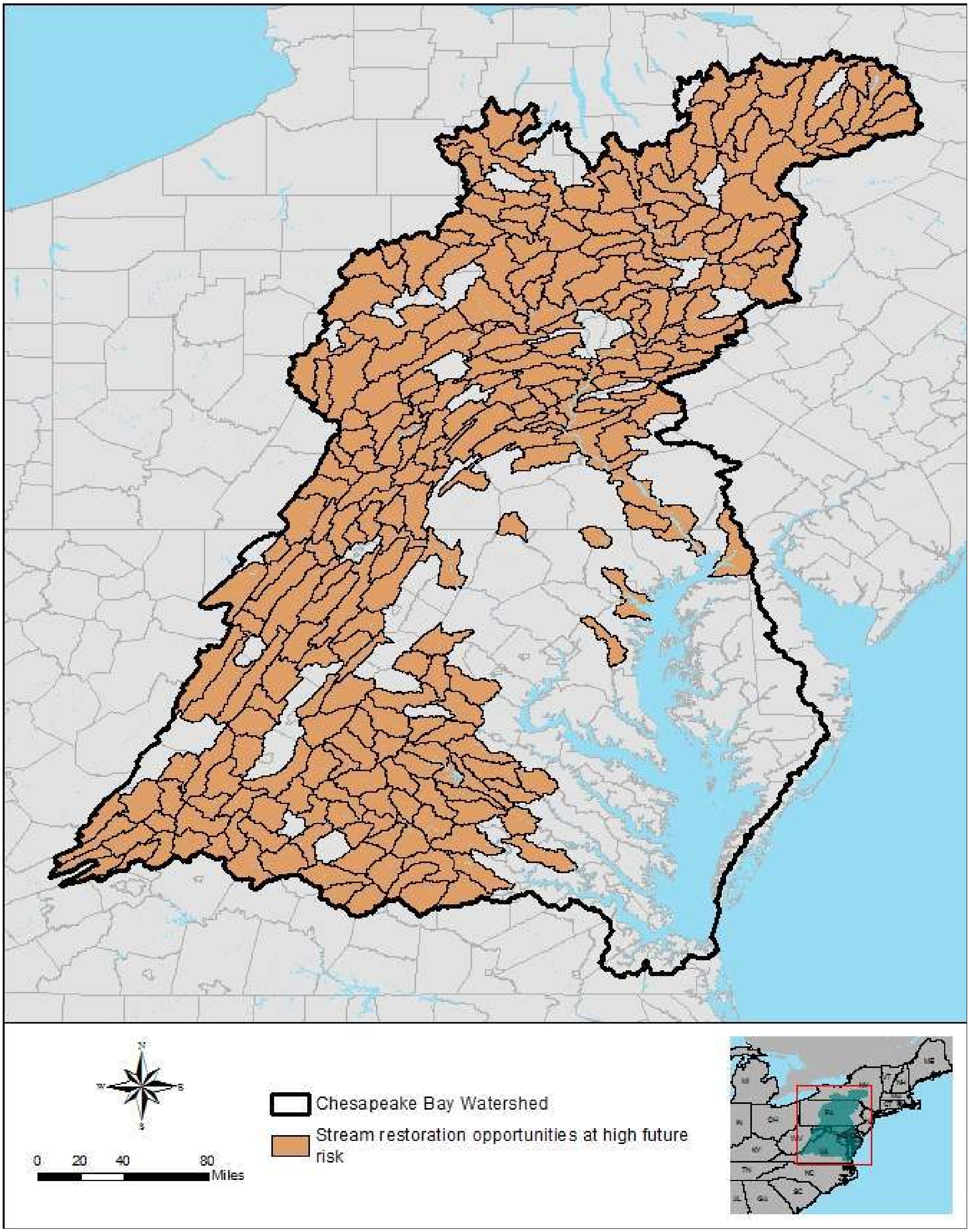


Figure 81. Stream restoration opportunities at risk to future nontidal threats (5-SS-SR)

Key Points:

1. Majority of the stream restoration opportunities have some level of nontidal threat associated with them.

2. Opportunities for stream restoration that do not have recognized future nontidal threats are:

    a) Upper Slate River (VA)
    b) Upper Cowpasture River (VA)
    c) Upper Jackson River (VA)
    d) Back Creek- Middle Jackson River (VA)
    e) Lower Tye River (VA)
    f) South Mill Creek (WV)
    g) Long Hollow Run (MD/WV)
    h) Savage River (MD)
    i) Upper West Branch Susquehanna (PA)
    j) Mosquito Creek (PA)
    k) Sinnemahoning Creek (PA)
    l) Upper West Branch Susquehanna (PA)
    m) Young Womans Creek (PA)
    n) Mehoopany Creek (PA)
    o) Tuscarora Creek (NY)

2.17.1 Toxic Contaminants

(6) Can restoration and conservation opportunities within the watershed be leveraged to assist with addressing toxic contamination?

2.18 Are there opportunities to address toxic contaminants? (6-TOX)

Overview: Identify areas within the Chesapeake Bay Watershed with known toxic contamination.

Data layers:

- *NPL (Superfund Sites)* – NPL Coordinate locations were downloaded from https://toxmap-classic.nlm.nih.gov/toxmap/superfund/identifyAll.do. Coordinates were then cross referenced with EPA Superfund NPL sites for accuracy.

- *Abandoned mines and Abandoned Mine Land Problem Areas* – PADEP – Priority 1, 2, and 3 Mine Drainage Treatment/Land Reclamation Locations are clean-up projects that are working to eliminate some form of abandoned mine. The following sub-facility types are included: Abandoned Coal Refuse Pile Reclamation Abandoned Deep Mine Reclamation Abandoned Mine Drainage Treatment Abandoned Oil and Gas Well Reclamation Abandoned Surface Mine Reclamation Internal Monitoring Point. Abandoned Mine Land Problem Areas -Areas containing public health, safety, and public welfare problems created by past coal mining. It is a subset of data contained in the Office of Surface Mining (OSM) Abandoned Mine Land Inventory. This layer identifies AML Points representing specific locations within an AML Inventory Site, examples include AML discharge.

Description of analysis: The NPL location data was depicted with the abandoned mines and abandoned mine land problem areas, but no computations were completed to identify any relationships, as this exercise was exclusively to identify and call attention to areas with toxic contaminants (**Figure 82**). **Figure 83** was generated to depict the extent of military lands with NPL sites.

Map products:

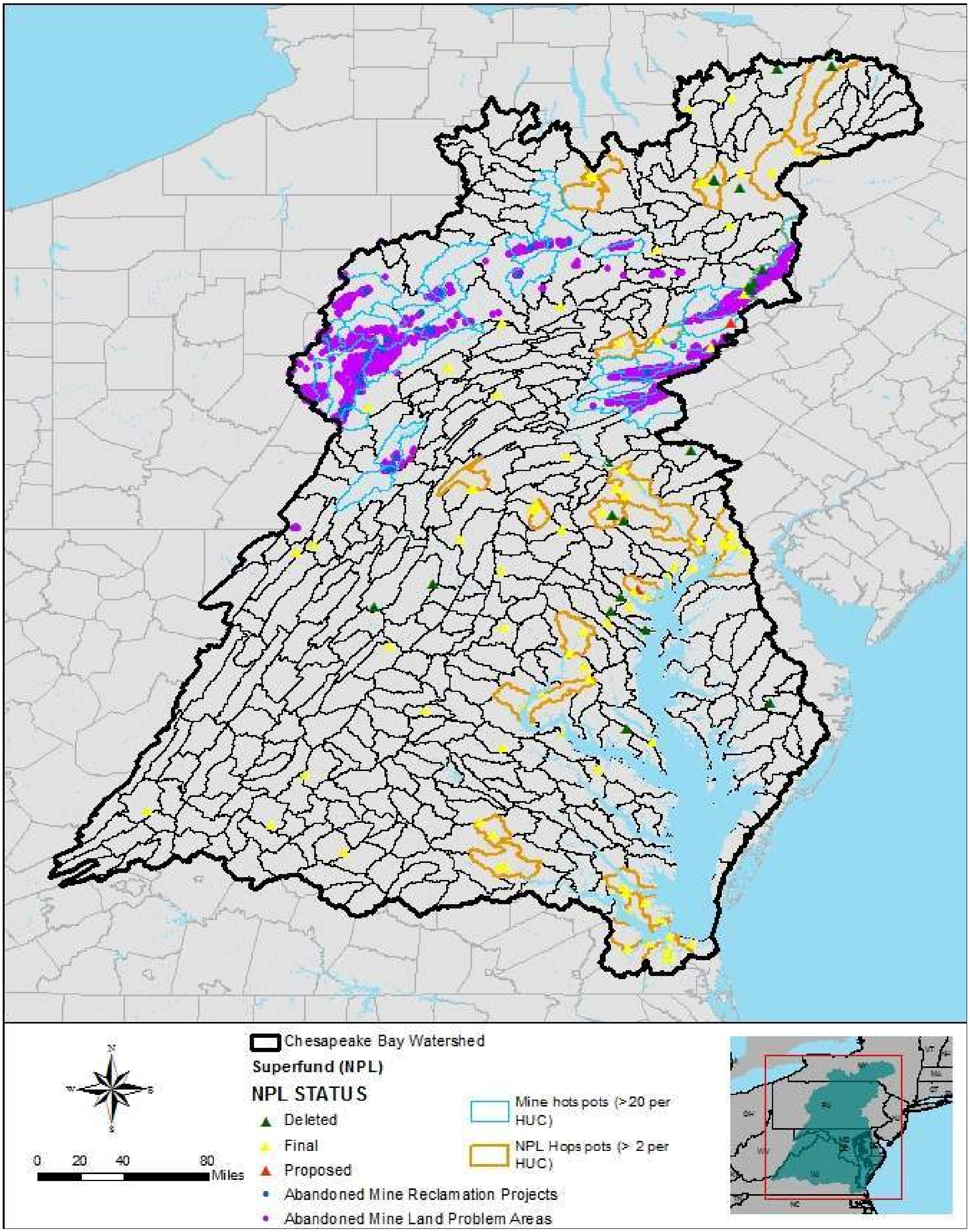


Figure 82. Locations of superfund sites and abandoned mine land problem areas and reclamation projects (6-TOX-A)

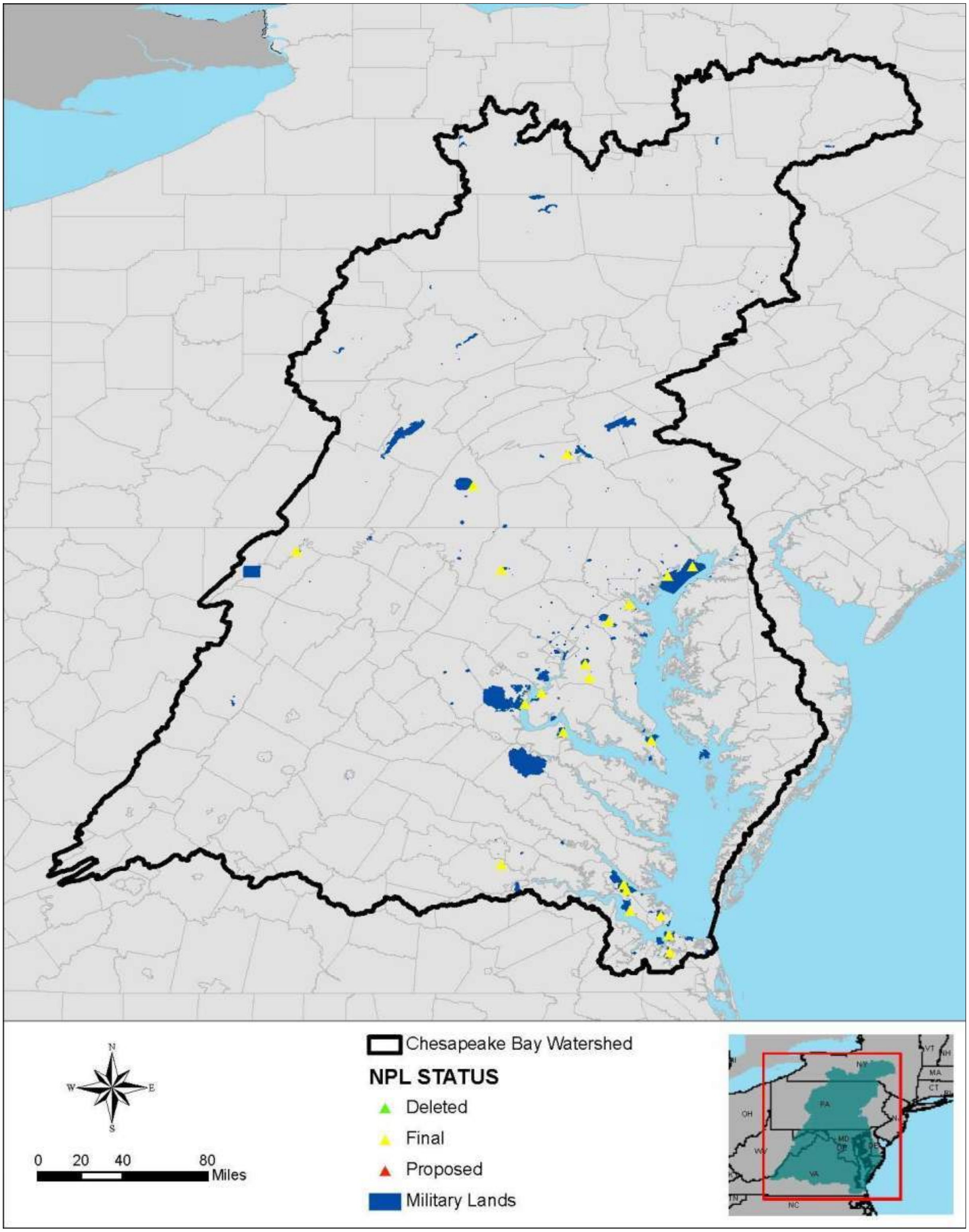


Figure 83. Military lands in conjunction with 'final' listings of NPL sites (6-TOX-B)

Key points:

1. There are broad habitat restoration and conservation opportunities associated with lands impacted by acid mine drainage in Pennsylvania.
2. Toxic contamination points are distributed throughout the Chesapeake Bay Watershed, but are minimal on the Delmarva Peninsula, in western Virginia, and in West Virginia.
3. A complete acid mine drainage data layer that includes data for all states in the watershed would be useful to compile.
4. An analysis at a finer scale is required to determine the exact relationship between a contamination point and restoration/conservation opportunities.

3.0 Other Considerations

3.1 Eastern Brook Trout

Analyses were taken one step further for EBT opportunities. The conservation portfolio developed by Trout Unlimited was considered within the context of the opportunities this analysis identified for stream restoration opportunities to benefit EBT. The acreage of each conservation strategy was tallied within each subwatershed. A map was developed to portray the conservation strategies and the boundaries of the stream restoration opportunities for EBT. The conservation strategies were incorporated into the Strategic Roadmap to assist with prioritizing between stream restoration opportunities.

Additionally, the CBCP evaluated the conservation portfolio to align recommendations based on how each strategy was defined (Fessenmeyer et al. 2017).

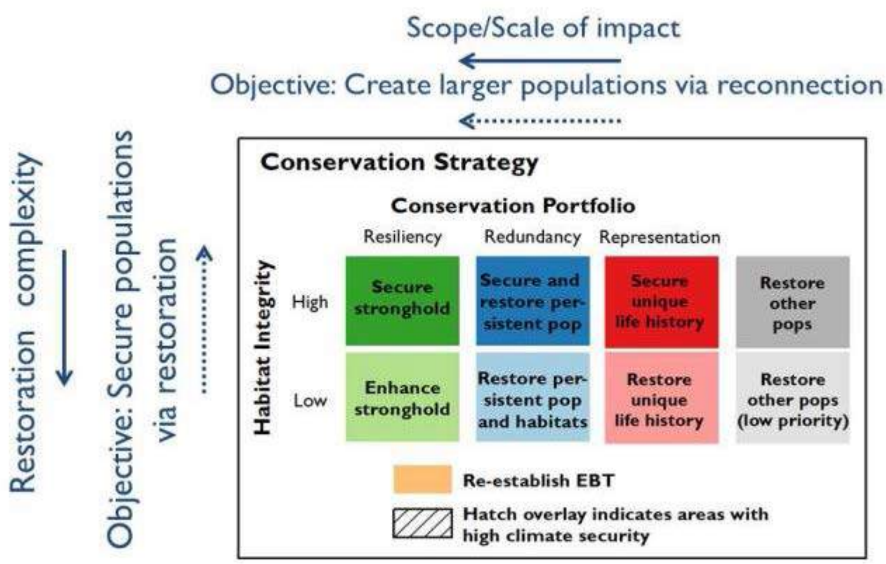


Figure 84. Eastern brook trout conservation portfolio (reproduced from Fessenmeyer et al. 2017)

The conservation portfolio assigned existing EBT patches to one of the following strategies identified in **Figure 84** and defined below. The aim of the conservation strategy is to address stressors and habitat needs in patches to increase habitat integrity and achieve resilience (move patches along the grid shown in **Figure 84** up and to the left). Towards that effort, the restoration opportunities that the CBCP identified in EBT patches (stream restoration, riparian buffer restoration, fish passage blockage removal, and management of watershed stressors) were evaluated in the context of the conservation portfolio strategies. Proposed actions to benefit EBT are presented in the following discussion for each of the conservation portfolio strategies focused on EBT restoration.

Secure stronghold strategy: Limited restoration action likely required to secure these populations. Conservation, protection to prevent new stressors, mitigation of future threats.

- CBCP Proposed Action – Identify conservation opportunities in opportunities with these patches.

Enhance stronghold strategy: Restoration focused on addressing existing stressors within these patches.

- CBCP Proposed Actions – Identify stressors using watershed stressors analysis and recommend measures to address stressors. Select WSA = 0.45–0.7, determine what the impairments are and recommend measures to improve conditions. If WSA >0.8, but IBI is fair, poor, or very poor, suggest stream (habitat) restoration.

Secure unique life history: Assigned to patches which do not meet portfolio redundancy and resiliency criteria, but which may contain unique life histories

- Comp Plan Proposed Action – conservation

Secure and restore persistent populations strategy: Restoration through non-native trout eradication or connectivity enhancements, limited habitat restoration efforts, remove fish blockages to connect larger blocks of habitat

- CBCP Recommendation – Primary actions are focused on increasing connectivity by removal of fish passage blockages. Identify if there are fish passage blockage removal opportunities by incorporating the number of EBT prioritized blockages. Select opportunities subwatersheds where "secure and restore persistent pops and habitat" (dark and light blue patches), overlay EBT prioritized fish passage blockages. Recommend consideration of habitat restoration if WSA > 8.0 and possible restoration if between 0.45–0.7. Also, recommend consideration of non-native trout eradication.

Restore persistent populations and habitats strategy: restoration through non-native trout eradication; likely with concurrent habitat restoration work (*Sequencing/dependency), remove fish blockages to connect larger blocks of habitat

- Comp Plan Proposed Action – Identify stream restoration for EBT opportunities with 'unstressed' conditions by selecting those with WSA = 0.8-1.0. Recommend these subwatersheds for stream (habitat) restoration and non-native trout eradication. Identify if there are fish passage blockage removal opportunities by incorporating the number of prioritized blockages. Determine if there are riparian buffer opportunities based on whether the subwatershed was a riparian buffer opportunity for EBT.

Restore unique life history: Provide opportunity for population and habitat restoration work to shift patches into redundant category

- Comp Plan Proposed Action – stream restoration

Actionable measures were identified for opportunities using the conservation portfolio strategies and the watershed stressors analysis as described in **Table 9**. Individual subwatersheds often contain patches that are classified into different strategies by the EBT conservation portfolio. Proposed actions incorporate the recommendations and strategies outlined in the Partnerhsip's management strategy for EBT and stream restoration, riparian buffer restoration, and fish passage blockage removal opportunity analyses undertaken as part of this CBCP.

Table 9. Proposed actions to benefit EBT

SUBWATERSHED	NAME	STATES	Watershed Stressor Scores	Brook Trout (Linear Feet)	IBI Scores	Secure stronghold (Linear Feet)	Enhance stronghold (Linear Feet)	Restore persistent pop and habitats (Linear Feet)	Secure and restore persistent pop. (Linear Feet)	Restore unique life history (Linear Feet)	Secure unique life history (Linear Feet)	Number of CBP Tier 1 Blockages within Brook Trout opportunity	Riparian Buffer opportunity (yes or no)	Proposed Actions
0205020106	Mosquito Creek	PA	0.7	508317	VERY_POOR		386441					4	N	address stressors = BMPs focused on N and P; address 303(d) listing; stream restoration
0205020608	Muncy Creek	PA	0.7	512567	GOOD			370825				5	N	fish passage; non-native trout eradication
0205010612	Tunkhannock Creek	PA	0.6	512948	FAIR		645928	123649		43063		30	Y	address stressors = BMPs focused on N and P, riparian buffers; address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0205020201	Sinnemahoning Portage Creek	PA	0.8	514463	GOOD			302997	36924			2	N	fish passage; non-native trout eradication
0208020104	Potts Creek	VA	0.8	515505	GOOD			279915	25815			1	Y	riparian buffers; fish passage; non-native trout eradication
0205010708	Catawissa Creek	PA	0.7	519114			492148	59204				18	N	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0205010113	Lower Susquehanna River	NY, PA	0.6	530897			372328	214259		70812		43	Y	address stressors = BMPs focused on N and P, riparian buffers; address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0205010602	Schrader Creek	PA	0.8	533689	VERY_POOR		515678					3	N	stream restoration
0207000505	Dry River	VA	0.7	539017	GOOD		288088		251197			3	N	address stressors = BMPs focused on N and P, address 303(d) listing; fish passage; non-native trout eradication
0208020201	Calfpasture River	VA	0.8	576241	FAIR		450467	114391	18279			2	Y	stream restoration; riparian buffers; fish passage; non-native trout eradication
0207000508	Naked Creek-South Fork Shenandoah River	VA	0.5	597132	VERY_POOR			310264	129829			1	Y	riparian buffers; fish passage; non-native trout eradication
0205010609	Mehoopany Creek	PA	0.8	614422	FAIR	325507	178570					5	N	conservation; stream (habitat) restoration
0205030501	Sherman Creek	PA	0.7	617716	FAIR			78104		113228		2	Y	riparian buffers; non-native trout eradication; stream restoration
0205010703	Middle Susquehanna River	PA	0.7	623694				275091		267289		24	Y	riparian buffers; fish passage; non-native trout eradication; stream restoration
0205010704	Nescopeck Creek	PA	0.7	631486			504964	16985				10	N	BMPs focused on N and P, possibly riparian buffers; address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0207000601	Shoemaker River-North Fork Shenandoah River	VA	0.8	645626	GOOD		293377	217689	68477			3	Y	stream restoration; riparian buffers; fish passage; non-native trout eradication
0208020305	Upper Tye River	VA	0.8	676372	FAIR		530850					1	N	stream restoration
0207000201	Savage River	MD	0.8	696899			326060	272138				2	N	stream restoration; fish passage; non-native trout eradication
0205020104	Upper West Branch Susquehanna River	PA	0.6	699153	VERY_POOR			533489				9	Y	riparian buffers; fish passage; non-native trout eradication
0205020105	Moshannon Creek	PA	0.7	717539	FAIR			368984	159235			11	Y	riparian buffers; fish passage; non-native trout eradication
0207000202	Stony River-North Branch Potomac River	MD, WV	0.6	741746				733245					Y	riparian buffers; non-native trout eradication
0205020603	Upper Loyalsock Creek	PA	0.7	754078	FAIR		639166					10	N	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration
0205010707	Fishing Creek	PA	0.6	756932	FAIR		381542					3	Y	address stressors = BMPs focused on N and P, riparian buffers; address 303(d) listing; stream restoration; fish passage
0205020402	Beech Creek	PA	0.8	773448	FAIR			517141	64143			3	N	stream restoration; fish passage; non-native trout eradication
0208020105	Lower Jackson River	VA	0.7	801641	GOOD		211012	419620	80044			3	Y	address stressors = BMPs focused on N and P, address 303(d) listing; riparian buffers; fish passage; non-native trout eradication
0205010409	Tioga River	NY, PA	0.6	819559	GOOD		316542	199396				7	Y	address stressors = BMPs focused on N and P, riparian buffers, address 303(d) listing; riparian buffers; fish passage; non-native trout eradication
0205020403	Fishing Creek	PA	0.8	828169	FAIR			737911				3	N	fish passage; non-native trout eradication

SUBWATERSHED	NAME	STATES	Watershed Stressor Scores	Brook Trout (Linear Feet)	IBI Scores	Secure stronghold (Linear Feet)	Enhance stronghold (Linear Feet)	Restore persistent pop and habitats (Linear Feet)	Secure and restore persistent pop. (Linear Feet)	Restore unique life history (Linear Feet)	Secure unique life history (Linear Feet)	Number of CBP Tier 1 Blockages within Brook Trout opportunity	Riparian Buffer opportunity (yes or no)	Proposed Actions
0205020103	Clearfield Creek	PA	0.6	915192	VERY_POOR		429510	360139		313746		15	Y	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration; riparian buffers; fish passage; non-native trout eradication
0205020505	Little Pine Creek	PA	0.7	949108	FAIR		90065	336725				1	N	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0205020602	Lycoming Creek	PA	0.8	1121430	FAIR		154413	539258	60987	25727		3	Y	stream restoration; riparian buffers; fish passage; non-native trout eradication
0205020502	Upper Pine Creek	PA	0.7	1170368	FAIR		415177	459141					N	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration; non-native trout eradication
0205020605	Lower Loyalsock Creek	PA	0.7	1234072	VERY_POOR			762821	121167			8	Y	riparian buffers; fish passage; non-native trout eradication
0207000101	North Fork South Branch Potomac River	VA, WV	0.7	1276369	GOOD		1074881	78118					Y	address stressors = BMPs focused on N and P, address 303(d) listing; riparian buffers; non-native trout eradication
0205010701	Lackawanna River	PA	0.5	1319087			4	241980		263687	48699	54	Y	conservation; address stressors = BMPs focused on N and P, riparian buffers; address 303(d) listing; stream restoration; fish passage; non-native trout eradication
0205020506	Lower Pine Creek	PA	0.7	1320049	FAIR			760737	91311				Y	riparian buffers; non-native trout eradication
0205020304	Lower West Branch Susquehanna River	PA	0.7	1336607	FAIR			839658	82920			5	Y	riparian buffers; fish passage
0205020202	Driftwood Branch Sinnemahoning Creek	PA	0.7	1369107	GOOD			760172	115649			1	Y	riparian buffers; fish passage; non-native trout eradication
0205020301	Kettle Creek	PA	0.7	1442818	GOOD		706792	318610	120764			1	Y	address stressors = BMPs focused on N and P, address 303(d) listing; riparian buffers; fish passage; non-native trout eradication
0205020107	Lower West Branch Susquehanna River	PA	0.7	1565802	VERY_POOR		395828	579956	122154			2	Y	address stressors = BMPs focused on N and P, address 303(d) listing; stream restoration; riparian buffers; fish passage; non-native trout eradication
0205020204	First Fork Sinnemahoning Creek	PA	0.8	1653693	GOOD		395229	861790	171128			1	Y	stream restoration; riparian buffers; fish passage; non-native trout eradication
0205020203	Bennett Branch Sinnemahoning Creek	PA	0.6	1804035	VERY_POOR		494584	747110	176150			3	Y	address stressors = BMPs focused on N and P, address 303(d) listing; riparian buffers; fish passage; non-native trout eradication

3.2 Marsh Migration

As sea levels rise, the ability of a marsh to migrate inland will be an important factor determining the future location of tidal wetlands. NOAA (2015) developed a model based on previous work by The Nature Conservancy that evaluates the potential for tidal wetlands to migrate inland. A cost distance approach was taken that considers elevation and land use adjacent to existing wetlands to estimate the inland migration potential. The results of NOAA's modeling were incorporated with CBCP analyses as described below. The intent was to identify where wetland restoration opportunities should consider inland migration corridors.

1. Overlay the existing wetlands layer to show the connectivity of migration corridors to existing wetlands.
2. Determine which subwatersheds have the greatest opportunity for marsh migration. Tally the acres of greens and blues in each subwatershed. Provide the results in the standard color ramp determined by the Jenks method.
3. Overlay the migration/cost corridor data on top of the tidal wetland restoration opportunity results.
4. Overlay the migration/cost corridor data on top of the threats to existing tidal wetlands opportunity results.

Figure 85 provides the results of NOAA's work and shows existing wetlands.

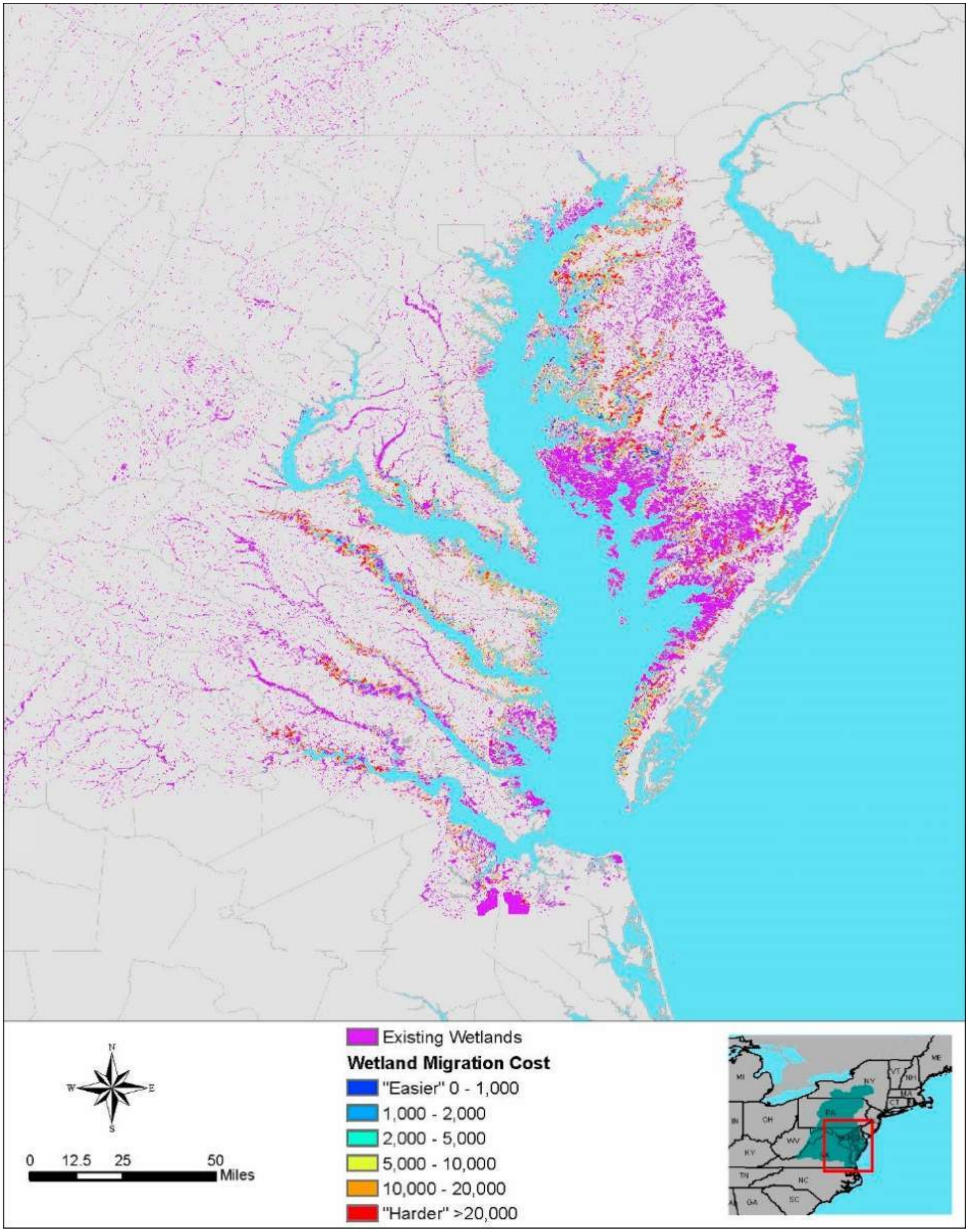


Figure 85. Marsh migration modeling by NOAA (2015) and existing wetlands (7-MM-A)

Figure 86 portrays the total number of acres that were determined by NOAA's modeling to have a low cost for migration (0-5,000 in **Figure 85**) as classified into five groups using the Jenks method. The upper/middle Eastern Shore of Maryland region is a focal location for low cost marsh migration: Chester River, Eastern Bay, Lower Choptank, and the Transquaking River. The Lower Patuxent, Nomini Creek (Potomac), Mobjack Bay, Pungoteague Creek, Occupacia Creek (Rappahannock), Middle Choptank, Nanticoke, Blackwater, and the Little Choptank River subwatershed are also areas where marsh migration may be possible on a meaningful scale.

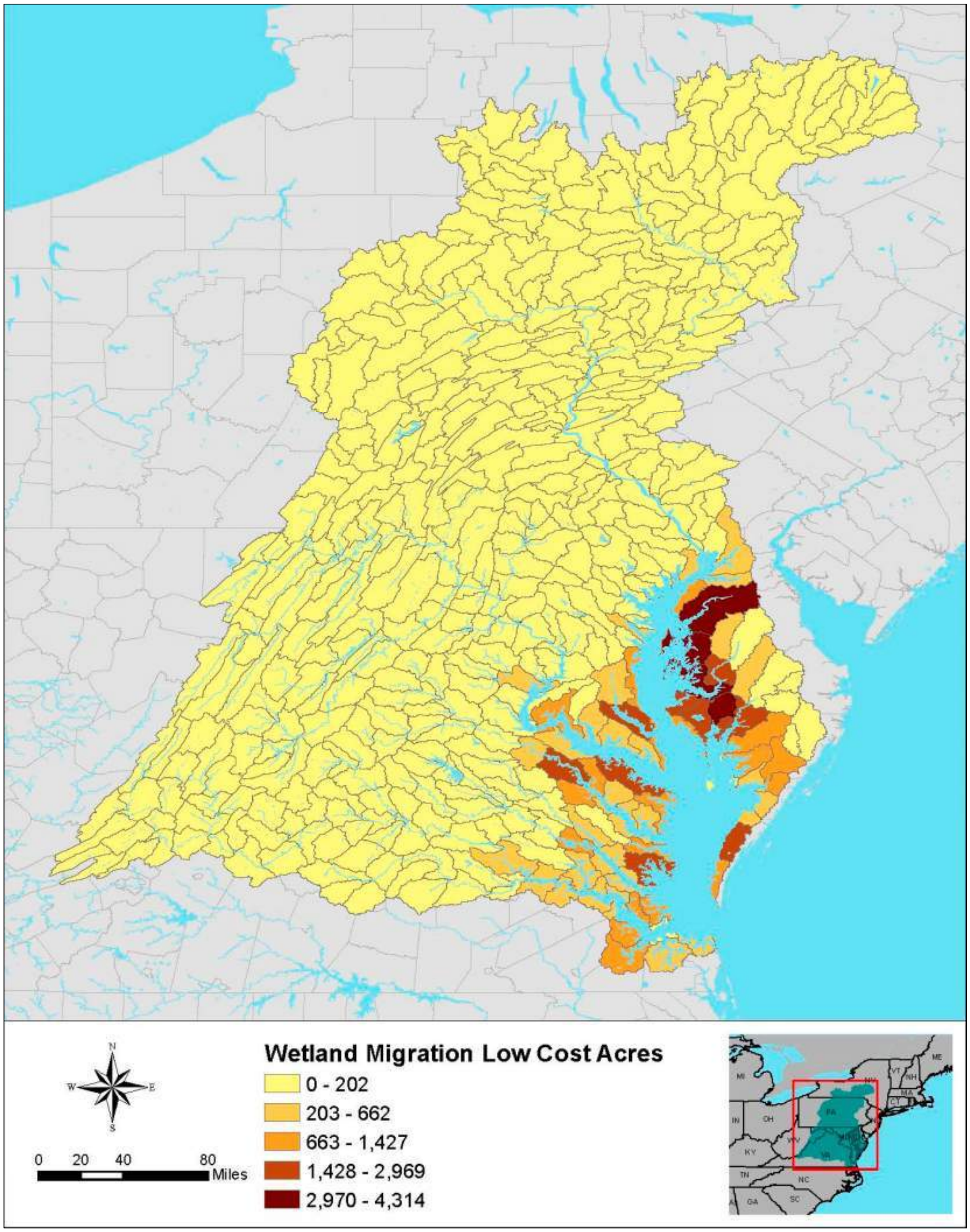


Figure 86. Total acres by subwatershed projected to have a low cost for marsh migration (7-MM-B)

The greatest need for marsh migration corridors will be where threats to sea level rise are the greatest. The following two figures consider where there is the greatest overlap of threatened (existing) wetlands and low-cost migration corridors (**Figure 87**) and where restoration opportunities exist that could be paired with facilitating migration corridors (**Figure 88**). The wetlands in the Blackwater/Tangier Sound region face the greatest threat to sea level rise. There are also vast opportunities for wetlands restoration in that area, as well as potential for low cost marsh migration.

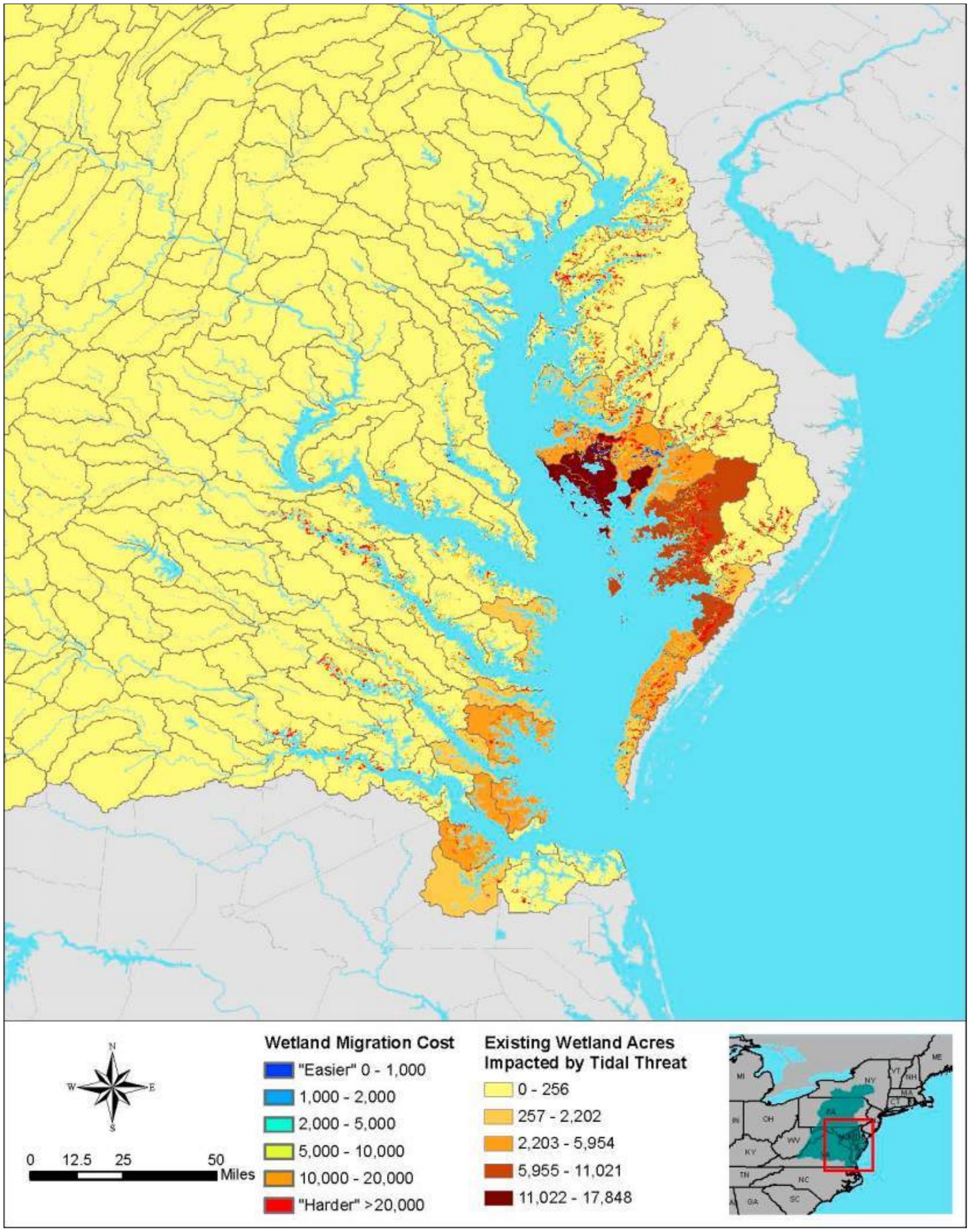


Figure 87. Overlap of threatened, existing wetlands, and low-cost migration corridors (7-MM-C)

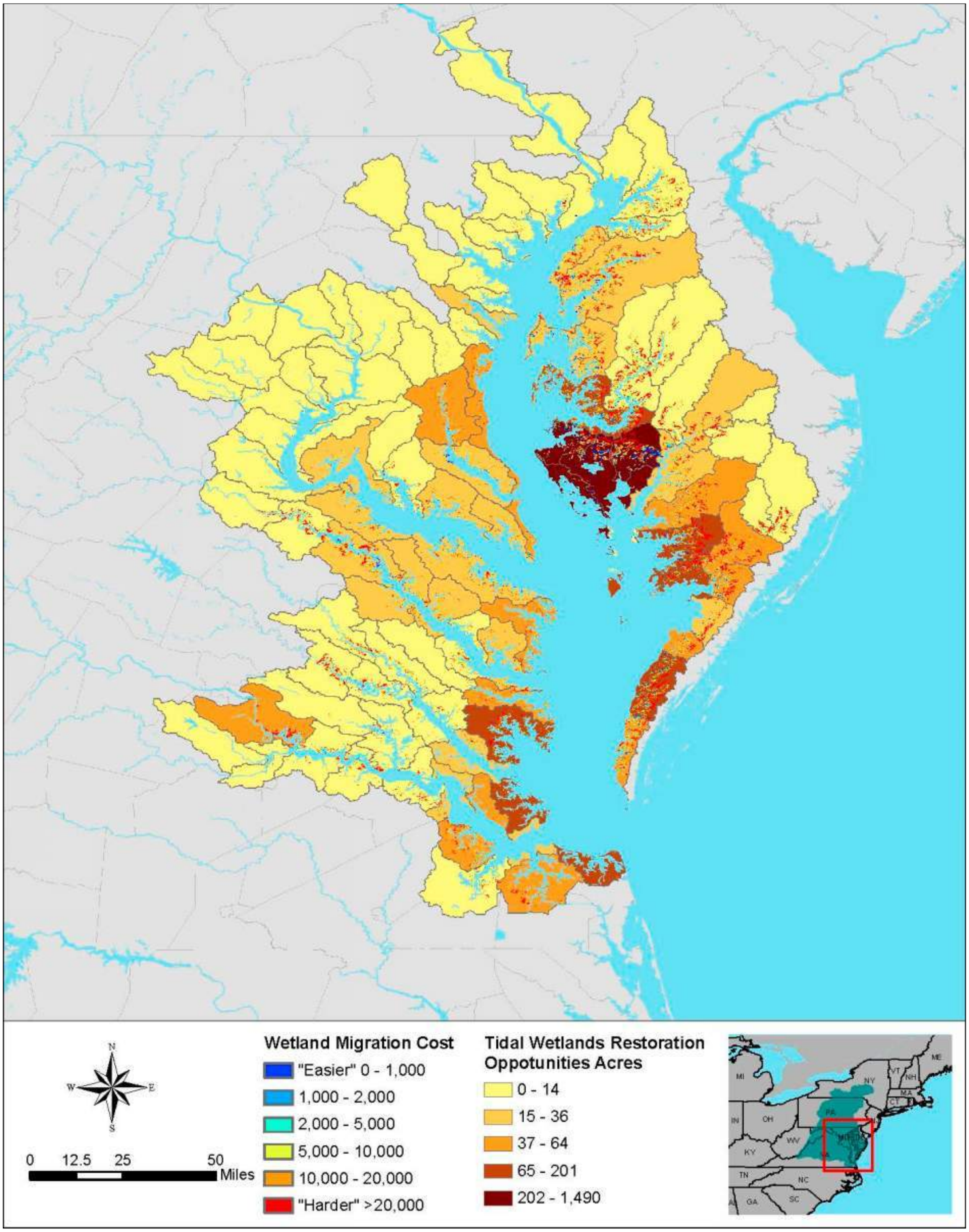


Figure 88. Extent of opportunities to undertake wetlands restoration within migration corridors (7-MM-D)

3.3 Rare, Threatened and Endangered Species

USFWS identified the presence of rare, threatened, and endangered (RTE) or T&E species and species of concern by subwatershed. To identify restoration and conservation opportunities that could be undertaken to enhance the habitat for these species, an assessment was made to identify whether these species were aquatic species. If an aquatic species, it was determined which were associated with streams or wetlands. **Figures 89 - 92** provide maps of the distribution of federally listed species as well as those identified as species of concern by USFWS. The spatial distribution (subwatershed locations) of these species were then matched with the subwatersheds identified for stream and wetland restoration and conservation opportunities through other CBCP analyses. **Figures 89 - 92** depict these results.

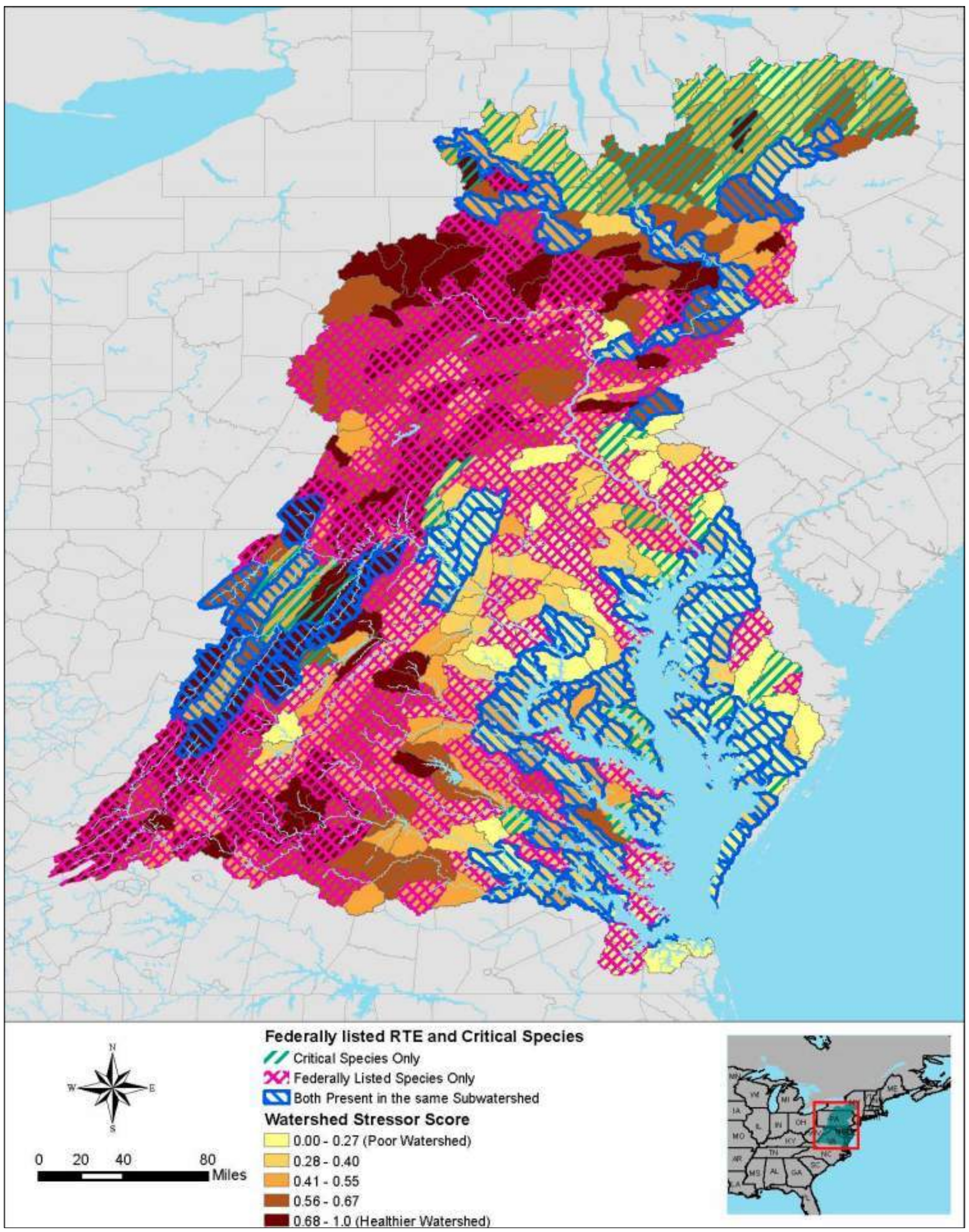


Figure 89. Spatial distribution of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed (7-RTE-A)

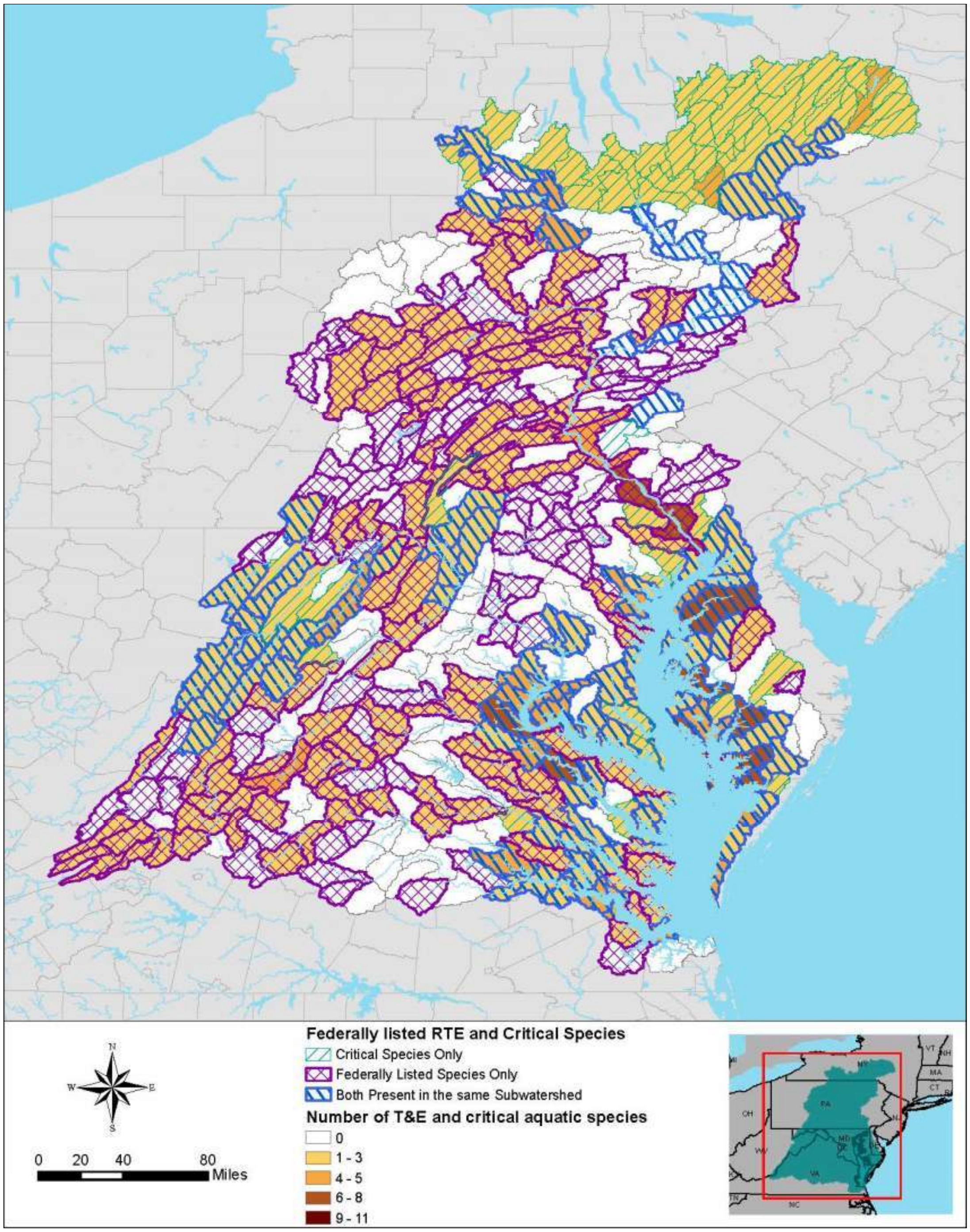


Figure 90. Spatial distribution and number of aquatic species by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed (7-RTE-B)

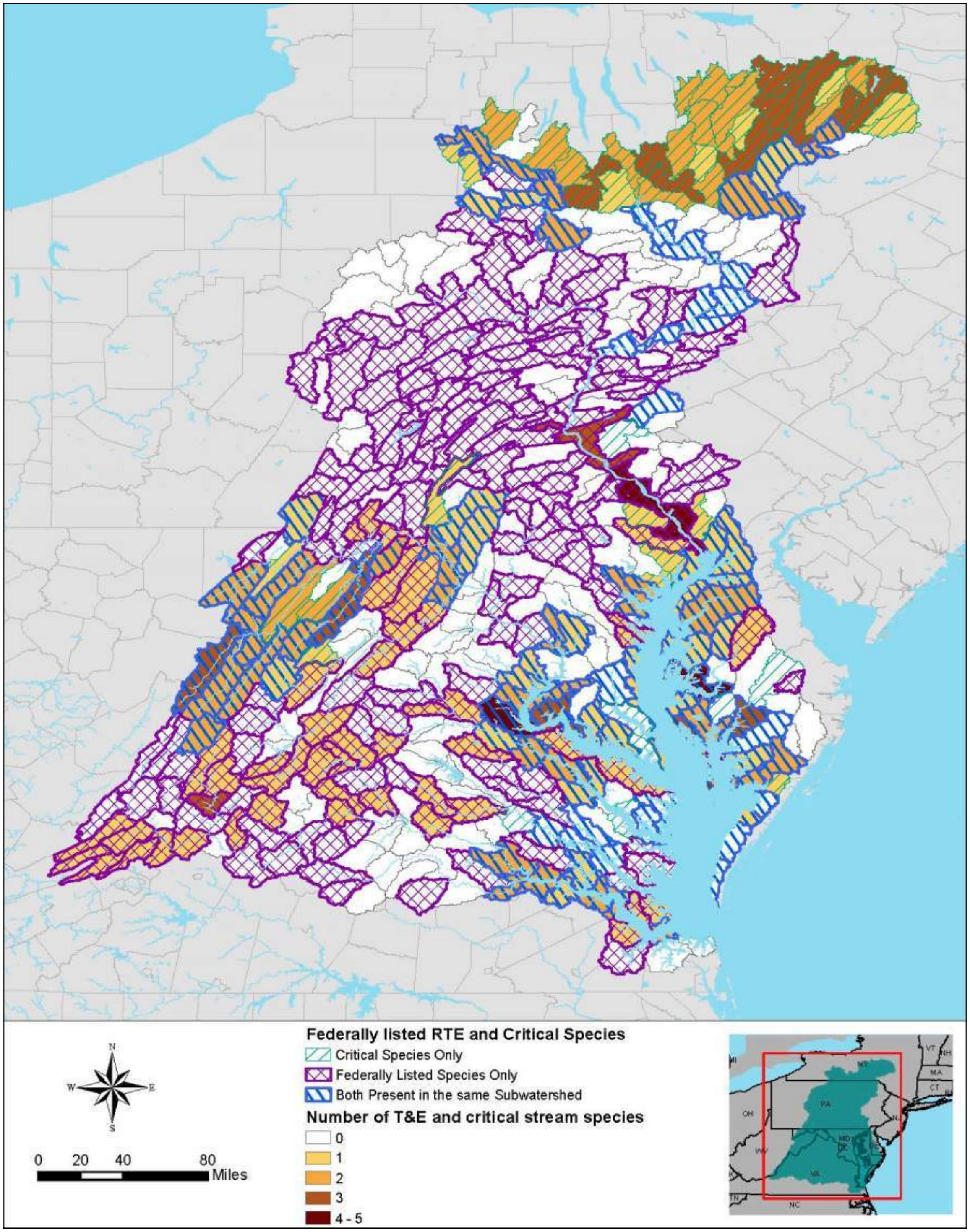


Figure 91. Spatial distribution and number of species associated with stream environments by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed (7-RTE-C)

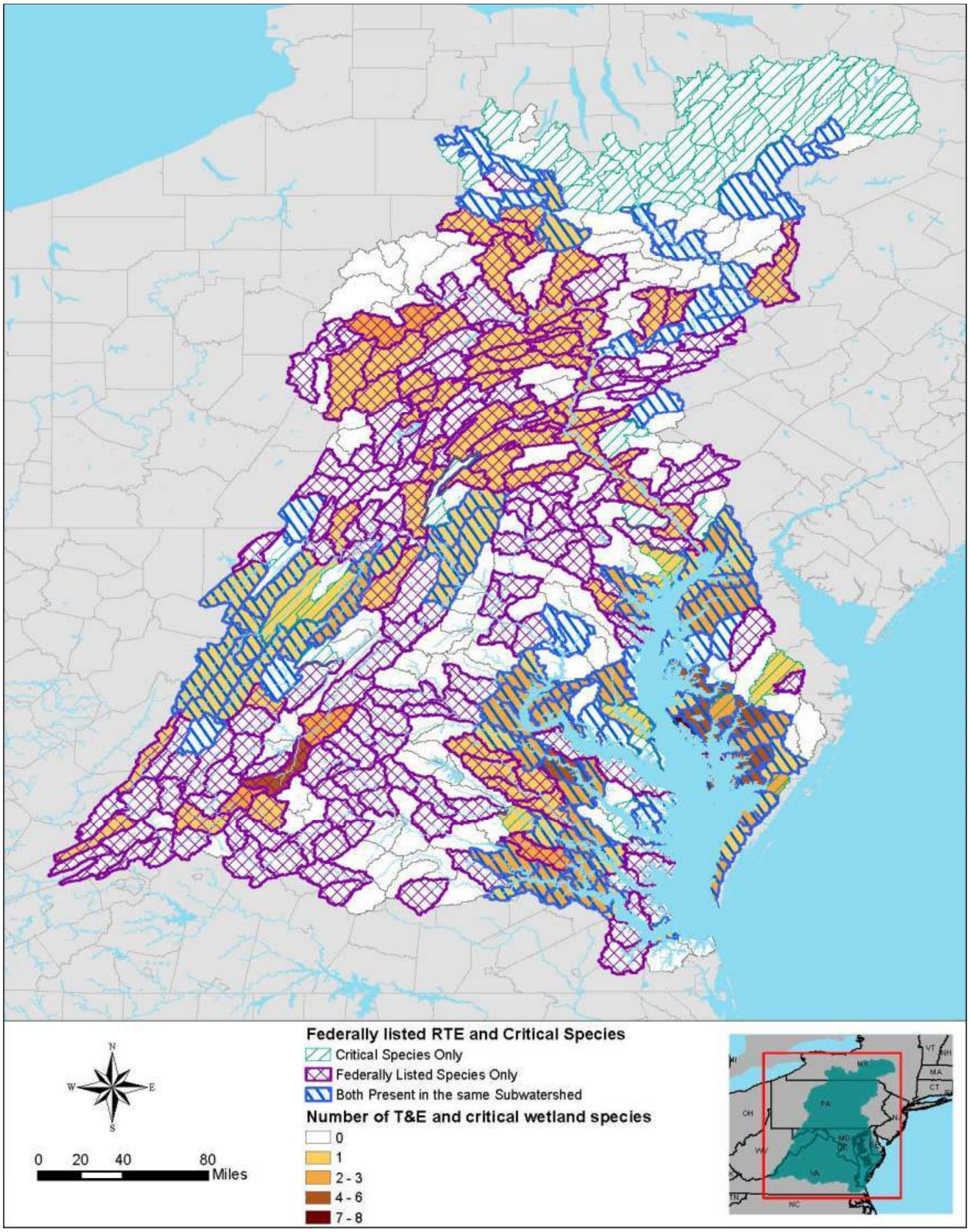


Figure 92. Spatial distribution and number of wetland species by subwatershed of federally listed rare, threatened, and endangered species and critical species identified by USFWS within the Chesapeake Bay Watershed (7-RTE-D)

The following series of maps (**Figures 93-96**) provide results compiled from combining RTE spatial information with the results for wetlands and stream restoration, and conservation. **Figure 95** presents the wetland restoration results. The intent of this evaluation was to identify where there are opportunities to undertake wetland restoration to benefit RTE. The upper

Eastern Shore of Maryland, the Lower Susquehanna in Pennsylvania, and the Conococheague-Opequon basin in the Potomac drainage in Pennsylvania, Maryland, and West Virginia provide large wetland restoration opportunities to benefit RTE. **Table 10** lists the subwatershed with the greatest opportunity (based on acreage) for wetland restoration to benefit T&E and critical wetland-dependent species.

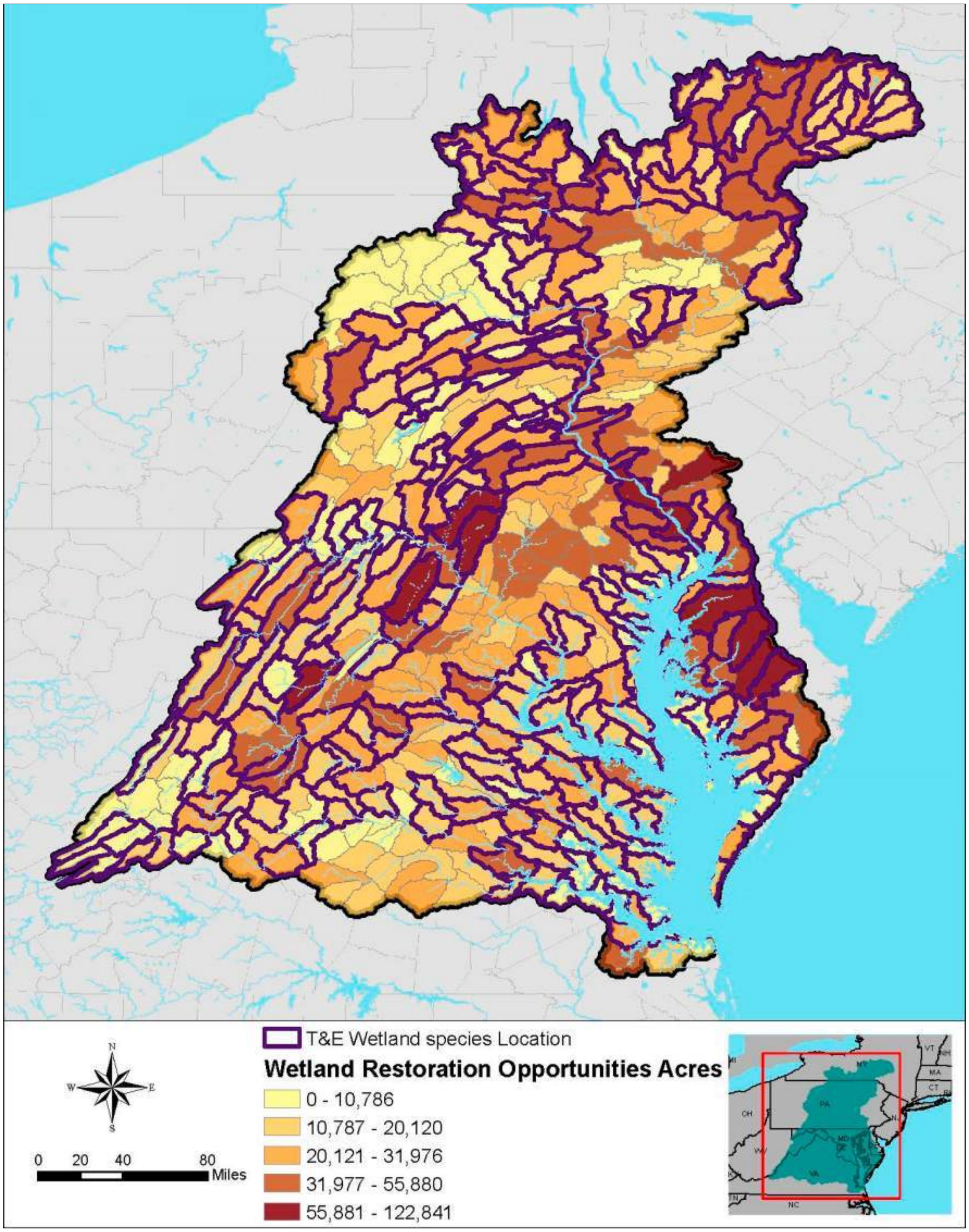


Figure 93. Comparison of combined wetland restoration *Opportunities* with presence of wetland species (either federally listed rare, threatened, and endangered species and critical species identified by USFWS) within the Chesapeake Bay Watershed (7-RTE-E)

Table 10. *Opportunities* focused on wetland restoration to benefit T&E and critical species

SUBWATERSHED	NAME	State	Federal listed / Critical Species	Number of wetland associated species
206000204	Chester River	DE, MD	Federal and Critical Species	2
205030617	Susquehanna River	MD, PA	Federal listed Only	1
208010904	Upper Nanticoke River	DE	Critical Species Only	1
207000410	Antietam Creek	MD, PA	Federal and Critical Species	1
207000408	Conococheague Creek	MD, PA	Federal and Critical Species	1
206000505	Lower Choptank River	MD	Federal and Critical Species	5
207000507	South River	VA	Federal listed Only	4
208020601	Falling Creek-James River	VA	Federal and Critical Species	3
208011003	Wicomico River	DE, MD	Federal and Critical Species	3
206000202	Elk River	DE, MD, PA	Federal and Critical Species	1
207000411	Rocky Marsh Run-Potomac River	MD, WV	Federal and Critical Species	1
205020103	Clearfield Creek	PA	Federal listed Only	1
205030503	Middle Conodoguinet Creek	PA	Federal listed Only	1
207000103	Upper South Branch Potomac River	VA, WV	Federal and Critical Species	1
205010409	Tioga River	NY, PA	Federal and Critical Species	1
205020612	West Branch Susquehanna River	PA	Federal listed Only	1
205030104	Penns Creek	PA	Federal listed Only	1
207000106	Lower South Branch Potomac River	WV	Critical Species Only	1
205030510	Susquehanna River	PA	Federal listed Only	1
205030110	Susquehanna River	PA	Federal listed Only	1

Stream-associated species were also isolated from the RTE data that USFWS provided. An evaluation was completed to identify opportunities to undertake stream restoration for either resident fish, EBT, or anadromous fish that would also provide benefit to stream-associated RTE. **Figure 94** and **Table 11** provide the results of that evaluation. The Lower Susquehanna River, the middle Eastern Shore of Maryland (Choptank River, Upper Tangier, and Lower Nanticoke), and subwatersheds in New York are prime areas for opportunities to restore streams to benefit RTE. Most of the identified subwatershed have been identified for stream restoration to improve resident fish species. However, along the bay mainstem, there is also overlap with stream restoration for anadromous fish species. There are also subwatersheds in West Virginia, Virginia, Pennsylvania, and New York where stream restoration could be undertaken to benefit T&E and critical species and EBT; EBT is a critical species identified by USFWS.

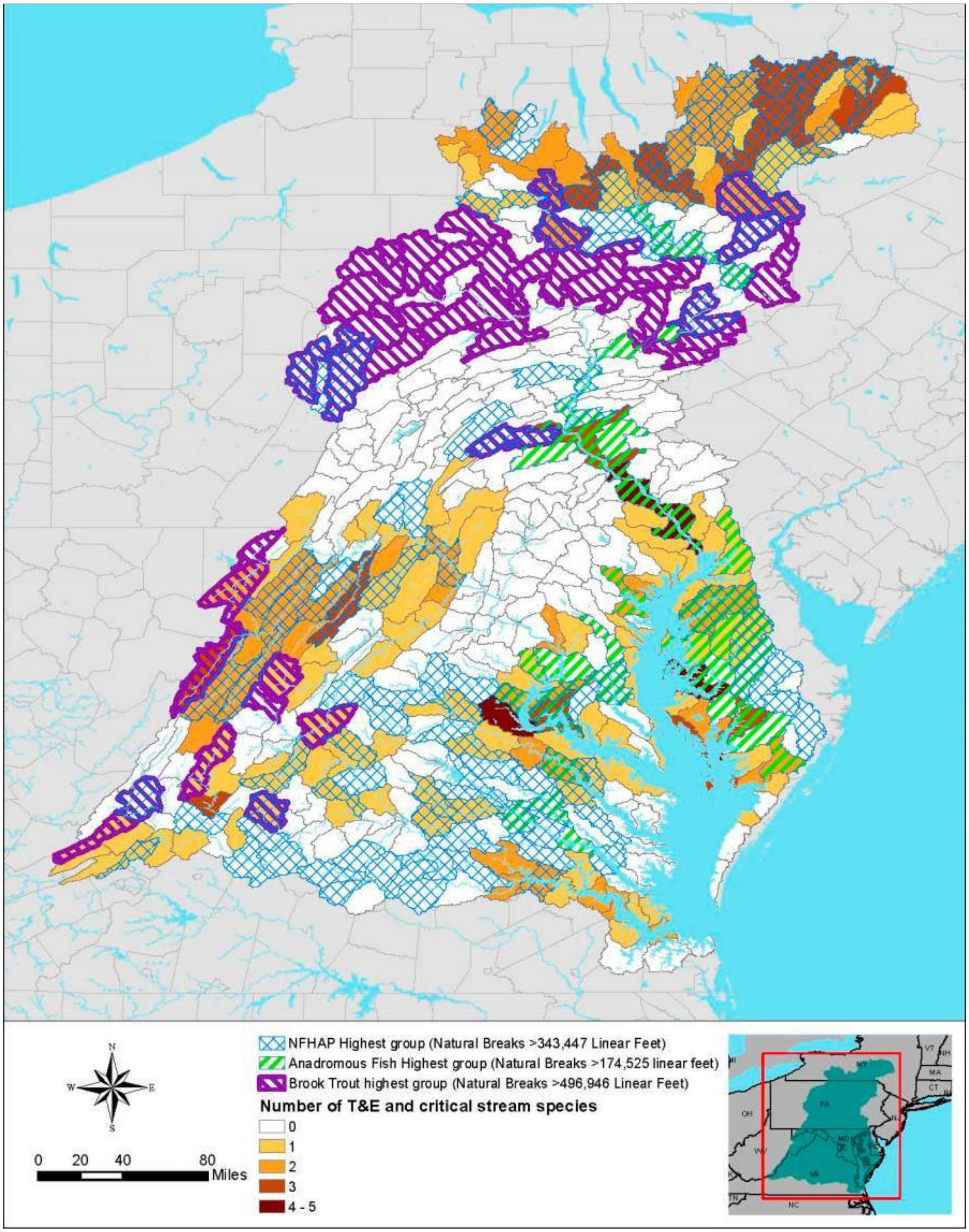


Figure 94. Comparison of stream restoration *Opportunities* with presence of stream species (either federally listed rare, threatened, and endangered species and critical species identified by USFWS) within the Chesapeake Bay Watershed (7-RTE-F)

Table 11. Opportunities focused on stream restoration to benefit T&E and critical species

SUBWATERSHED	NAME	State	Federal Listed / Critical Species	Number of stream-associated species
205030617	Susquehanna River	MD, PA	Federal listed Only	5
208011005	Upper Tangier Sound	MD	Federal listed Only	4
206000505	Lower Choptank River	MD	Federal and Critical Species	4
207001102	Potomac Creek-Potomac River	MD, VA	Federal and Critical Species	4
205030510	Susquehanna River	PA	Federal listed Only	3
208020203	Middle Maury River	VA	Federal listed Only	3
208010905	Lower Nanticoke River	DE, MD	Federal and Critical Species	3
207000101	North Fork South Branch Potomac River	VA, WV	Federal and Critical Species	3
207000307	Cacapon River	WV	Federal and Critical Species	3
207001103	Nanjemoy Creek-Potomac River	MD	Federal and Critical Species	3
205010109	Unadilla River	NY	Critical Species Only	3
205010505	Middle Chemung River	NY	Critical Species Only	3
205010208	Lower Chenango River	NY	Critical Species Only	3
205010205	Upper Chenango River	NY	Critical Species Only	3
205010206	Middle Chenango River	NY	Critical Species Only	3
205010305	Pipe Creek-Susquehanna River	NY	Critical Species Only	3
205010106	Headwaters Susquehanna River	NY	Critical Species Only	3
205010303	Catatonk Creek	NY	Critical Species Only	3
205010105	Otego Creek	NY	Critical Species Only	3
205010102	Cherry Valley Creek	NY	Critical Species Only	3
206000204	Chester River	DE, MD	Federal and Critical Species	2
207000411	Rocky Marsh Run-Potomac River	MD, WV	Federal and Critical Species	2
207000103	Upper South Branch Potomac River	VA, WV	Federal and Critical Species	2
205010409	Tioga River	NY, PA	Federal and Critical Species	2
205010113	Lower Susquehanna River	NY, PA	Federal and Critical Species	2
207000207	Patterson Creek	WV	Federal and Critical Species	2
205010404	Canisteo River	NY	Federal and Critical Species	2
208010403	Occupacia Creek-Rappahannock River	VA	Federal and Critical Species	2
207000202	Stony River-North Branch Potomac River	MD, WV	Federal and Critical Species	2
208011103	Dividing Creek-Pocomoke River	MD	Federal and Critical Species	2
208020602	Herring Creek-James River	VA	Federal and Critical Species	2
205010111	Upper Susquehanna River	NY	Federal and Critical Species	2
206000312	Patapsco River-Chesapeake Bay	MD	Federal and Critical Species	2
207000105	South Fork South Branch Potomac River	VA, WV	Federal and Critical Species	2
208010402	Mill Creek-Rappahannock River	VA	Federal and Critical Species	2
207000102	Lunice Creek	WV	Federal and Critical Species	2
208020106	Upper Cowpasture River	VA	Federal and Critical Species	2
207001101	Quantico Creek-Potomac River	MD, VA	Federal and Critical Species	2
207000305	Lost River	VA, WV	Federal and Critical Species	2
207000402	Sleepy Creek	VA, WV	Federal and Critical Species	2
207000104	South Mill Creek-Mill Creek	WV	Federal and Critical Species	2
208010100	Lower Chesapeake Bay	MD, VA	Federal and Critical Species	2
205010203	Otselic River	NY	Critical Species Only	2
207000106	Lower South Branch Potomac River	WV	Critical Species Only	2
205010204	Tioughnioga River	NY	Critical Species Only	2
205010501	Upper Cohocton River	NY	Critical Species Only	2
205010304	Owego Creek	NY	Critical Species Only	2
205010307	Wappasening Creek-Susquehanna River	NY, PA	Critical Species Only	2
207000306	North River	WV	Critical Species Only	2
205010201	East Branch Tioughnioga River	NY	Critical Species Only	2
205010108	Butternut Creek	NY	Critical Species Only	2
205010101	Canadarago Lake	NY	Critical Species Only	2
205010306	Cayuta Creek	NY	Critical Species Only	2

One final consideration of the species data provided by USFWS was to compare species distributions to conservation *Opportunities* (**Figure 95**). There are a number of areas where conservation could be further explored for the purpose of benefiting RTE and critical species. Based upon the Jenks method, there are broad opportunities concentrated in the West Branch Susquehanna Basin in PA. There are also large opportunities scattered throughout the watershed: Tioga River (NY), Stony River-North Branch Potomac River (WV/MD), Wills Creek (MD/PA), Cat Point Creek-Rappahannock River (VA), Potomac Creek-Potomac River (VA/MD), and Sherman Creek (PA).

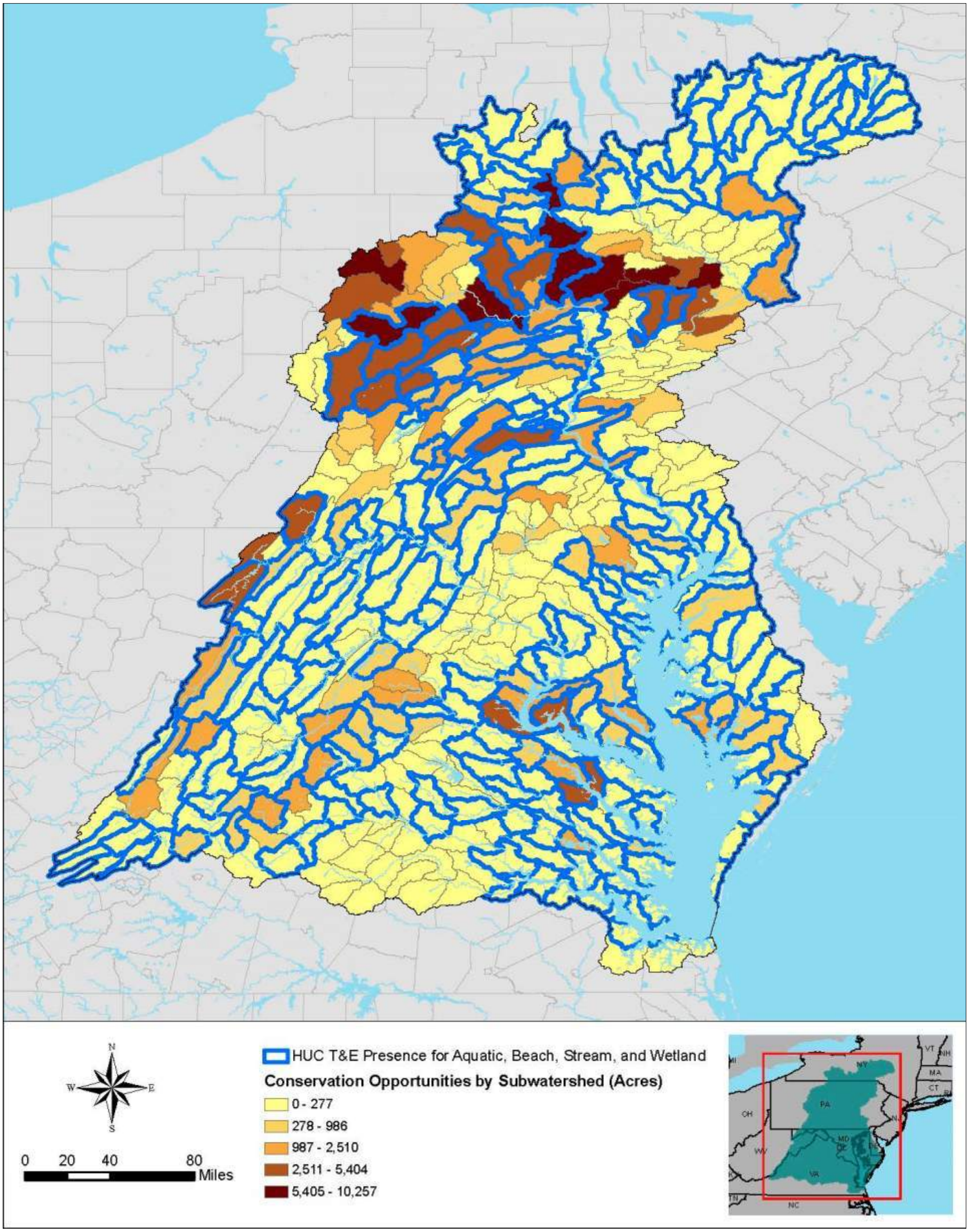


Figure 95. Comparison of conservation opportunity locations to benefit federally listed rare, threatened, and endangered species and critical species (identified by USFWS) within the Chesapeake Bay Watershed (7-RTE-G)

3.4 Road Crossings

A number of human activities can disrupt the continuity of river and stream ecosystems. The most familiar human-caused barriers are dams. Using the Chesapeake Fish Passage Prioritization Tool, the Chesapeake Bay Fish Passage Workgroup (FPWG) was successful in prioritizing nearly 5,000 dams in the Chesapeake Bay Watershed for their potential removal that for the benefit of anadromous fish. In general, high priority dams targeted for future removal have anadromous fish present downstream of the dam and open more high-quality habitat than lower priority dam removals (**Figure 96**). Future priority dam removal projects tend to be clustered closer to the Chesapeake Bay than in headwater areas since the target species include anadromous fish such as river herring and American shad. Prioritization has been completed for EBT and resident fish passage and has been used to determine the highest priority dams for removal in headwater and higher gradient streams.

Fish passage projects and dam removals have been a focus of the FPWG since 1989, and many dams have been removed or fish passage structures installed, opening thousands of miles of potential fish habitat. In recent years, there is growing concern about the role of road-stream crossings, especially culverts, in altering habitats, disrupting river and stream continuity, and blocking fish passage. Over 160,000 road-stream crossings exist in the Chesapeake Bay Watershed (**Figure 97**). However, few culverts in the Chesapeake Bay Watershed have been assessed for fish passage. **Figure 98** depicts where surveys have been conducted and includes a breakdown of the number of crossings by jurisdiction and the number that have been surveyed. The information presented in **Figure 98** is available as an interactive viewer online at http://maps.tnc.org/EROF_ChesapeakeFPP/. Given the sheer volume of potential fish blockages, funding and time constraints do not allow for assessment of all potential road crossings. In the past, culvert assessments have been focused near priority dam removal projects and in previously identified high priority watersheds, such as the Choptank River Habitat Focus Area. This was done as a cost savings measure and to conduct targeted restoration in watersheds that were previously designed for habitat restoration work.

More recently, road-stream crossings have been assessed using a regional assessment protocol developed by the North Atlantic Aquatic Connectivity Collaborative (NAACC). The NAACC is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia, and includes the Chesapeake Bay region. The goal of the collaborative is to assess stream crossings for flood resiliency and aquatic organism passage. Assessments using these methods in the Chesapeake Bay have focused on watersheds that are used by priority species including anadromous fish, EBT, and endangered freshwater mussel species. While much progress has been made, additional road-stream crossing assessments are needed. Data are entered into the NAACC database and automatically assigned a passability score ranging from 0 (not passable) to 1 (fully passable). According to data collected in Maryland, over 50 percent of road-stream crossings pose some barrier to aquatic organism passage, but only about 27 percent of the crossings assessed are moderate, significant, or severe blockages (**Figures 99 and 100**).

Once assessments are complete, the FPWG pursues funding for design and implementation of removal or replacement for each of the priority blockages. Potential future projects for fish passage may include removal or retrofits to the existing roadways/culverts or implementation of more fish friendly designs such as bottomless culverts and bridges. These types of projects often have the added benefit of reduced flooding in the surrounding area. Damage to roadways during storm events is reduced, meaning less costly repairs and improved public safety. Identification of future projects is critical for meeting the fish passage outcome in the 2014 Bay Agreement, which includes opening 1,000 additional miles by 2025.

Although an individual stream crossing may appear to have a minor impact on the landscape, cumulatively the magnitude of the number of stream crossings within the Chesapeake Bay basin is significant to not only fish passage, but also to habitat connectivity and flooding. Going forward, stream crossings and their impact on the landscape should receive greater attention. When undertaking watershed restoration projects, stream crossings should be evaluated.

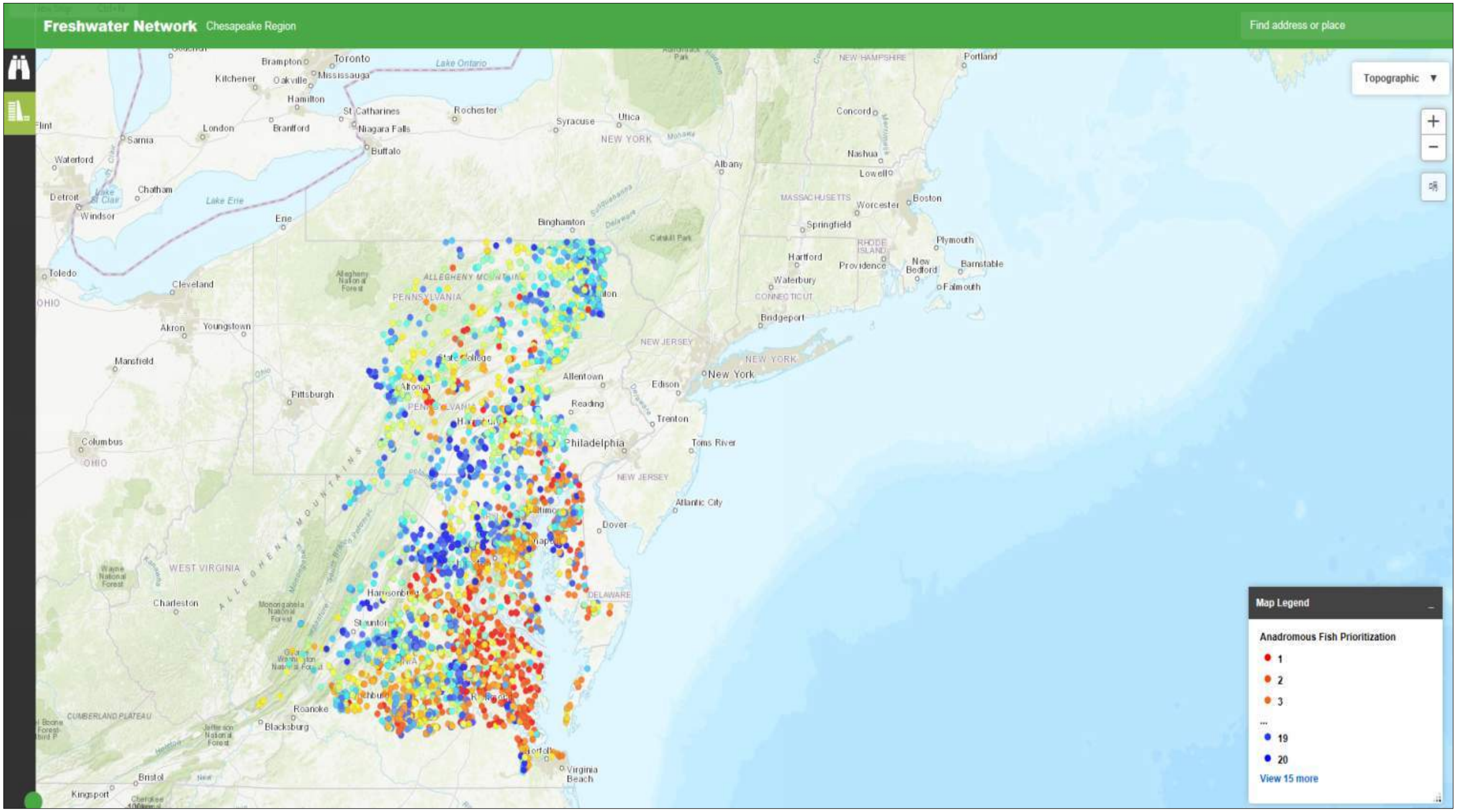


Figure 96. High priority fish passage blockages from the CB FPWG

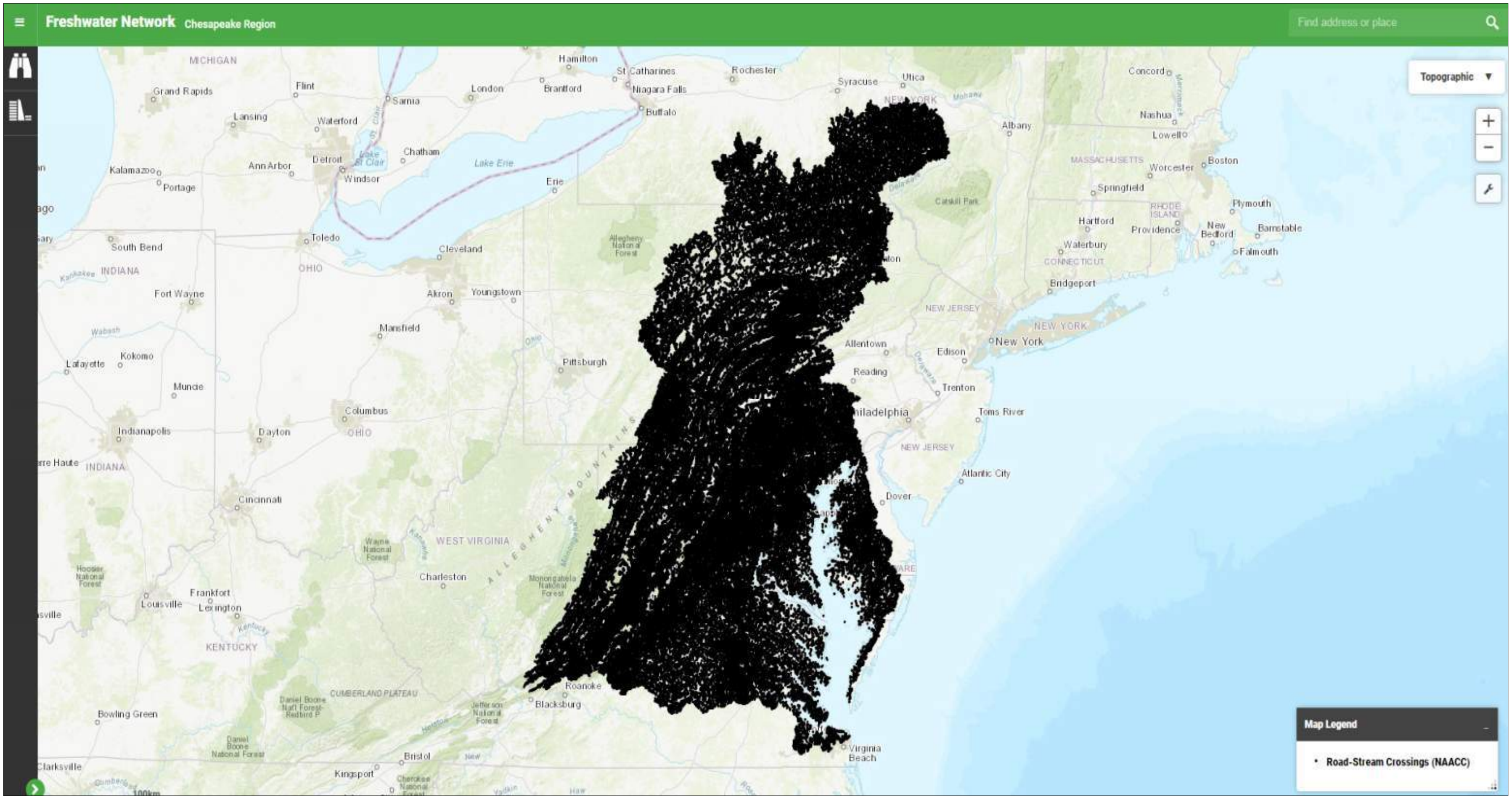


Figure 97. Fish passage blockages identified in the Chesapeake Bay Fish Passage Prioritization Tool

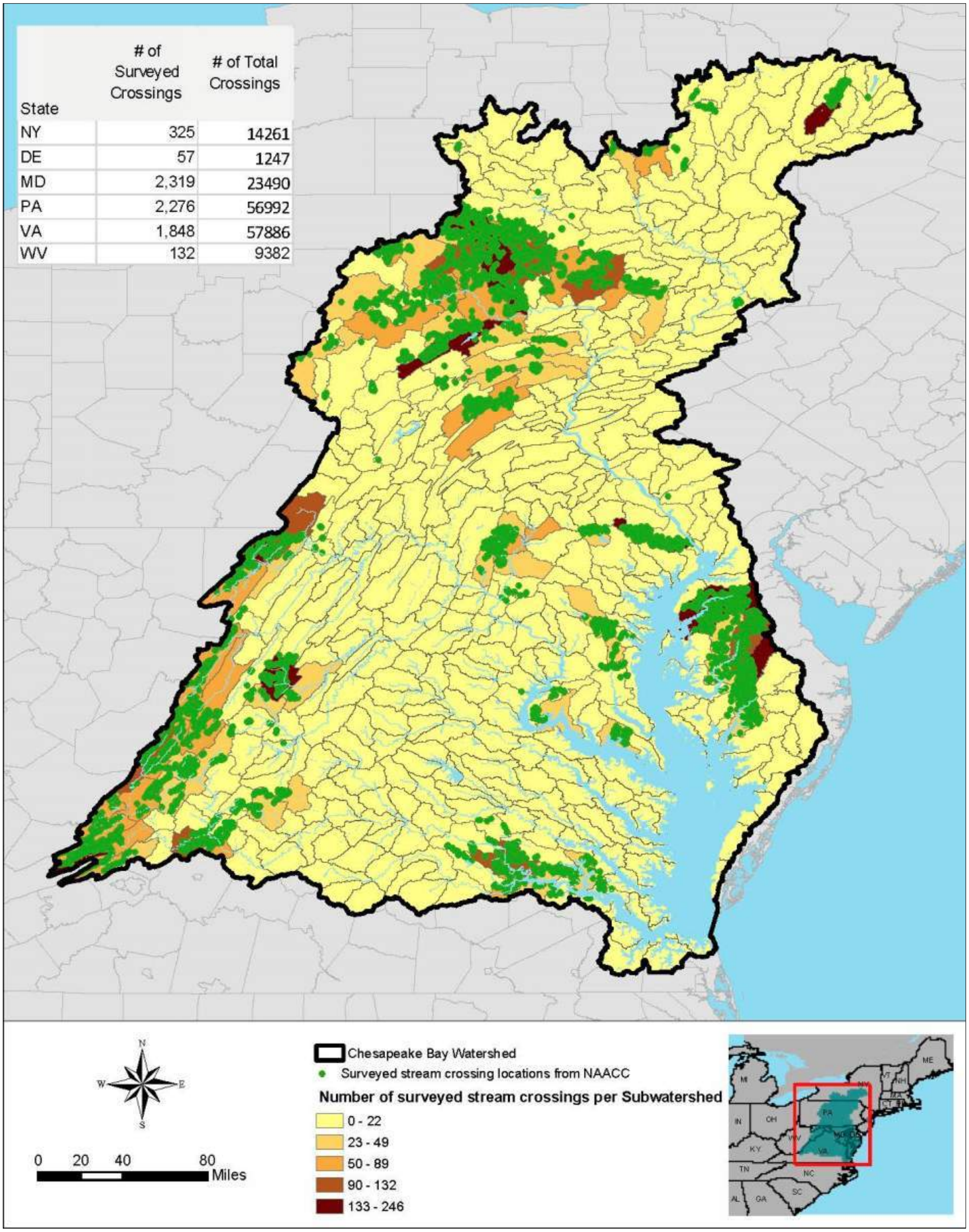


Figure 98. Surveyed stream crossing in the Chesapeake Bay Watershed (7-RC-A)

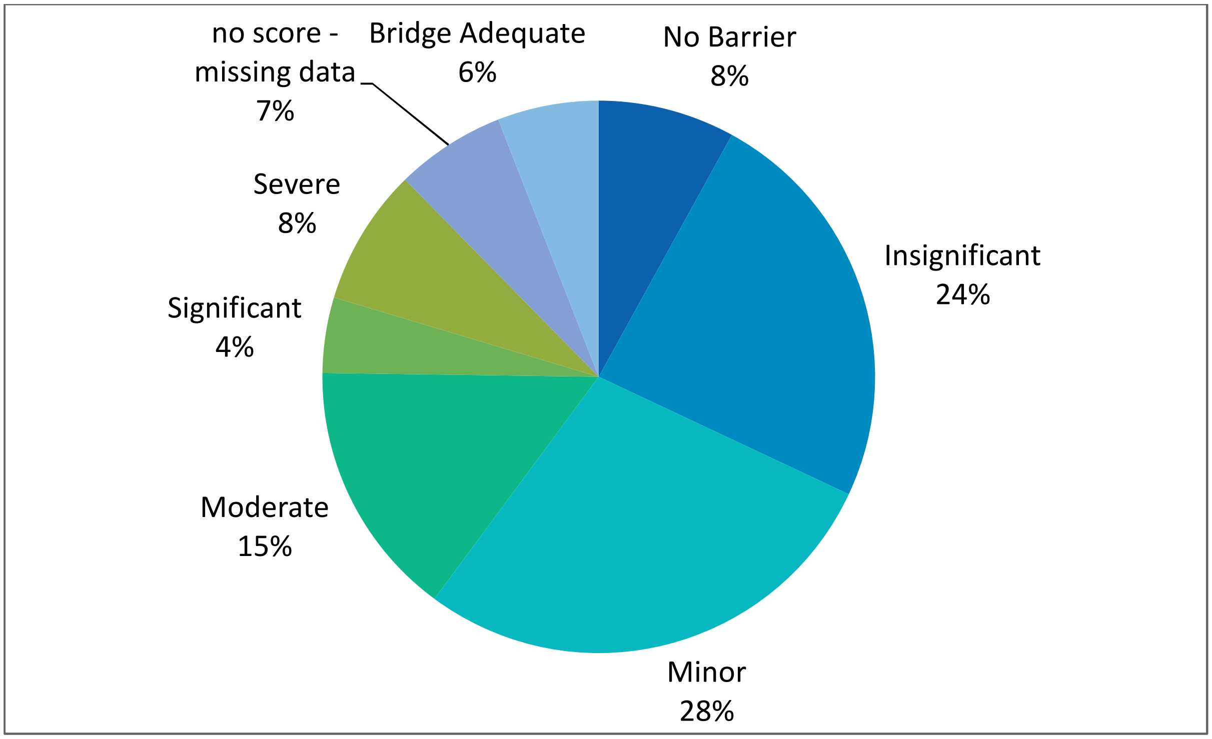


Figure 99. Fish passage blockage rating for stream crossings surveyed in Maryland

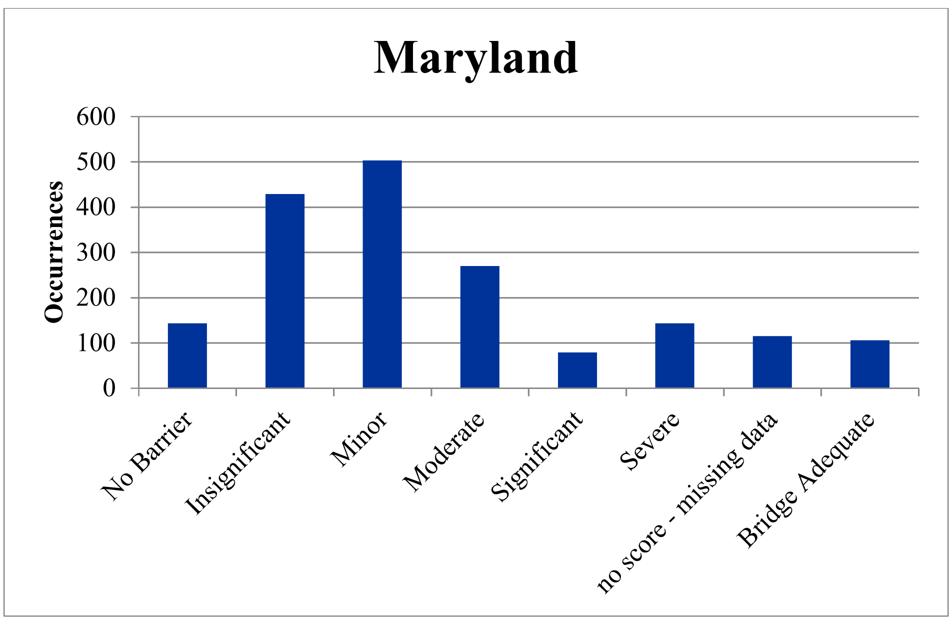


Figure 100. Occurrence of fish passage blockages surveyed in Maryland based on blockage rating

3.5 Regional Flow and Connectivity

Nature's Network developed data that characterizes the ability to flora and fauna to move across the landscape. This regional flow data ranges from constrained flow to high diffuse flow (**Figure 101**). The purpose of this analysis is to discern where there are important areas of regional flow, as determined by the Nature Conservancy (2016), which could benefit from tidal and/or nontidal wetland restoration. By aligning areas for potential wetland restoration with regional flow, opportunities to improve connectivity and ease of passage are identified. To investigate this concept, the CBCP overlaid the combined wetland restoration opportunities with this regional flow data (**Figure 101**). The acreage that is identified by Nature's Network as being a regional flow corridor of any degree was summed within each subwatershed. The total acreage of restoration opportunity was classified into 5 groups utilizing the Jenks method in ArcGIS. The top 2 groups of watersheds based on acreage of opportunity are identified as opportunities.

The results display wetland restoration opportunities with varying classifications of flow patterns within the landscape; this helps to pinpoint areas that would benefit the most from restoration actions to wetlands (**Figure 102**). The wetland restoration opportunities were classified with the TNC 2016 flow categories shown below:

- Diffuse Flow: areas that are extremely intact and consequently facilitate high levels of dispersed flow that spreads out to follow many different and alternative pathways. A conservation strategy is to keep these areas intact and prevent the flow from becoming concentrated.
  - Low Diffuse Flow: Similar to Diffuse Flow, but the areas are not as intact and flow cannot disperse as readily
  - Medium Diffuse Flow: Similar to Low Diffuse Flow, but the areas are more intact and can disperse a bit more readily
  - High Diffuse Flow: refers to the best areas of Diffuse Flow
- Concentrated Flow: areas where large quantities of flow are concentrated through a narrow area. Because of their importance in maintaining flow across a larger network, these pinch points are good for land conservation.
  - High Concentrated Flow: Refers to areas where there is the greatest amount of Concentrated Flow
- Constrained Flow: areas of flow that are neither concentrated nor fully blocked but instead move across the landscape in a weak reticulated network. These areas present large conservation challenges and restoration may be necessary for effective connectivity to be achieved.

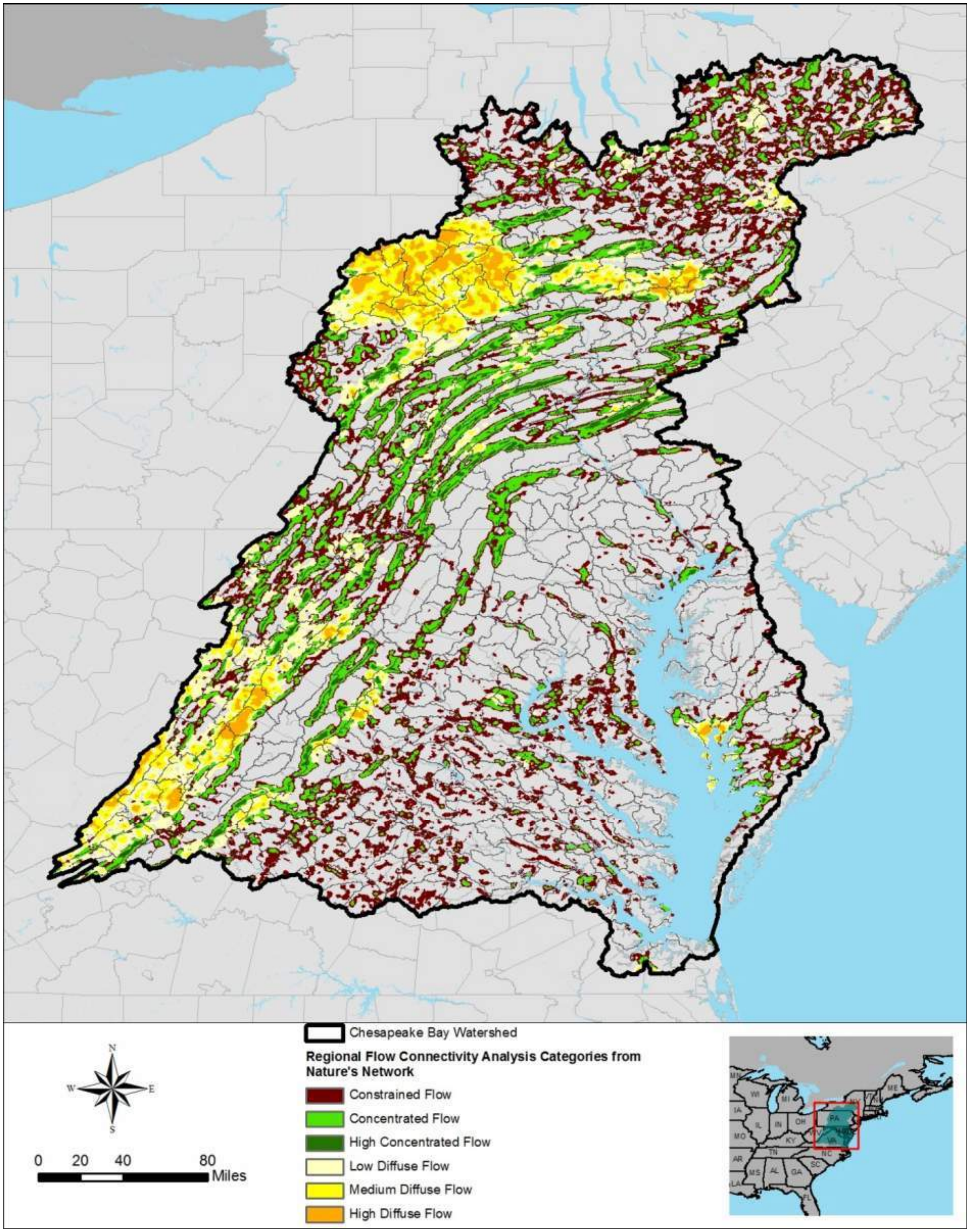


Figure 101. Regional flow from Nature's Network (7-RG-A)

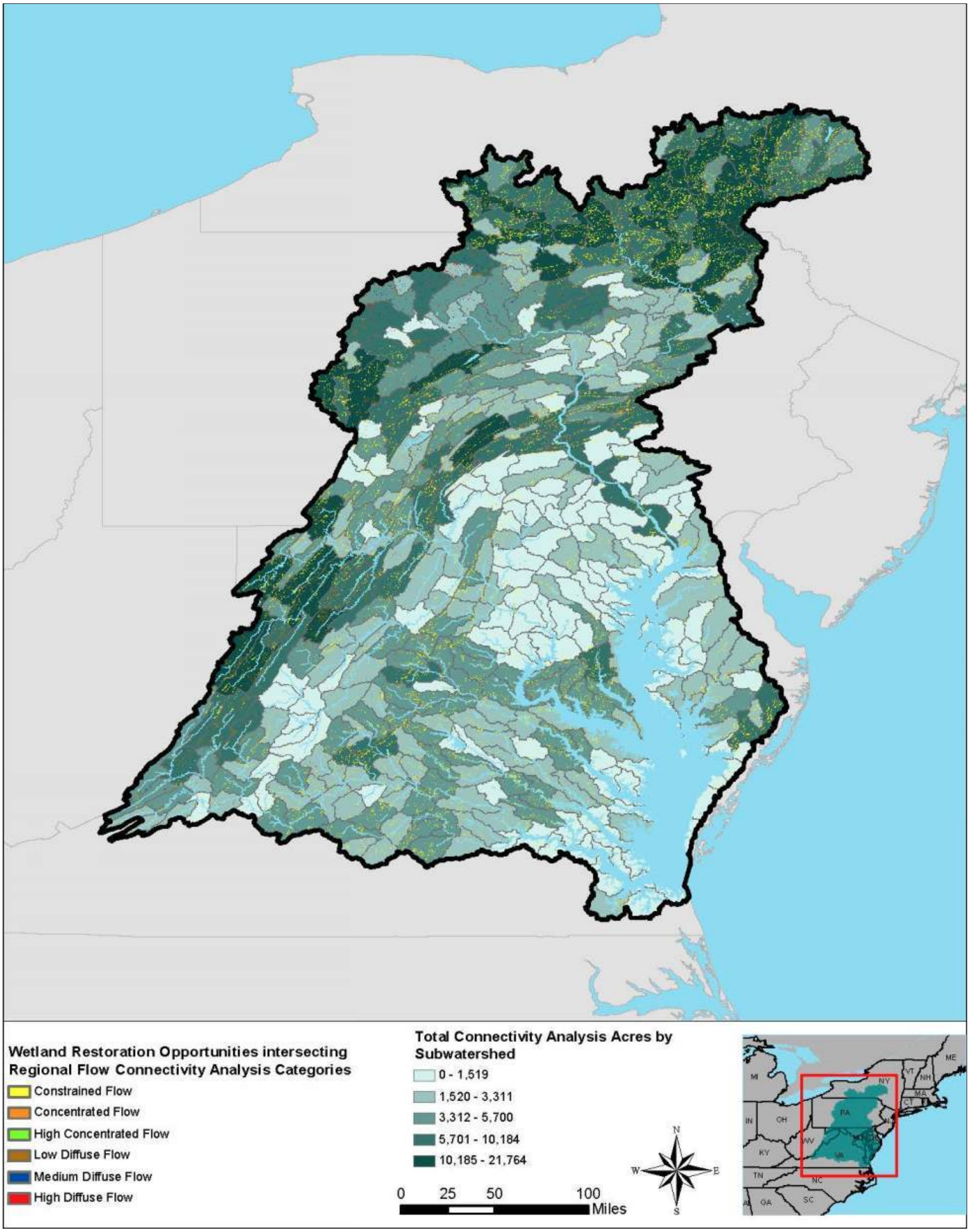


Figure 102. Regional flow and wetland restoration opportunities analysis (7-RG-B)

3.6 The Sediment Shadow and Considerations for Resilience in Wetlands Restoration

In its effort to build resiliency in the Chesapeake Bay Watershed restoration efforts, USACE worked with NOAA and other CBP partners to consider the latest research available on sediment transport in the Chesapeake Bay as related to the ability of wetlands to maintain elevation in the face of relative sea level change (e.g., sea level rise and subsidence) as erosion. The following section describes the results of the the discussion and provides information based on personal communication and discussion with CBP and Greg Noe, research ecologist (USGS) to educate the application of sediment additions to wetland restoration, and where those additions may be best directed and needed.

Tidal rivers around the world can trap large quantities of sediment between the head-of-tide and mouth of the estuary, depositing sediment in both channel and wetlands, leading to meaningful reductions in sediment loading to estuaries (Meade 1982, Downing-Kunz and Schoellhamer 2015, Ralston 2017). This phenomenon of substantial trapping of sediment by tidal rivers has been called the ‘sediment shadow’ (Ensign et al. 2015), where contemporary sediment availability in tidal freshwater rivers is often minimal compared to upstream nontidal reaches and downstream oligohaline reaches. Sediment loads from watersheds can be trapped at large rates by nontidal floodplain deposition and river channel storage downstream of watershed nontidal loading gages (Noe and Hupp 2009), as well as by tidal freshwater forested wetlands (TFFW) located downstream of the head-of-tide (Ensign et al. 2015, 2016). As a result, much of the sediment load has been reduced to low levels in lower tidal freshwater rivers downstream of these sedimentation hotspots. Further downstream past the tidal freshwater zone and into oligohaline river reaches, sediment availability increases substantially associated with estuarine sources of sediment including the estuarine turbidity maximum. These patterns have been observed for either channel suspended sediment concentrations (SSC) of floodplain wetland sedimentation rates along many rivers along the U.S. Atlantic Coast, including in the Chesapeake Bay (Ensign et al. 2015, 2016, Hupp et al. 2015, Noe et al. 2016).

In the Chesapeake, sampling of suspended sediment in river channels along longitudinal riverine gradients has revealed minimal SSC in TFFW reaches, somewhat greater SSC in upstream nontidal reaches, and much greater SSC in downstream oligohaline reaches. Suspended sediment concentrations over month-long measurement periods was much greater in the river channel at an oligohaline (median = 21 and 31 mg L-1) compared to TFFW (3 and 2 mg L-1) or nontidal reach (8 and 7 mg L-1) of both the Choptank and Pocomoke rivers, respectively (Ensign et al. 2014). Along the Mattaponi River, mean SSC increased from 7, 7, 12, 16, to 20 mg L-1, and along the Pamunkey River increased from 14, 13, 25, to 32 mg L-1, along gradients from microtidal river, upper TFFW, lower TFFW, salt-stressed TFFW, to oligohaline river (Hupp, unpublished data). In comparison, the long-term mean SSC concentration at the closest nontidal reaches are 10 and 23 mg L-1 in the Mattaponi and Pamunkey rivers, respectively (USGS, https://cbrim.er.usgs.gov/index.html, gages 01674500 and 01673000). Suspended sediment concentrations also steeply decrease downstream along the tidal freshwater James River during high flow events (Bukaveckas and Isenberg 2013).

Longitudinal patterns of sedimentation in Chesapeake tidal river wetlands generally match the river channel SSC patterns. Along both the Choptank and Pocomoke rivers, short-term wetland sediment accretion rates increased from nontidal (mean = 8 mm yr-1) to lower TFFW (12 mm yr-1) to oligohaline (19 mm yr-1; Ensign et al. 2014). However, TFFW situated just downstream from the head-of-tide (32 mm yr-1) had very high (Choptank) or somewhat higher (Pocomoke) accretion rates associated with Tropical Storm Lee that caused the largest flood of record on the Choptank but a smaller flood on the Pocomoke River (Ensign et al. 2014). Long-term sedimentation rates were similar along the same river gradients (Ensign et al. 2015). Tidal freshwater marshes along the Mattaponi River had increasing short-term sedimentation and accretion rates towards downriver locations near the oligohaline boundary and estuary turbidity maximum (Darke and Megonigal 2003). Short-term wetland sediment accretion increased monotonically downstream along the Mattaponi and Pamunkey rivers, averaging from 4, 7, 10, 12, to 14 mm yr-1 from nontidal (microtidal channel), upper TFFW, lower TFFW, salt-stressed TFFW, to oligohaline floodplain wetlands (Noe, unpublished data). In contrast, short-term sediment accretion along the Nanticoke River on the eastern shore of Maryland decreased slightly from tidal freshwater marsh to downstream mesohaline marsh (Beckett et al. 2016). Long-term tidal marsh and subtidal sedimentation rates along the Patuxent River were similar between the upper estuary (tidal fresh and oligohaline) and lower estuary (mesohaline), with the mass of sediment trapped annually in the upper estuary similar to the watershed sediment load (Boynton et al. 2008).

In summary, tidal channels and wetlands along lower tidal rivers often experience minimal sediment availability compared to upstream (nontidal or tidal freshwater near the head-of-tide) and downstream (oligohaline or mesohaline) reaches. Watershed sediment loads are largely removed by sedimentation in wetlands and channels upstream, and estuarine sediment loads are not transported upstream from the saline estuary into lower tidal freshwater reaches. This phenomenon appears to be widespread among Chesapeake tidal rivers, suggesting that contemporary watershed derived sediment loads (and sediment-associated nutrient and contaminant loads) mostly do not get transported through tidal rivers to downstream, saline portions of the estuary, most of the time.

Because the resilience of tidal wetlands to SLR is a function of suspended sediment concentration (Kirwan et al. 2016), the rates of sediment supply to TFFW can predict the impact of SLR on ecosystem resilience. Low sediment availability limits wetland elevation growth in TFFW and could accelerate their conversion (Stagg et al. 2016). In the Chesapeake, a tidal freshwater marsh along the Nanticoke River was gaining elevation at a rate similar to relative SLR, whereas oligohaline marshes were decreasing in elevation, and mesohaline marsh was gaining elevation at a slower rate than relative SLR, despite all of the sites having substantial sedimentation rates that suggested high rates of soil subsidence (Beckett et al. 2016). Tidal freshwater marsh along the Patuxent River had varying rates of elevation change, either no change or increasing elevation gain rates that were greater than relative SLR (Delgado et al. 2013). Preliminary data from the TFFW along the Mattaponi and Pamunkey rivers indicate rates of elevation change are less than relative SLR along the upper tidal freshwater reaches of these Chesapeake rivers (Noe, unpublished data). Tidal freshwater wetlands in the Chesapeake are likely (but not always) experiencing sediment deficits relative to their need to gain elevation in response to relative SLR. In particular, TFFW along lower tidal freshwater rivers where 'sediment shadows' are common likely are experiencing sediment deficits. The addition of sediment directly to TFFW could augment their sediment supply sufficiently to enable their elevations to grow upward relative to SLR, and as a result increase their ecosystem resilience, while maintaining the goals of low sediment delivery to downstream portions of the Chesapeake Bay. Targeting wetlands for restoration through sediment addition would be best informed by measurements of channel sediment concentrations and tidal wetland sediment accretion and elevation change (identifying hotspots of sediment deficits). However, more research is needed to evaluate the impacts of sediment addition on TFFW ecosystem health and elevation change in response to sediment additions.

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Annex 3

Data and sources used in analyses

DATA THEME / CATEGORY	DATA DESCRIPTION	DATA SOURCE	Chesapeake Bay Comprehensive Water Resources and Restoration Plan (CBCP) Analyses
Boundaries	U.S. Army Corps of Engineers (USACE) Authorities	Army Chesapeake Bay Comprehensive Plan (2013)	USACE Authorities
	Hydrologic Unit Code 10 Subwatershed Boundaries	U.S. Geological Survey (USGS) Watershed Boundary Dataset; http://nhd.usgs.gov/wbd.html (2018)	All Analyses
Land Use/Land Cover	Chesapeake Bay Watershed High Resolution Land Cover Data	Chesapeake Conservancy & Virginia Department of Environmental Quality (VADEQ) via the National Fish and Wildlife Foundation (NFWF) (2016)	Wetland Restoration and Enhancement Opportunities
	Percent Impervious Cover	Chesapeake Bay Watershed High Resolution Land Cover Data; Chesapeake Conservancy & VADEQ via NFWF (2016)	Watershed Stressors Analysis
	Locations of Water Supply Withdraws in the Susquehanna River Basin	Susquehanna River Basin Commission/Pennsylvania Boundary Dataset (USGS and Natural Resources Conservation Service (NRCS))	Socioeconomic Analysis
	Percent Forest Cover	Chesapeake Bay Watershed High Resolution Land Cover Data; Chesapeake Conservancy & VADEQ via NFWF (2016)	Watershed Stressors Analysis
	Percent Stream Network within a Subwatershed with Forested Riparian Buffers	Environmental Protection Agency (EPA)/U.S. Fish and Wildlife Service (USFWS) (Army Chesapeake Bay Comprehensive Plan (2013))	Watershed Stressors Analysis; Riparian Buffer Analysis
	Eroding Shorelines	Virginia Institute of Marine Science (VIMS) Shoreline Inventory; http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/	Shoreline Erosion Analysis
	Coastal Vulnerability Index (CVI)/Vulnerable Shorelines	National Oceanic and Atmospheric Administration (NOAA); https://www.coast.noaa.gov/digitalcoast/data/	Tidal Threats Analysis
	USACE Levees	USACE National Levee Database; http://nld.usace.army.mil/egis/f?p=471:1:	USACE Projects
	USACE Reservoirs	USACE	USACE Projects; Socioeconomic Analysis
	Dams	2016 National Inventory of Dams; http://nid.usace.army.mil/cm_apex/f?p=838:12	USACE Projects; Socioeconomic Analysis
	Military Lands	Chesapeake Bay Program (CBP)	USACE Projects
	Road Crossings	North Atlantic Aquatic Connectivity Collaborative (NAACC); https://www.streamcontinuity.org/cdb2/naacc_search_crossing.cfm	Road Crossings Analysis

US Army Corps of Engineers

DATA THEME / CATEGORY	DATA DESCRIPTION	DATA SOURCE	Chesapeake Bay Comprehensive Water Resources and Restoration Plan (CBCP) Analyses
Habitat	Submerged aquatic vegetation (SAV) Data (1971-2015)	VIMS http://web.vims.edu/bio/sav/gis_data.html	SAV Restoration Analysis
	Oyster Restoration Data Layer	CBP Cross-Goal Implementation Team (GIT) - Oyster Restoration Areas	Oyster Restoration Analysis
	State Identified Healthy Watersheds	CBP Cross GIT Mapping Team - State Identified Healthy Waters and Watersheds	Healthy/High-value Habitats Analysis
	Brook Trout Prioritized Subwatersheds (Catchments)	CBP	Healthy High/Value Habitats Analysis; Riparian Buffer Analysis; Stream Restoration Analysis
	Riparian Forest Buffer Priority Areas	http://www.landscope.org/chesapeake/chesapeake_map_layers/conservation_priorities/high_value_forests/26051	Riparian Buffer Analysis
	National Fish Habitat Assessment	National Fish Habitat Partnership	Nontidal Threats Analysis; Riparian Buffer Analysis; Stream Restoration Analysis
	Extent of Anadromous Fish Habitat	The Nature Conservancy (TNC) Chesapeake Fish Passage Prioritization Tool; http://maps.tnc.org/EROF_ChesapeakeFPP/	Stream Restoration Analysis
	Nesting Locations of Wading and Waterbirds	Center for Conservation Biology 2017; http://www.northeastoceandata.org/	Wetland Restoration Opportunities Analysis
	Core and Connector Habitat	Nature's Network – USFWS; http://rcoa.cicapps.org/data-tools - North Atlantic Landscape Conservation Cooperative	Healthy High/Value Habitats Analysis; Connectivity Analysis
Chesapeake Bay Watershed Model Data	303(d) Impaired Waterways List	https://www.epa.gov/exposure-assessment-models/303d-listed-impaired-waters	Watershed Stressor Analysis
	Areas projected to have more frequent "normal" flooding	North Atlantic Coast Comprehensive Study (NACCS) and USGS	Tidal Threats Analysis
	Resources at Risk to Coastal Storms	NACCS	Tidal Threats Analysis
	Nontidal flooding	Quentin Stubbs, USGS CBP Office GIS Team	Nontidal Threats Analysis
	Spatially Referenced Regressions on Watershed (SPARROW) Nutrient Yields	CBP Cross GIT Mapping Team	Watershed Stressor Analysis; Riparian Buffer Analysis
	Index of Ecological Integrity	North Atlantic Landscape Conservation Cooperative (NALCC); http://northatlanticlcc.org/spatial-data;	Healthy High/Value Habitats Analysis
	Benthic Index of Biotic Integrity	CBP	Watershed Stressors Analysis
	Sea Level Rise Curves	USGS Sea Level Rise Calculator; Sea-Level Change Curve Calculator	Tidal Threats Analysis

DATA THEME / CATEGORY	DATA DESCRIPTION	DATA SOURCE	Chesapeake Bay Comprehensive Water Resources and Restoration Plan (CBCP) Analyses
		(2015.46), NOAA Gauges, USGS NED 10m DEM	
	Trout Unlimited Conservation Strategies for Eastern Brook Trout	Trout Unlimited	Riparian Buffer Analysis; Stream Restoration Analysis
	Existing CBP Management Strategies	CBP Cross-GIT	Restoration Efforts by Others
	Prioritized List of Fish Passage Blockages	TNC; http://maps.tnc.org/EROF_ChesapeakeFPP/assets/ChesapeakeFishPassagePrioritization_Report.pdf	Fish Passage Blockages Analysis
	Marsh Migration Cost	NOAA (2015)	Marsh Migration Analysis
	Future Projected Development	NACCS (USEPA 2009)	Nontidal Threats Analysis; Tidal Threats Analysis
	Regional Flow - Nature's Network	Nature's network (2016)	Regional Flow and Connectivity
	Digital Elevation Model	USGS	Wetland Restoration and Enhancement Opportunities
	Hydric Soils	CBP	Wetland Restoration and Enhancement Opportunities
Implemented Projects	Projects that have received a USACE Nationwide Permit 27	USACE	Restoration Efforts by Others
	Coastal Storm Damage Reduction Projects	USACE	USACE Projects
	Systems Approach to Geomorphic Engineering (SAGE) Implemented Projects	VIMS Map Service	Restoration Efforts by Others
	NFWF Legacy Grants	NFWF	Restoration Efforts by Others
	Projects Implemented on Military Lands	USACE	Restoration Efforts by Others
	Aquatic Ecosystem Restoration Projects	USACE Baltimore (NAB) and Norfolk (NAO) Districts and CPN data	USACE Projects
Stakeholder Priorities	NFWF Business Plan Focus Areas	NFWF	Restoration Priorities Identified by Others
	USFWS Focus Areas for Threatened and Endangered Species	USFWS	Restoration Priorities Identified by Others
	Other species data including birds, fish, invertebrates	USFWS	Conservation Priorities Identified by Others
	NOAA Habitat Focus Areas	NOAA	Restoration Priorities Identified by Others
	Ducks Unlimited Focus/Project Areas	Ducks Unlimited	Restoration Priorities Identified by Others
	Conservation Fund Focus Areas	Conservation Fund	Conservation Priorities Identified by Others
	TNC Priority Areas	The Nature Conservancy; http://www.uspriorityareas.tnc.org/	Conservation Priorities Identified by Others
	Stakeholder Candidate Restoration Projects	Stakeholder Input to CBCP data calls	Restoration Efforts by Others
	CBP Black Duck Focus Areas	https://nalcc.databasin.org/datasets/4b3c716ee6c24529b1af7abb69adc1eb	Healthy High/Value Habitats Analysis; Wetland

DATA THEME / CATEGORY	DATA DESCRIPTION	DATA SOURCE	Chesapeake Bay Comprehensive Water Resources and Restoration Plan (CBCP) Analyses
			Restoration Opportunities Analysis
	USFWS Critical habitat for Rare, Threatened, & Endangered Species (RTE)	https://catalog.data.gov/dataset/fws-critical-habitat-for-threatened-and-endangered-species-datasetf6b00	Rare, Threatened and Endangered Species
	Audubon Important Bird Areas	Army Chesapeake Bay Comprehensive Plan (2013), and http://www.audubon.org/important-bird-areas	Healthy High/Value Habitats Analysis; Wetland Restoration Opportunities Analysis
	Imperiled Species Dataset	Nature’s Network	Wetland Restoration Opportunities Analysis
Navigation	Dredged Material Placement Sites	USACE	USACE Projects
	Navigation Channels and Structures	NAO & NAB	USACE Projects; Wetland Restoration Opportunities Analysis
Socioeconomic	US National, state, county, regional and local parks	ESRI data from US Parks 2016	Socioeconomic Analysis
	Public Access Points	CBP Cross GIT Mapping Team - Public Access	Socioeconomic Analysis
	Low income Populations	ftp://newftp.epa.gov/EJSCREEN/2016/	Socioeconomic Analysis
	Minority Populations	ftp://newftp.epa.gov/EJSCREEN/2016/	Socioeconomic Analysis
Toxic Contaminants	National Priority List (Superfund Sites)	https://toxmap-classic.nlm.nih.gov/toxmap/superfund/identifyAll.do	Toxic Contaminants Analysis
	Pennsylvania Abandoned Mine Reclamation Projects	PADEP; http://www.pasda.psu.edu/	Toxic Contaminants Analysis

USFWS

Planning Aid Report for the Chesapeake Bay Watershed Comprehensive Study

U.S. Fish & Wildlife Service

Planning Aid Report for the Chesapeake Bay Watershed Comprehensive Study:

A Summary of U.S. Fish and Wildlife Service Biological Resources in Chesapeake Bay Watershed

November 2017

Prepared for:
U.S. Army Corps of Engineers

Prepared by:
U.S. Fish and Wildlife Service
New York Field Office
Pennsylvania Field Office
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EXECUTIVE SUMMARY

The purpose of the Chesapeake Bay Comprehensive Water Resources and Restoration Plan (Comprehensive Plan) is to address current and potential risks to water resources in the Chesapeake Bay watershed. The U.S. Army Corps of Engineers (Corps) initiated coordination with U.S. Fish and Wildlife Service (Service) in a May 20, 2015 letter. The letter expressed the Corps' desire to strategically align implementation of the Comprehensive Plan objectives with ongoing initiatives of Chesapeake Bay partners. The goals of the Comprehensive Plan include: identifying land areas vulnerable to degradation and/or loss; identifying rare, threatened, and endangered species within the watershed; and providing strategies to reduce risk from stressors including measures to protect and restore fish and wildlife habitat. The Corps' letter further requests continued participation of the Service in the development of a Planning Aid Report (PAR). The Corps requested that the PAR include two deliverables:

- Identification and GIS inventory of species based priority biological resources per strategic plans from each of the Service's field offices within the Chesapeake Bay watershed. The primary focus will be identifying habitat improvement opportunities to benefit federally listed threatened and endangered and Service trust resources. The strategies and priorities of each field office's strategic plan will be briefly presented. Focus will be on aquatic habitats, tidal and non-tidal, stream networks, and wetlands.

- Description of the stressors, both natural and man-made, that could affect priority resources with special emphasis on climate change stressors.

The Service developed the PAR in two components. The first component, a written report (Parts 1 and 2 below) provides a description of Service resource priorities and stressors. The second component is a GIS inventory submitted to the Corps electronically and summarized in the appendices of the written report. The PAR is a collaborative effort between the Service's New York Field Office (NYFO), Pennsylvania Field Office (PAFO), West Virginia Field Office (WVFO) and the Chesapeake Bay Field Office (CBFO), with inputs from the Virginia Field Office (VAFO).

The PAR is presented as a narrative with supplemental figures showing locations of priority species at the 10-digit Hydrologic Unit Code (HUC) watershed scale. The priorities of each field office's strategic plan are presented and broken down by chapter into field office responsibility by state with focus on aquatic habitats, tidal and nontidal, stream networks, and wetlands.

The GIS inventory consists of data layers presented at the 10-digit HUC watershed scale for the Chesapeake Bay watershed. The data layers depict species documented in each field office's strategic plan or identified by the field office as a priority based on current workload. The data layers are organized by state in four geodatabases: FWS_Refuges.mdb, FWS_TE.mdb, CBRA_Units.mdb, and FWS_Other_Priority_Sp.mdb.

ACKNOWLEDGEMENTS

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PART 1 INTRODUCTION

REFUGES
The Service's National Wildlife Refuge System is the world's largest collection of lands and waters set aside specifically for the conservation of fish, wildlife, and plants. The mission of the National Wildlife Refuge System is to administer a national network of land and waters for the conservation, management, and where appropriate, the restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans (The National Wildlife Refuge System Improvement Act, 1997). Refuges provide important habitats for native plants and animals, including diverse populations of migratory birds, including songbirds, shorebirds, and waterfowl, and endangered and threatened species. Nationally, there are more than 95 million acres of land on more than 545 national wildlife refuges that form the system.

The National Wildlife Refuge System works with public and private partners to identify priority species; develop measurable population objectives; and conserve habitats capable of supporting these species. Landscape and habitat must be resilient to both short-term climate fluctuations and long-term climate change. Lands protected through the National Wildlife Refuge System are in public ownership to meet the lifelong habitat needs of fish, wildlife, and plant resources for the benefit of current and future generations of Americans.
To determine whether or not a refuge was found within the Chesapeake Bay watershed, the Service viewed the Chesapeake Bay watershed boundary in GIS in conjunction with the Service's refuge property layer. Any refuge that had any part of its property in the watershed is identified in this report. There are 16 refuges in the Chesapeake Bay watershed (Map B3). In Maryland they include: Chesapeake Marshlands National Wildlife Refuge Complex (Susquehanna, Eastern Neck, Blackwater, and Martin) and Patuxent Research Refuge. In Virginia they include: Eastern Virginia Rivers National Wildlife Refuge Complex (Rappahannock River Valley, Presquile, James River, and Plum Tree Island), Potomac River National Wildlife Refuge Complex (Elizabeth Hartwell Mason Neck, Occoquan Bay, and Featherstone), Great Dismal Swamp, Nansemond, Fisherman Island, and Eastern Shore of Virginia National Wildlife Refuges. The PAR expands upon each of these refuges in further detail in Part 2 of the report.

The National Wildlife Refuge System Improvement Act of 1997 requires that every refuge develop a Comprehensive Conservation Plan (CCP) and revise it every 15 years, as needed. CCPs ensure that each refuge unit is managed to fulfill the purpose(s) for which it was established. Completed CCPs allow refuge managers to take actions that support State Wildlife Action Plans, improve the condition of habitats, and benefit wildlife. CCPs focus on individual refuge actions that contribute to larger, landscape-level goals identified through the Landscape Conservation Design process. The CCPs are the primary tool used to develop the refuge resource priorities for this PAR.

ENDANGERED SPECIES

When Congress passed the Endangered Species Act (ESA) in 1973, it recognized that our rich natural heritage is of "esthetic, ecological, educational, recreational, and scientific value to our Nation and its people." It further expressed concern that many of our nation's native plants and animals were in danger of becoming extinct. The purpose of the ESA is to protect and recover imperiled species and the ecosystems upon which they depend. There are over 1,300 species listed as either threatened or endangered in the United States under the ESA. The Service and the National Marine Fisheries Service (NMFS), under the Department of Commerce, share responsibility for administering the ESA. These responsibilities include: listing and delisting species; designating critical habitat; developing recovery plans; and evaluating the status of the species in 5-year reviews. The Service manages the terrestrial and freshwater species and shares responsibilities with the NMFS for the anadromous and catadromous species. Once listed, a species is afforded the full range of protections available under the ESA, including prohibitions on killing, harming, or otherwise "taking" a species.

The Service takes the lead in recovering and conserving our Nation's imperiled species by fostering partnerships, employing scientific excellence, and developing a workforce of conservation leaders. Working in partnership with others, the Service's two major goals are to: protect endangered and threatened species, and then pursue their recovery; and conserve candidate species and species-at-risk so that listing under the ESA is not necessary. These goals are achieved through the following activities.

Candidate Conservation

Working in partnership with public and private landowners, the Candidate Conservation Program assesses species and develops and facilitates the use of voluntary conservation tools for collaborative conservation of candidate and other species-at-risk and their habitats, so that these species do not need the protection of the Endangered Species Act.

Consultations

The ESA directs all Federal agencies to use their existing authorities to conserve threatened and endangered species and, in consultation with the Service, to ensure that their actions do not jeopardize listed species or destroy or adversely modify critical habitat. This applies to management of Federal lands as well as other Federal actions that may affect listed species, such as approval of private activities through the issuance of Federal permits, licenses, or other actions.

Grants

Grants for states and territories, offered through the Cooperative Endangered Species Conservation Fund, fund participation in a wide array of voluntary conservation projects for candidate, proposed, and listed species. These funds may in turn be awarded to private landowners and groups for conservation projects.

Habitat Conservation Plans

To obtain a permit for conducting activities that might incidentally harm endangered or threatened wildlife, private landowners, corporations, state or local governments, tribes or other non-Federal landowners develop a Habitat Conservation Plan (HCP), designed to offset any harmful effects the proposed activity might have on the species. The Service assists applicants throughout the HCP process, allowing development to proceed consistent with conserving listed species.

Listing and Critical Habitat

Through the Listing Program, the Service determines whether to add a species to the Federal list of endangered and threatened wildlife and plants. Listing affords a species the full range of protections available under the ESA, including prohibitions on killing, harming, or otherwise "taking" a species. In some instances, listing can be avoided by the development of Candidate Conservation Agreements which may remove threats facing the candidate species.

Recovery

The goal of the Endangered Species Act is the recovery of listed species to levels where protection under the ESA is no longer necessary. Towards that goal, the Service develops and implements recovery plans that provide detailed site-specific management actions for private, Federal, and state cooperation in conserving listed species and their ecosystems.

For this PAR, the Service used endangered species occurrence information and joined the species name to the 10-digit Hydrologic Unit Code (HUC) to tag each watershed with presence or absence of the species. This allowed us to develop a species list for the entire Chesapeake Bay watershed. Once the list was developed, each species was evaluated for its relevance to the objectives of the Comprehensive Plan. All species in the watershed are identified but Part 2 of the plan addresses species as aquatic dependent or not aquatic dependent species, to better aid the Corps in focusing on the aquatic dependent species and their stressors.

COASTAL BARRIER RESOURCES ACT (CBRA)

In the 1970s and 1980s, Congress recognized that certain actions and programs of the Federal government have historically subsidized and encouraged development on coastal barriers, resulting in the loss of natural resources; threats to human life, health, and property; and the expenditure of millions of tax dollars each year. To remove the Federal incentive to develop these areas, the Coastal Barrier Resources Act (CBRA, 1982) designated relatively undeveloped coastal barriers along the Atlantic and Gulf Coasts. These areas were designated as part of the Coastal Barrier Resource System (CBRS) making them ineligible for most new Federal expenditures and financial assistance. CBRA encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting Federal expenditures that encourage development, such as Federal flood insurance. Areas within the CBRS can be developed provided that private developers or other non-Federal parties bear the full cost. CBRS zones are only found in Maryland and Virginia part of the Chesapeake Bay watershed. Part 2 of the PAR expands on these zones.

NORTHEAST REGION PRIORTIES

Watersheds are the foundation of the Service's Northeast Region landscapes. The history, economics, recreation, fish and wildlife all depend on rivers, streams, wetlands, forests, and coastal areas. The Service's strategic conservation over the next 10 years emphasizes sustainable watersheds to support fish and wildlife in the Chesapeake Bay watershed. To achieve this goal, the Service identified four Regional Focal Strategies: landscape conservation, aquatic connectivity, at-risk species, and coastal resiliency (USFWS, Northeast Region, 2016). The strategies are summarized below and expanded upon in Part 2 of the PAR.

Landscape Conservation

Using best available science, facilitate conservation for suites of species on Service lands with willing private landowners, states, tribes, and other partners. The Service approaches conservation of these suites of species and their watersheds from a landscape perspective.

Aquatic Connectivity

Prioritizing aquatic connectivity efforts that provide for passage, community protection, and enhanced recreational opportunities is a conservation legacy. Actions are prioritized within watersheds using best available science and decision support tools.

At-Risk Species

The Service's relationships, and the partnerships that stem from them, enable us to proactively conserve and recover at-risk species. Using new and developing planning tools, adaptive management, and special partnership with states and tribes, the Service continues to proactively address threats and avoid the need to list species under the Endangered Species Act. Working at landscape levels, the Service will conserve and recover species, with a special emphasis on species facing threats that can be reasonably addressed.

Coastal Resiliency

The Service applies hybrid approaches to provide for a more resilient coast that better withstands storms, sea level rise, and other climate-related changes to provide more resilient habitat for wildlife, as well as protect communities and infrastructure.

WATERSHED STRESSORS TO U.S. FISH AND WILDLIFE SERVICE RESOURCES

The resources described above are primarily at risk because of human activities on the landscape. Each resource discussed in Part 2 of this report is tied to one of the stressors summarized below.

Climate Change

The Chesapeake Bay is especially vulnerable to the effects of climate change because the environment is already stressed from pollution, development, and other pressures. Many species are already at the edge of their habitable range. Global warming results from increased carbon dioxide levels which is expected to worsen problems of low dissolved oxygen concentrations in waters of the Chesapeake Bay. Sea level rise is a continuing threat which can affect coastal ecosystems in several ways. Sea level in the Chesapeake Bay is rising at an average rate of 0.14 in/yr. This rate is almost 0.08 inches faster than the global average because the land around the Chesapeake Bay is also subsiding (NOAA, 2012). It can cause low lying lands to be inundated, and shorelines to experience increased erosion. In response to sea level rise, shoreline armoring/stabilization practices are beneficial to reduce erosion to vulnerable areas. Salinity intrusion into upland environments or into freshwater areas can result in major changes in the floral and faunal communities. Tidal marshes, barrier islands, low-lying uplands, beaches, tidal shorelines, estuaries, and coastal bays are the most vulnerable environments. Rising sea levels will submerge some of the Chesapeake Bay's wetlands, which will likely impact (ecologically and economically) important foraging and nursery areas for fish. Water temperatures have also increased, approximately 2 degrees F since 1960 (NOAA, 2012). Scientists predict that many cold-water fish species will disappear or become less abundant in the Chesapeake Bay, including yellow perch, white perch, striped bass, black sea bass, summer flounder, and winter flounder. Also, an increase of carbon dioxide in the Chesapeake Bay may raise the acidity of the water and gradually reduce the ability of oysters, clams, mussels, and other animals to build calcium carbonate shells. Some fish parasites will likely benefit from warmer water, increasing their impact on fish and oysters in the Chesapeake Bay (Smithsonian, 2009). In addition to climate change, overharvesting and altered aquatic foodwebs have contributed to declines of anadromous and diadromous fish species over the last decades.

Urbanization

Urban sprawl results in the incremental loss of natural vegetative landscapes, which impacts and reduces species diversity. When residential, commercial, and/or industrial development occurs, it is accompanied by a significant change in hydrological cycles (Barnes et al., 2001). Urban development brings an increase in impervious surfaces. During rain events, pollutants, such as heavy metals and polynuclear aromatic hydrocarbons (PAHs), are washed from impervious surfaces. In addition, lawns, gardens, and grassy areas flush sediment, pesticides, and nutrients (Clark, 1985; Novotny and Chesters, 1981; Whipple, 1977). Together, these pollutants are often deposited through storm water drainage systems into streams and rivers. Metals are naturally occurring elements in most streams. In urban areas, there is additional loading from construction materials and industrial areas. This excess loading may be significant enough to have adverse effects on aquatic life. Gray (2004) demonstrated a direct correlation with urbanization and increased concentrations of dissolved copper, lead, and zinc. The rapid increase in metals along with the decrease in conductivity and dissolved oxygen were directly reflected by decreased abundance and total species diversity in the macroinvertebrate community.

As of 2007, approximately 1,000 out of Maryland's ~7,000 mile long Chesapeake Bay shoreline was anthropogenically stabilized (MD DNR, 2007). Virginia has a comparable condition. Shoreline armoring has been recognized for some time as a concern for shoreline dependent fish and wildlife species. Studies conducted by National Oceanic and Atmospheric Administration (NOAA), Smithsonian Environmental Research Center (SERC), Maryland Department of Natural Resources (MD DNR), and others have raised concerns over shoreline armoring detrimental impacts to submerged aquatic vegetation (SAV) as well (Orth et al, 2017 Historically, industrial activity in urban centers such as Baltimore Harbor, Anacostia River, and

Elizabeth River continually reveal problematic issues pertaining to pollutants and contamination.

Invasive Species

Invasive species are plants or animals that are not considered native to a locality. Native species are those that have evolved naturally in an ecosystem over decades to hundreds of years. Invasive species are introduced species and can include lifeforms as small as viruses, as large mammals, and everything in between, including amphibians, reptiles, birds, insects, plants, fish, shellfish, even jellyfish (MD DNR, 2017). Terrestrial habitats have become degraded or choked-out when invasive plant species outcompete the natural plant communities. As carbon dioxide increases, vines increase threatening existing canopy and interfering with tree reproduction. Phragmites (*Phragmites australis*), mile-a-minute vine (*Persicaria perfoliata*), and kudzu (*Pueraria montana*) benefit from high nutrient levels. These plant species are very destructive and require persistent spraying to control their spread into new areas. Other introduced species include blue catfish (*Ictalurus furcatus*), zebra mussel (*Dreissena polymorpha*), nutria (*Myocaster coypus*), mute swan (*Cygnus olor*), northern snakehead (*Channa argus*), and purple loosestrife (*Lythrum salicaria*).

Agriculture

Sediment Loading and Fertilizers

Conversion of forest blocks to agricultural lands occurred historically and remains a stressor in some areas of the Chesapeake Bay watershed. There are more than 35,000 farms totaling over 6,400 square miles of agricultural land within the Susquehanna River basin portion of the Chesapeake Bay watershed alone (Chesapeake Conservancy, 2017). Production of cash crops is a necessity to meet the world-wide need for food. Farming practices stress aquatic systems when erosion carries sediment and fertilizers into streams and rivers. Agriculture is the single largest source of nutrient and sediment pollution entering the Chesapeake Bay. According to 2015 estimates from the EPA Chesapeake Bay Program (EPA, 2015), agriculture contributes 42 percent of the nitrogen, 55 percent of the phosphorous, and 60 percent of the sediment entering the Chesapeake Bay. Excess sediment delivered to streams increases phosphorous delivery, while nitrogen that is bioavailable in streams is delivered in dissolved form from fertilizers and animal and human waste. This accounts for almost half of the nutrients entering the Chesapeake Bay. Agricultural chemicals not absorbed by crops result in excess loads into streams and rivers. Increased levels of sediment combined with excess levels of fertilizers (including manure and poultry litter) increases nitrogen in the water. Livestock are also a source of ammonia and nitrogen oxides which release greenhouse gas into the atmosphere. These compounds are harmful to aquatic life (CBP, 2017).Other stressors include, agricultural practices of ditching and filling of wetlands and channelization of water which caused degradation or destruction to wetlands on a large scale.

Silviculture

In the 1600s forests covered about 95 percent of the Chesapeake Bay watershed. Forest cover was down to approximately 30 percent during the 1900’s and, by 2011, only 55 percent of the watershed was forested (Chesapeake Bay Program, 2017). Forests are crucial to the health of the Chesapeake Bay. They provide habitat to wildlife, protect clean air and water, store carbon, contribute to flood amelioration, and support the region's economy. Human activities have altered the Chesapeake Bay watershed's forestlands, leading to forest fragmentation, reduced canopy cover, compromised water quality, and increased erosion. Studies have shown that skid trails, haul roads, landings, and stream crossings are potential sources of sedimentation, erosion, and siltation of streams and other water bodies, and damage bed and banks of streams (USDA, 1998).

Since colonists first settled in the Chesapeake Bay watershed, people have depended on the Chesapeake Bay watershed's forests to produce food, fuel, shelter, and commercial products. One problematic practice still used today on private land is to high grade, or remove all of the biggest, best, and most valuable trees. This method leaves poorer quality trees to regenerate the forest, reduces future economic return, reduces the overall health of the forest, and eliminates wildlife food sources and important habitat features (CBP, 2017).

The consumption of wood products has grown. The average person in the Chesapeake Bay watershed uses an amount of forest products equivalent to the clearing of more than 2 acres of forest per person per year, 2.5 times the European and 3.4 times the world averages (USDA, 2017). The demand for forest products by residents in the Chesapeake region is three times the annual yield from forests in Maryland, Virginia, and Pennsylvania. Virginia leads the Chesapeake Bay states in terms of wood harvested (20,600 acres), but New York leads the region in terms of wood products consumed (44,500 acres) (CBP, 2017; USDA, 2017). The impact of forest fragmentation on wildlife in the eastern United States has emerged as an important issue. Numerous studies of small woodlots in rural and suburban settings have shown major declines in forest bird populations. Other taxa have not been studied as thoroughly, but evidence suggests that certain mammals, amphibians, reptiles, and plants are adversely affected by forest fragmentation. Some studies have shown that plants are affected by fragmentation through changes in seed dispersal and herbivory, including over-browsing by white-tailed deer (*Odocoileus virginianus*) (DeGraaf and Healy, 1990). Other studies have shown that bats and small mammals also experience adverse effects associated with edges, small patch size, and habitat fragmentation (Hobson, 1995; Ontario Ministry of Natural Resources, 2001; Robbins, 1988). Although poorly studied, forest-dwelling reptiles and amphibians (salamanders and treefrogs) that require two or more habitat types and a range of microhabitats are also sensitive to forest fragmentation (Cushman, 2005).

Oil and Gas Development

Oil and gas development activities present a conservation challenge because they contribute to habitat loss and fragmentation, increase spread of invasive species, result in soil and water contamination, and increase water scarcity. There are about 12,000 active shale well sites and associated infrastructure (pipelines) within the Chesapeake Bay watershed (Chesapeake Conservancy, 2017). Horizontal wells drilled in shale oil or shale gas formations typically require fracturing the oil or gas bearing rock by injecting large volumes of fluids (water, sand, and chemicals) under very high pressure. Hydraulic fracturing (fracking) operations use 2 to 5 million gallons of water per well. After the well is fracked, 10 to 70 percent of the fluid (flowback) is temporarily stored in either steel tanks (frack tanks) or an earthen pit (reserve pit) (USFWS, 2016).

Highly saline formation water or brine is extracted along with oil and gas. Often, brine is collected in storage tanks and injected under pressure back into the formation to force more oil out of the ground. A network of pipes or flowlines moves the brine from the oil wells to storage tanks and to injection wells. Pipe failures and leaks are common. Small diameter pipelines, or flow-lines, transport the liquids and gases to separators and storage tanks designed to store 3 to 7 days of production. Liquids from the storage tanks are typically transported off site by tanker trucks (USFWS, 2016).

Mining

Energy resource development is increasing, including traditional energy sources such as oil, gas, and coal, and renewable sources such as wind, solar, and geothermal. Energy development is necessary to meet the needs of the American public, but there often are environmental impacts. Surface mining and deep underground mining are the two basic methods of coal extraction. Many types of coal also require washing in a coal preparation plant. The most economical mining method depends on the depth of the coal, its quality and thickness, and the density of the overburden (material above the coal seam). Geology and environmental factors are also important considerations. Mountaintop coal mining is a type of surface mining that removes mountaintops to expose coal seams and discards the overburden in adjacent valley fills. Valley fills occur in steep terrain where there are limited disposal alternatives (USFWS, 2015).

Trees and vegetation may be removed from the area to be mined for coal. Roads are constructed to provide access for trucks, heavy equipment, and larger conveyor beltlines. Blasting, excavation, and placing excess material into valley fills or other locations may further degrade habitats. Stream crossings, stream relocation, or even complete stream burial may occur. Soil placed in streams may contain contaminants or other materials that can change the water chemistry, acidity, and conductivity. Species living in or near streams may be harmed or killed when material is placed in streams. Changes in water quality and quantity may result in changes in the number and types of species living in and around the stream. Invertebrates and salamanders are especially sensitive to changes in water flow and chemistry. It is best to avoid high quality streams in favor of previously impacted streams whenever possible (USFWS, 2015).

Environmental problems associated with abandoned mine lands include surface and ground water pollution, open mine entrances, water-filled pits, and subsidence. Mine sites and refuse piles may be unreclaimed or inadequately reclaimed, including some with dangerous highwalls that can be several stories tall. Other problems include sediment-clogged streams and damage from landslides. Environmental restoration activities under the Abandoned Mine Land Reclamation Program are designed to correct or mitigate these problems (USFWS, 2015).

Hydropower, Dams, Road Crossings, and Culverts

Rivers and streams are long linear ecosystems, and, as such, are particularly vulnerable to fragmentation. Human activities can disrupt the continuity of river and stream ecosystems that aquatic organisms need. Waters fragmented by small or large dams and poorly placed road culverts keep aquatic species from accessing habitat.

Road and rail systems can result in significant habitat fragmentation of stream ecosystems. Road systems and stream networks frequently intersect, often with significant negative consequences for river and stream ecosystems. Most culverts currently in place were designed with the principal objective of moving water across a road alignment. Little consideration was given to ecosystem processes such as the natural hydrology, sediment transport, fish and wildlife passage, or the movement of woody debris (University of Massachusetts, 2017; The Nature Conservancy, 2013; USFWS, 2017). Culvert design using open-bottom structures (arches, rigid frame arches, bridge-in-a-backpack, or con-span arches), depressing the subverts of conventional culverts (to avoid a perched condition), and oversizing the culvert to include floodplain benches (for wildlife passage and sheer stress reduction) will help to alleviate aquatic life movement barriers at road/infrastructure crossings. Culvert replacement and retrofit has been identified as a priority throughout the watershed by landowners concerned about stormwater and flooding, and by wildlife experts who have identified culverts to be barriers to aquatic organisms (Chesapeake Conservancy, 2017).

Water Withdrawal

The Susquehanna River Basin Commission (SRBC) located in Harrisburg, Pennsylvania regulates water withdrawals from the Susquehanna River in Pennsylvania, Maryland, and New York. Subbasins include: Chemung and Upper Susquehanna in New York; and West Branch Susquehanna, Middle Susquehanna, Juniata, and Lower Susquehanna in Pennsylvania (SRBC, 2015).

The main purposes of the Commission’s regulations are to: protect public health, safety and welfare; regulate water flows and supplies of surface and ground waters; protect fisheries and aquatic habitat; consider economic development factors; protect flows to the Chesapeake Bay; and avoid conflicts among water users (SRBC, 2015).

The SRBC regulates the removal or withdrawal of 100,000 gallons per day (gpd) or more over a 30-day average from any source or combination of sources within the Basin. All withdrawals that supply water to a regulated consumptive use are also regulated (SRBC, 2015).

Consumptive use includes public water supply, electric generation, manufacturing, mining, natural gas, and agriculture. Public water supply includes the diversion of water outside of the Basin to the City of Baltimore and the Philadelphia area (SRBC, 2015).

The Cumulative Water Use and Availability Study, dated August, 2016, is a comprehensive analysis that characterizes water use and availability for the Susquehanna River Basin. The study analyses were conducted for 170 distinct watersheds covering the entire Basin. The watersheds correspond to the U.S. Geological Survey’s (USGS) designated 10-digit Hydrologic Unit Codes (HUC-10). The results of the study show that the largest water use sectors are public water supply, electric power generation, and agriculture. Basin-wide, in 2014, the SRBC approved 1 billion gallons per day (bgd)and reported consumptive water use (CU) of approximately 370 million gallons per day (mgd (SRBC, 2014.)

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Part 2. U.S. FISH AND WILDLIFE PRIORITY BIOLOGICAL RESOURCES AND THEIR STRESSORS IN THE CHESAPEAKE BAY WATERSHED

Chapter 1. Virginia

The Commonwealth of Virginia has 15.3 million acres of land (approximately 56 percent of the state) in the Chesapeake Bay Watershed. Over half of Virginia's streams and rivers flow to the Chesapeake Bay. Almost three-fourths of the state's 8 million residents live within the watershed (USDA, 2017). Through strategic planning, the Service identified Watershed Priority Areas to protect ecologically sensitive terrestrial and aquatic species, including endangered and threatened plants and animals, and to maintain or restore their habitats in Virginia. These include the Blackwater River Watershed Priority Area, Clinch and Powell Rivers Watershed Priority Area, Eastern Shore Priority Area, Holston River Watershed Priority Area, and Nottoway River Watershed Priority Area (USFWS, 2012a).

REFUGES

There are 16 National Wildlife Refuges (NWR) in the Chesapeake Bay watershed. The refuges in Virginia include: Eastern Virginia Rivers National Wildlife Refuge Complex, Potomac River National Wildlife Refuge Complex, Nansemond National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, Fisherman Island National Wildlife Refuge, and Eastern Shore of Virginia National Wildlife Refuge. Each of these refuges may have individual refuge units within the Refuge Complex. The complex and refuge units, along with the goals and associated stressors, are described in detail in this section. All refuge information in this section was summarized from the most recent Comprehensive Conservation Plan (CCP). The date of the most recent update is provided next to the title of the Refuge.

Eastern Virginia Rivers National Wildlife Refuge Complex

The Eastern Virginia Rivers National Wildlife Refuge Complex is comprised of Rappahannock River Valley NWR, James River NWR, Presquile NWR, and Plum Tree Island NWR. The Refuge Complex staff share responsibility for the four refuges and are located at Rappahannock NWR in Charles City, Virginia.

James River National Wildlife Refuge (2015)

James River NWR is located in Prince George County, Virginia, along the south bank of the lower James River. The Refuge encompasses 4,324 acres of pine-dominated, moist hardwood, and floodplain forests; freshwater marshes and shrub swamps; aquatic habitats; erosional bluffs; and non-forested uplands. The description, goals and stressors were identified in the James River National Wildlife Refuge CCP (James River National Wildlife Refuge, 2015).

James River NWR was established to conserve fish, wildlife, and plants listed as endangered or threatened species. The Refuge safeguards nationally significant habitats along the lower James River for bald eagles (*Haliaeetus* leucocephalus)and vulnerable species of the Chesapeake Bay, while healthy, contiguous forests of pine and mixed hardwoods offer respite to diminishing wildlife populations. As a living laboratory, the Refuge supports environmental research conducted by partner organizations and institutions recognized for their scientific excellence.

Stressors

Climate change poses a major threat to James River NWR. Potential impacts to the Refuge include species range shifts, species extinctions, behavioral or physical changes in species, and shifts in primary productivity periods. Changes in phenology (timing of important life history events such as flowering, egg laying, and migration) are also anticipated. Changes in body sizes and behaviors may occur, and genetic frequencies may shift. The density of species may change locally and their ranges may shift in response to the need to find areas within their range of tolerance. Plant communities and species adapted to warmer subtropical latitudes are expected to expand and establish beyond the northern edge of their current range (U.S. Climate Change Science Program, 2008).

Species with short life cycles, such as insects and annual plants, should have fewer problems adapting to climate change because of their more rapid evolution. Longer-lived species such as trees would be less adaptable (Rogers and McCarty, 2000).

Sea level rise is expected to be one of the greatest effects from climate change on the Refuge. In an effort to address the potential effects of sea level rise on refuges, the Service ran the Sea Level Affecting Marshes Model (SLAMM) for most Northeast Region refuges. The SLAMM report for James River NWR indicates that the Refuge is vulnerable to the sea level rise scenarios modeled over the next century with some changes to tidal marsh possibly occurring sooner, by 2025 (Clough and Larson, 2010). An increase in sea level rise along the higher ends of projections would inundate much of the Refuge's tidal-fresh marshes and tidal swamps. The Refuge's dry lands, inland-fresh marshes, and non-tidal swamps are expected to be relatively resilient to sea level rise (Clough and Larson, 2010).

An additional effect of climate change in the Northeast Region is increased wildfire frequency and severity (Scholze et al., 2006). Wildfire regimes have also changed due to long periods of fire suppression, forestry practices, and other land management trends, but higher temperatures and decreased precipitation are fundamental to wildfire intensification. Intensified fire regimes modify fish and wildlife habitats, benefiting some species while harming others. However, the risk of catastrophic fire that causes widespread and permanent damage to current ecosystems increases in warmer and drier conditions.

Observed changes and documented responses in natural and managed systems resulting from climate change are diverse and include the magnitude, timing, distribution, and type of precipitation, with corresponding effects on surface and groundwater resources (IPCC, 2007). Climate change may alter storm frequency and intensity (Henderson-Sellers et al., 1998; Huntington, 2006); result in changes in availability, uptake, and toxicity of contaminants and increased sensitivity of fish and wildlife to contaminants (Noyes et al., 2009); alter wildlife disease transmission dynamics and ranges (Acevedo-Whitehouse and Duffus, 2009); and introduce new invasive species and spread present invasive species (Mooney and Hobbs, 2000).

In addition to potential effects of climate change, the potential for future chemical pollution of the Refuge and surrounding waters is noteworthy. Of particular concern is potential contamination of food sources for the bald eagle and of waters used in support of Refuge operations and public use. In 1993, a study found that DDT concentration levels were high enough to cause concern for the stability of bald eagle populations of the James River. The study recommended that fish contaminants continue to be monitored, and that a sediment monitoring program be started as well as an eaglet blood monitoring program (Morse et al., 1993).

From 1966 to 1975, the James River and its tributaries from Richmond to Newport News were polluted with Kepone, a chlorinated hydrocarbon insecticide that was produced by the Allied Chemical Company. Virginia Department of Environmental Quality (VDEQ) has continually monitored Kepone levels in the James River since 1975, and since 1996 no fish-fillet samples from the lower James River have exceeded 0.30 ppm Kepone, a level of concern established by Virginia Department of Health (VDEQ , 2012).

Additionally, asbestos used to be present on the Refuge. In 2005, Prion Compliance & Testing Services removed 1,600 square feet of asbestos from refuge land. All known asbestos has been removed from the Refuge.

Lead contamination on the Refuge is also of concern. Prior to the Refuge's establishment, a 25-acre skeet range was used by five different hunt clubs. Upon establishment, the skeet range was closed. During the summer of 2014, Virginia Field Office and Refuge staff initiated a site characterization of the former skeet range to assess the extent and nature of the contamination associated with the former skeet range, focusing on soil where shot was deposited within the footprint of the former skeet range. Soil outside the areas directly impacted by shot will also be assessed to determine whether lead or other chemical constituents have migrated as the result of runoff or windblown movement of soil particles. The primary constituent of concern is from the lead shot.

The Service evaluated various contaminant sites for the potential risk to trust resources utilizing James River NWR (USFWS, 2013). The following sites were identified as contributors to poor water quality in the James River and tributaries: Chesterfield Power, Hercules Hopewell Plant, Honeywell International Inc., Rocktenn, Hopewell Cogeneration Facility and Power Station, Hopewell Wastewater Treatment Plant, Philip Morris, and Proctors Creek Wastewater Treatment Plant (USFWS, 2013). Future contaminant concerns will most likely be related to a potential spill event in the James River, potentially contaminated areas identified above for which little or no data exists on the presence of contaminants and potential contaminant threats associated with the site, and proposed development in the vicinity of the refuge.

Invasive species also pose a threat to the Refuge. Invasive plants adversely impact the biological integrity, diversity, and environmental health of refuges and other natural areas. In pine-dominated forest, the invasive plant shrubby lespedeza (*Lespedeza bicolor*) is known to exist on the Refuge. In the Refuge's moist hardwood forest, princess tree (*Paulownia tomentosa*) and periwinkle (*Vinca minor*) are known to occur, while hydrilla (*Hydrilla verticillata*) occurs in the Refuge's aquatic habitats. Japanese privet (*Ligustrum japonicum*), Japanese stiltgrass (*Microstegium vimineum*), Japanese wisteria (*Wisteria floribunda*), and tree-of-heaven (*Ailanthus* altissima) occur in the most hardwood forest and non-forested upland on the Refuge CCP (James River National Wildlife Refuge, 2015).

Refuge staff controls invasive species using a combination of mechanical removal (brush hogging and pulling), prescribed fire, and herbicide applications (typically glyphosate and triclopyr products). Refuge staff plans to continue to control invasive species as funding, staffing, and equipment logistics allow, with particular attention to controlling Japanese privet and Japanese stiltgrass in moist hardwood forest, as well as tree-of-heaven and princess tree along roadsides and within non-forested upland.

Invasive wildlife species of potential management concern include feral hogs (*Sus scrofa*), nutria (*Myocastor coypus*), and mute swans (*Cygnus olor*). However, none of these species has been detected on the Refuge to date.

Urbanization is also a stressor to the Refuge. Located within the Richmond Metropolitan Statistical Area and close to the population centers of Richmond, Petersburg, Hopewell, and Colonial Heights, James River NWR is considered an urban refuge. According to the Service's Urban Wildlife Refuge Initiative (USFWS, 2017a), existing refuges that are located within a 25-mile radius of urban areas are to provide public use benefits associated with fish and wildlife resources that include, but are not limited to, bird watching, fishing, scientific research, environmental education, open space in an urban setting, and protection of cultural resources. Because James River NWR is an urban refuge, the Service anticipates that interest in the Refuge and annual visitation will increase in the future.

Goals

The goal of James River NWR is to protect, enhance, and restore the ecological integrity of inner coastal plain forest and non-forest ecosystems of the lower James River to support native wildlife and plant communities, including species of conservation concern, and to ensure those ecosystems are resilient in anticipation of climate change. Additionally, James River NWR aims to protect and conserve the Refuge's cultural resources and landscape, and seek opportunities to increase knowledge and appreciation of the Refuge's history as part of the lower James River (James River National Wildlife Refuge, 2015).

With its proximity to cities including Petersburg and Williamsburg, the Refuge provides wildlife-dependent recreational opportunities for visitors to connect with nature and foster enhanced stewardship of the lower James River and the Chesapeake Bay.

Presquile National Wildlife Refuge (2012)

Presquile NWR was officially established in 1953 for use as a sanctuary, or for any other management purposes, for migratory birds. It is one of many important migratory bird stopover sites along the Atlantic Flyway, providing protected breeding habitat for state-listed threatened and endangered species, as well as many neotropical migrant bird species. The 1,329-acre island Refuge is comprised of a variety of wildlife habitats including open waters of the James River and associated backwaters, tidal swamp forests, tidal freshwater marshes, grasslands, mixed mesic forests (transitional and mature), and river escarpment. The description, goals, and stressors were identified in the Presquile National Wildlife Refuge CCP (Presquile National Wildlife Refuge, 2012).

Stressors

Climate change is one of the greatest stressors to Presquile NWR (Presquile National Wildlife Refuge, 2012). Climate change and its corresponding effects on sea level rise, species migrations or range distributions, extreme shifts in temperature and precipitation, and invasive species introductions may pose dramatic threats and alterations to the habitats within the Refuge. Presquile NWR is located at or near sea level and is subject to tidal hydrology. Located between coastal and inland plant communities as well as the upper extent of the James River's tidal range, the Refuge is a transitional zone for many plant, fish, and wildlife species. Given the projections for shifts in mean temperature and precipitation, new introductions or altered distributions of both native and nonnative species are possible results of climate change. The Refuge is evaluating potential habitat changes caused by rising sea levels, and has analyzed the effect of sea level rise on refuge habitats through the use of a Sea Level Affecting Marshes Model (SLAMM) analysis originally completed in 2009 (Presquile National Wildlife Refuge, 2012).

Climate change will have a range of effects on vegetation and ecological systems and the biological resources that depend on them. Land birds are already exhibiting shifts in their winter centers of abundances and some migrants are possibly returning earlier in the season. The possibilities for change in invertebrate fauna in response to climate change are poorly understood. This is particularly true for pollinators and their larvae, in terms of species composition and distribution of their host plants. It is expected that species ranges will shift northward or toward higher elevations as temperatures rise, but responses will likely vary depending on species or taxonomic group. Under these rapidly changing conditions, migration, not evolution, will determine which species are able to survive. For example, plants, mussels, and amphibians — species that are vulnerable to temperature shifts — may be affected in their ability to survive, grow, and reproduce. Data collected over the last 21 years through a Virginia Commonwealth University (VCU) study indicate that male prothonotary warblers (*Protonotaria citrea*) are arriving to Presquile NWR earlier in the breeding season (an average of 1 day per year), and the earlier arrival dates are correlated with a rise in average atmospheric temperature on the breeding grounds.

The Virginia Climate Change Strategy for Species of Greatest Conservation Need predicts that there will be significant challenges for species of greatest conservation need (VDGIF, 2009). Over 60 percent of these species are aquatic and another 15 to 20 percent rely on riparian and wetland habitats. Since Presquile NWR is an island, the buffering effect against climate change provided by contiguous connection with adjacent habitat is not available to non-mobile species.

In addition to threats from climate change and sea level rise, aquatic habitats are under pressure from urbanization within the James River Basin, with approximately 12 percent of the river basin considered urban. Most impairment to water quality in the James River watershed comes from E. coli (*Escherichia coli*), which is primarily related to agriculture practices, but is also a result of urban runoff, leaking sanitary sewers, urban storm sewers, and failing septic tanks. Additionally, urbanization and development can more than double the natural background sediment yield, with the highest increase in sediment yield occurring during early development stages (USFWS, 2007b).

Approximately 19 percent of the James River Basin is cropland and pasture. Despite the fact that three of the critical habitats — underwater grasses, riparian forests, and tidal water —have improved in recent years, agriculture in the James River Basin continues to threaten the Refuge's aquatic habitats. Currently, 61 percent of the James River's and streams are categorized as being in good or excellent condition. However, many streams are still under moderate to severe stress. The tidal James River continues to have problems with excessive algae growth and water clarity remains very poor, meeting the State standard only 6 percent of the time. The most pervasive forms of pollution in the James River are sediments, phosphorus, nitrogen, and bacteria (JRA, 2009).

Based on a review of current and historic aerial photography, the Service estimates that Presquile NWR has lost more than 11 acres of land since 1968 (Presquile National Wildlife Refuge, 2012). Erosion along the Turkey Island Cutoff poses a threat to loss of land and associated resources. The Turkey Island Cutoff, completed in 1934, allows transport of commercial shipping along the James River. However, erosion of the southern boundary of the Refuge has resulted in large losses of land in recent decades (Presquile National Wildlife Refuge, 2012).

Sediment deposition in other portions of the James River poses potential concerns related to waterfowl protection at the Refuge (Presquile National Wildlife Refuge, 2012). Sedimentation in the oxbow has resulted in the mean low water line moving into the former channel. Without dredging and other mitigation, this increased sedimentation could stop the flow of water there, threatening waterfowl habitat (Presquile National Wildlife Refuge, 2012).

In addition to sedimentation, the unchecked spread of invasive plants threatens the biological diversity, integrity, and environmental health of all Refuge habitats (Presquile National Wildlife Refuge, 2012). Presquile NWR staff has begun identifying and mapping locations of invasive species on the refuge as time and resources allow, and have identified Johnson grass (*Sorghum halepense*) and Canada thistle (*Cirsium arvense*) as the biggest concerns, guiding the development of monitoring, control, and eradication projects. When control is deemed necessary, the Refuge uses the most effective combinations of mechanical, biological, and chemical controls to achieve long-term control or eradication. Only herbicides approved by the regional contaminants coordinator are used, and only in accordance with the approved rate and timing of application. Currently, the Refuge uses the following chemicals to treat invasive species, when resources allow: Garlon 4, Glypro, and Plateau (Presquile National Wildlife Refuge, 2012).

There are additional concerns that other invasive species, such as exotic insects, fish, and other animals, should be considered and managed as well. Climate change may also result in a shift of species distributions or conditions across the region that may allow introduction of additional species in the future (Presquile National Wildlife Refuge, 2012).

Goals

Presquile NWR seeks to protect, maintain, and restore the integrity of the Refuge's tidal swamp forest, tidal freshwater marsh, and upland habitats, with emphasis on the mixed mesic forest ecological community, to sustain native plants and wildlife, including species of conservation concern, and benefit aquatic resources of the James River watershed and Chesapeake Bay. The Refuge also seeks to protect and conserve the Refuge's cultural resources and landscape, and seeks opportunities to increase knowledge and appreciation of the Refuge's history as part of the James River region (Presquile National Wildlife Refuge, 2012).

With its proximity to cities, including Petersburg and Williamsburg, the Refuge aims to provide wildlife-dependent recreational opportunities (interpretation, wildlife observation, nature photography, and hunting) for visitors to enjoy and connect with nature, and to develop an enhanced appreciation for, and understanding of, the Refuge's natural and cultural resources (Presquile National Wildlife Refuge, 2012).

Plum Tree Island National Wildlife Refuge (2017)

Plum Tree Island NWR is one of many important migratory bird stopover sites along the Atlantic Flyway, providing protected breeding habitat for State-listed threatened and endangered species, as well as many neotropical migrant bird species. The Refuge encompasses the largest contiguous salt marsh ecosystem in the lower Chesapeake Bay. Located along the Atlantic Flyway, Plum Tree Island NWR offers diverse salt marshes, tidal streams, and wooded ridges that support fish, waterfowl, marsh and wading birds, and shorebirds. Shorelines offer secluded habitat for breeding and nesting wildlife, including the northern diamondback terrapin (*Malaclemys terrapin terrapin*). The description, goals, and stressors were identified in the Plum Tree Island National Wildlife Refuge CCP (Plum Tree Island National Wildlife Refuge, 2017).

Plum Tree Island NWR was established on April 24, 1972. The Refuge is intended for use as a sanctuary and other activities valuable to migratory bird management. The Refuge is also intended for the development, advancement, management, conservation, and protection of fish and wildlife resources (Plum Tree Island National Wildlife Refuge, 2017).

Stressors

Plum Tree Island NWR is located in the Virginia Beach–Norfolk–Newport News Metropolitan Statistical Area (MSA). It is the fifth largest MSA in the southeastern United Statesand is the largest MSA between Washington, D.C., and Atlanta, Georgia. Urban sprawl and other developed land uses will continue to result in loss of wildlife habitat within the MSA. Engaging these communities in wildlife-dependent recreation on the Refuge will play a critical role in fostering enhanced stewardship within the Chesapeake Bay watershed (Plum Tree Island National Wildlife Refuge, 2017).

In addition to urbanization, climate change also poses a threat to the Refuge and its habitats. Some of the current and predicted impacts of climate change in the coastal zone include: shoreline erosion and shoreline displacement; displacement of wildlife (as critical habitats decline); conversion of upland habitats to wetter habitats and freshwater habitats to saline; conversion of forested areas to emergent wetlands; conversion of tidal wetlands to mudflats or open water; decreased water quality as a result of increased temperatures; runoff associated with stronger, more frequent storm events; and decreased groundwater availability due to changes in precipitation (Plum Tree Island National Wildlife Refuge, 2017).

Along the coast, rising sea levels have begun to affect fish and wildlife habitats, including those used by waterfowl, wading birds, and shorebirds on refuges. Sea level rise, a manifestation of a warming climate, has the potential to significantly impact the Refuge, Virginia's coastal resources and communities, and Virginia's overall economy over the next several decades. In addition to the volume of the ocean increasing, land in the Mid-Atlantic region is sinking as a result of geologic changes near the surface and deep within the Earth, known as shallow and deep zone subsidence (Holdahl and Morrison, 1974). Thermal expansion, melting of the polar ice caps, increased storm frequency, and subsidence will all have profound effects on the Refuge (Plum Tree Island National Wildlife Refuge, 2017).

Successful conservation strategies recognize that climate change is a continuing, ongoing condition, so refuges need to understand how natural systems have evolved in this context and predict how those changes will affect fish and wildlife at multiple scales. The Refuge needs to develop, test, and implement conservation strategies to cope with the physical changes in the coastal environment resulting from climate change (Plum Tree Island National Wildlife Refuge, 2017).

Additionally, the presence of invasive plants can have an adverse impact on the biological integrity, diversity, and environmental health of refuges and other natural areas. A comprehensive survey of invasive plants occurring on the Refuge has not been conducted. Currently, phragmites (*Phragmites australis*) is the only invasive plant species known to occur on the Refuge (Mowbray, 2014, pers. comm.). Aerial surveys conducted in 2006 and 2007 documented phragmites on approximately 20 acres located in the salt marsh, maritime shrubland, and dune habitats (Virginia Polytechnic Institute and State University, 2007). Refuge staff has not attempted to control phragmites infestations due to the safety concerns associated with the Plum Tree Island Range, as well as limited staff time and resources to use a combination of mechanical removal and herbicide application (Plum Tree Island National Wildlife Refuge, 2017).

Goals
Plum Tree Island NWR seeks to conserve the coastal estuarine ecosystem to sustain high ecological integrity for the benefit of native flora and fauna within the lower Chesapeake Bay. With its proximity to cities, including Newport News and Norfolk, the Refuge aims to provide safe and compatible wildlife-dependent recreational opportunities for visitors to connect with nature and foster enhanced stewardship of the lower Chesapeake Bay (Plum Tree Island National Wildlife Refuge, 2017).

Rappahannock River Valley National Wildlife Refuge (2009)
The Rappahannock River Valley NWR was established to conserve and protect fish and wildlife resources, including threatened and endangered species, and wetlands. Refuge habitats include freshwater tidal marshes, forested swamps, upland deciduous forests, mixed pine forests, and managed grasslands. The description, goals, and stressors were identified in the Rappahannock River Valley National Wildlife Refuge CCP (Rappahannock River Valley National Wildlife Refuge, 2009).

Stressors
Climate change is a significant concern. Scientists are predicting dramatic changes in temperature, precipitation, soil moisture, and sea level, and increased frequency and magnitude of storm-surge flooding and coastal erosion, all of which could adversely affect the function of ecological systems and modify vegetation and wildlife distributions (U.S. Climate Change Science Program, 2008). Species' ranges are expected to shift northward or toward higher elevations as temperatures rise, but responses are likely to be highly variable and species specific. Under those rapidly changing conditions, migration, not evolution, will determine which species are able to survive (USFWS, 2006). For example, plants, mussels, and amphibians are more vulnerable to shifts in temperature that may affect their ability to survive, grow, and reproduce (Rappahannock River Valley National Wildlife Refuge, 2009).

Sea level rise is one of the most potentially serious consequences of climate change on coastal ecosystems such as the Chesapeake Bay, including the lower Rappahannock River. Sea level rise is particularly high in the Chesapeake Bay due to natural geological subsidence and groundwater extraction, in addition to climate change. Tidal wetland collapse occurs when marsh grasses cannot build up fast enough to keep abreast of rising sea level in locations where inorganic sediment inputs are low. This impact will be exacerbated by the predicted increased frequency and magnitude of storm-surge flooding and coastal erosion. Eventually, plant productivity decreases because excessive submergence effectively drains carbon reserves, thereby reducing peat formation and converting marshes to un-vegetated mudflats. Moreover, a rise in ambient temperature reduces oxygen concentrations in the water column of eroded marsh embayments, rendering them poor habitat for most fish and shellfish species (Stevenson et al., 2002).

Rising sea levels also has the potential to cause saltwater intrusion into estuaries and threaten freshwater resources. Sea level rise allows saltwater to penetrate upstream and inland into wetlands, bays, and rivers affecting salinity levels and, in turn, the types of wildlife, fish, and plants that can persist there (Titus et al., 1991). Saltwater intrusion, due to extensive groundwater extraction, is also a concern for coastal freshwater supplies, as it can decrease the amount of freshwater stored in aquifers, and in extreme cases, result in the complete loss of an aquifer (USGS, 2008). There is concern at Rappahannock NWR that marsh collapse resulting in increased sedimentation and nitrate entering the Chesapeake Bay, as well as loss of submerged aquatic vegetation beds, is likely to occur in the tidal marshes of the Rappahannock River (Rappahannock River Valley National Wildlife Refuge, 2009).

Rappahannock River Valley NWR uplands are not as susceptible to sea level rise as marshes at or near current sea level. However, if saltwater intrusion increases, coupled with sea level rise, there is the potential to kill standing trees and other vegetation at higher elevations. While the Refuge has not established a baseline monitoring program to track climate change impacts, they hope to work with partners throughout the area to begin such a program (Rappahannock River Valley National Wildlife Refuge, 2009).

Additionally, the presence of invasive plants can have a major adverse impact on the biological integrity, diversity, and environmental health of refuges and other natural areas. Broadly occurring invasive species that have the potential to cause stand replacement in the Refuge's upland terrestrial habitats are tree-of-heaven (*Ailanthus altissima*), autumn olive (*Eleaganus umbellate*), multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), kudzu (*Pueraria lobate*), Japanese stiltgrass (*Microstigeium vimineum*), princess tree (*Paulownia tomentosa*), Johnsongrass (*Sorghum halepense*), lespedeza (*Lespedeza cuneate*), Chinese privet (*Ligustrum sinense*), Japanese knotweed (*Polygonum cuspidatum*), Canada thistle (*Cirsium arvense*), and bull thistle (*Cirsium vulgare*) (Rappahannock River Valley National Wildlife Refuge, 2009).

Common reed (*Phragmites australis*) is the most frequent and broadly occurring invasive species in Refuge wetlands habitats, and the Refuge has an aggressive control program in place. The invasive marsh dew flower (*Murdannia keisak*) is another wetlands species of priority concern that is prevalent at Drakes Marsh (Rappahannock River Valley National Wildlife Refuge, 2009).

Hydrilla (*Hydrilla verticillata*) is found in scattered locations within the project area (Belden et al. 2002). This could threaten diminutive mudflat plant species when mats of decaying hydrilla wash up along the shores and mudflats during fall senescence (Belden et al., 2002).

In addition to effects of climate change and invasive species, urbanization is another stressor. Urbanization and sprawl continues to pose a threat to land surrounding the Refuge, resulting in either habitat fragmentation or the loss of the upland forests, grasslands, and shrublands that buffer wetlands and palustrine systems. Urbanization and development can more than double the natural background sediment yield, with the highest sediment yield increase in the early development stages (Langdon and Cronin, 2003).

Goals

One of Rappahannock River Valley NWR's primary goals is to contribute to the biological diversity of the Mid-Atlantic region by protecting, enhancing, and restoring the Refuge's upland habitats, with an emphasis on breeding, migrating, and wintering birds. Additionally, the Refuge seeks to maintain the long-term biological integrity of riparian habitats along the Rappahannock River and its tributaries for bald eagles and other migratory birds. The Refuge also aims to maintain and enhance the biological diversity and environmental health of tidal and non-tidal wetlands to benefit endangered and threatened species, waterfowl, other migratory birds, fish and shellfish, reptiles, and amphibians (Rappahannock River Valley National Wildlife Refuge, 2009).

Additionally, the Refuge seeks to provide high-quality, wildlife-dependent recreational and educational opportunities on land and water. Engaging residents from the surrounding urban and suburban communities is essential for fostering stewardship values in an area that is becoming increasingly more urban (Rappahannock River Valley National Wildlife Refuge, 2009).

Potomac River National Wildlife Refuge Complex
In 1998, Elizabeth Hartwell Mason Neck National Wildlife Refuge, Featherstone National Wildlife Refuge, and Occoquan Bay National Wildlife Refuge were organized into the Potomac River National Wildlife Refuge Complex. The Refuge Complex provides exceptional forest, grassland, and wetland habitats for wildlife in a dynamic, highly urbanized region of northern Virginia. Those quality habitats, along the middle tidal Potomac River, will be maintained for native wildlife, particularly bald eagles and other species of conservation concern. The proximity of the Complex to our Nation's capital provides unparalleled opportunities to demonstrate the importance of the natural world in enhancing the quality of human life and raising public awareness about the value of the National Wildlife Refuge System (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011). The description, goals, and stressors were identified in the Rappahannock River Valley National Wildlife Refuge CCP (Rappahannock River Valley National Wildlife Refuge, 2009).

Elizabeth Hartwell Mason Neck National Wildlife Refuge (2011)
Elizabeth Hartwell Mason Neck NWR protects and enhances regionally important habitat for the bald eagle, migratory birds, and native wildlife and plant species along the tidal Potomac River. The Refuge provides quality wildlife-dependent recreational and educational opportunities, in particular, wildlife viewing and photography. In cooperation with the other agencies in the Mason Neck Management area, the Refuge works to resolve resource issues on the Mason Neck Peninsula. The description, goals, and stressors were identified in the Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge CCP (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Elizabeth Hartwell Mason Neck NWR was established in 1969 as the Nation's first refuge specifically established to protect a federally listed endangered or threatened species—the bald eagle, which was federally listed as threatened until 2007. Elizabeth Hartwell Mason Neck NWR encompasses 2,277 acres, including 789 acres leased in 1982 for 60 years from the Northern

Virginia Regional Park Authority (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Stressors

Climate change is a major stressor to the Refuge, and is of increasing concern regarding Refuge management. In addition to warming temperatures, other predicted climate-related changes include changing patterns of precipitation, significant acceleration of sea level rise, changes in season lengths, decreasing range of nighttime versus daytime temperatures, increasing water temperatures, and increasing frequency and intensity of severe weather events (TWS, 2004). Each of these changes would affect wildlife and habitats, but the level of impact would vary depending on the species. Shoreline erosion is an existing problem on the Refuge that would be exacerbated with predicted climate change impacts. Erosion is occurring along the entire Refuge shoreline, but is most visible along the bluffs (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

In addition to impacts from climate change, invasive species, both plants and animals, also act as stressors to the Refuge. Japanese stiltgrass (*Microstegium vimineum*) is the most problematic invasive plant on the Refuge. However, there are several others that may pose problems in the future. Emerald ash borer (*Agrilus planipennis*) and gypsy moth (*Lymantria dispar*) are pests recorded on the Refuge, that could become problematic without vigilant monitoring and control where warranted (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Urbanization also acts as a stressor to the Refuge. Elizabeth Hartwell Mason Neck NWR is located within driving distance of approximately 10 million residents of Virginia, Maryland, and Washington, D.C. While the current estimate of Refuge visitors is 19,100 annually, that number is likely to increase over the next 15 years with increasing urbanization (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Goals

Elizabeth Hartwell Mason Neck NWR seeks to protect, enhance, and restore the biological integrity, diversity, and environmental health of mature hardwood-mixed forests, wetlands, and shorelines to support native wildlife and plant communities, including species of conservation concern. The Refuge also seeks to enhance efforts to protect and interpret cultural resources (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

With the large population in the metropolitan area surrounding the Refuge, Elizabeth Hartwell Mason Neck NWR seeks to provide quality, compatible wildlife-dependent recreational opportunities with particular emphasis on interpretation, wildlife observation, and photography (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Featherstone National Wildlife Refuge (2011)
Featherstone NWR provides 325 valuable acres of forest and wetland which are rapidly disappearing within this region of Virginia. The Refuge protects wetlands, bottomland hardwoods, and associated native wildlife and plants in an otherwise highly urbanized setting along the tidal Potomac River. The description, goals, and stressors were identified in the Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge CCP (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Stressors
The factors of burgeoning population and development, and resulting recreational demands influence decision making for Featherstone NWR. Featherstone NWR is located within driving distance of approximately 10 million residents of Virginia, Maryland, and Washington, D.C. Public access to Featherstone NWR is limited due to the adjacent railroad, but recently a non-motorized boat landing was constructed for public use. Water is the only point of access for the public until an agreement of safe access is reached between Prince William County and CSX (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Despite accessibility limitations, trespassing and vandalism have been recurring problems on the Refuge, although incidents have dramatically decreased with the presence of law enforcement personnel on the Refuge. Anglers looking for access to the Potomac River and shelters being built by homeless and displaced people are examples of trespassing, while vandalism has included dumping of household and commercial debris and waste (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Featherstone NWR is at risk from predicted impacts related to climate change and shoreline erosion. Due to its lower elevation, compared to Elizabeth Hartwell Mason Neck NWR, Featherstone NWR is more likely to be affected by rising water levels in the tidal Potomac River. Shoreline erosion is an existing problem that will be exacerbated with predicted climate change impacts; however, the shoreline of Featherstone NWR has a gradual slope and is backed by wetlands. Rising waters would inundate lower areas and create a mix of new wetland habitats while losing some current shoreline areas (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

In addition to issues related to urbanization and climate change, establishment and spread of invasive plants is a significant stressor to all refuge habitat types. The Refuge currently has two invasive plants of primary concern: Japanese stiltgrass (*Microstegium vimineum*) and mile-a-minute (*Polygonum perfoliatum*). Other invasive plants of concern on the Refuge are tree-of-heaven (*Ailanthus altissima*), Japanese honeysuckle (*Lonicera japonica*), Japanese barberry (*Berberis thunbergii*), and beefsteak plant (*Perilla frutescens*). The invasive plant phragmites (*Phragmites australis*) is not yet a major problem in Featherstone NWR wetlands, but it could pose a future threat (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Goals
Featherstone NWR seeks to protect forest, wetland, and shoreline habitats to support native wildlife and plant communities, including species of conservation concern. Additionally, the Refuge seeks to provide compatible wildlife-dependent recreational opportunities to increase the enjoyment and appreciation of the Refuge's resources to visitors and nearby residents (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011).

Occoquan Bay National Wildlife Refuge (1997)
Occoquan Bay NWR serves as a refuge and breeding area for migratory birds, interjurisdictional fishes, and threatened and endangered species. The Refuge also serves as an outdoor classroom to provide the public with educational opportunities relating to fish and wildlife resources, and for other compatible recreational uses such as fishing, wildlife observation, interpretation, and wildlife photography. The description, goals, and stressors were identified in the Occoquan Bay National Wildlife Refuge CCP (Occoquan Bay National Wildlife Refuge, 1997).

Occoquan Bay NWR was established in 1998 and is comprised of lands previously acquired (Marumsco NWR) and recently acquired (Woodbridge Research Facility - military surplus lands) to form the 640-acre Refuge. This unique landscape has been recognized as an Important Bird Area by the Audubon Society for its significance in providing essential habitat for birds. The vast man-made meadows and freshwater tidal marshes play a vital role in preserving the diversity of plant and animal life in the heavily populated region of northern Virginia (Occoquan Bay National Wildlife Refuge, 1997).

Stressors
Invasive plants are a stressor to the Refuge. Invasive plants on the Refuge include phragmites (*Phragmites australis*), Japanese knotweed (*Polygonum japonica*), Japanese clematis (*Clematis japonica*), tree-of-heaven (*Ailanthus altissima*), autumn olive (*Elaeagnus umbellatus*), crown vetch (*Coronilla varia*), bicolor bush clover (*Lespedeza bicolor*), and Japanese honeysuckle (*Lonicera japonica*). Removal or control of these plants using physical or chemical methods ensures native species keep their role in the ecosystem (Occoquan Bay National Wildlife Refuge, 1997).

Goals
The primary goal of Occoquan Bay NWR is to maintain, restore, and enhance grassland and wetland habitats to support a diversity of plants and animals. The Refuge also aims to provide habitat and protection for federally listed threatened and endangered species, while preventing and controlling invasive species that impact native plant and animal communities. Occoquan Bay NWR also seeks to create a public that values fish and wildlife resources, understands events and issues related to these resources, and acts to promote fish and wildlife conservation (Elizabeth Hartwell Mason Neck and Featherstone National Wildlife Refuge, 2011; Occoquan Bay National Wildlife Refuge, 1997).

The Great Dismal Swamp National Wildlife Refuge (2006)
The Great Dismal Swamp NWR, established in 1974, is the largest intact remnant of a vast habitat that once covered more than 1 million acres of southeastern Virginia and northeastern North Carolina. Located at the southern boundary of the Service's Northeast Region, the Refuge is the Region's largest and protects nearly 25 percent of all Service-owned land found in the Region. While the Refuge is large, less than 20 percent of the Refuge lies within the Chesapeake Bay watershed. The description, goals, and stressors were identified in the Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge CCP (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Stressors
Urbanization is a major stressor to the Refuge. Census estimates for 2002 place the population surrounding the Great Dismal Swamp NWR (Hampton Roads, Virginia, and adjacent North Carolina counties) at more than 1.5 million people. Furthermore, the area is continuing to develop rapidly, with the cities of Chesapeake and Suffolk having the highest growth rates. The City of Suffolk, once a rural tidewater county, is now one of the fastest growing areas in the United States. Between July 2001 and July 2002, the population for the City of Suffolk grew at an astounding 4.8 percent, ranking it as the 33rd fastest growing city/county in the United States (U.S. Census, 2002).

Urban sprawl places commercial and residential development near the Refuge boundary and threatens wildlife corridors. It increases habitat management complexity related to water and fire management, and increases nuisance wildlife concerns. Wildlife corridors connect the Refuge to other natural areas within the Great Dismal Swamp watershed. They are important for maintaining a healthy gene pool for bears and other wildlife. There is a need for highway designs that incorporate bear crossings and therein improve highway safety by reducing the probability of vehicle collisions with bears (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Refuge water conservation strategies and beavers often are blamed for downstream flooding of private lands. Most flooding problems are related to disruption of surface water flow by highways, railroads, and general development within the historic Great Dismal Swamp floodplains (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

In addition to issues related to urbanization, invasive species are also a stressor to the Refuge. While no comprehensive survey has been conducted to identify and locate invasive species at the Great Dismal Swamp NWR, several occur on Refuge land. Phragmites (*Phragmites australis*) and privet bush (*Ligustrum spp*.) are the plants of the greatest concern. Invasive animals on the Refuge include coyote (*Canis latrans*) and nutria (*Myocastor coypus*) (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Agriculture is also a stressor to the Refuge, though not as extreme as urbanization and invasive species. Agriculture and forestry are primary industries in the outlying rural areas. The major agricultural products are cotton, soybeans, corn, livestock, and poultry. The number of farms has declined, however, as is the case nationwide (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Goals
The primary purpose of the Great Dismal Swamp NWR is to protect and preserve a unique and outstanding ecosystem, as well as to protect and perpetuate the diversity of animal and plant life therein. The Great Dismal Swamp NWR also seeks to protect and restore those areas that are remnants of the Great Dismal Swamp habitat (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

The Refuge aims to protect and enhance Service trust resources and other significant species. The Refuge has a Red-Cockaded Woodpecker Reintroduction Program, Neotropical Migratory Birds Program, Waterfowl Management Program, and Black Bear Management Program (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Additionally, the Refuge has a goal to promote a public use program. With its proximity to urban populations, the Great Dismal Swamp NWR supports hunting, boating, fishing, environmental education, wildlife observation, and photography through volunteer programs, outreach, and visitor facilities (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006

Nansemond National Wildlife Refuge (2006)
The Nansemond NWR is a non-staffed, satellite refuge of the Great Dismal Swamp NWR that is contained entirely within the Chesapeake Bay watershed. It is not open to the public. Located on the Nansemond River in Suffolk, VA, the Refuge lies approximately 5 miles northwest of Great Dismal Swamp NWR. The 423-acre Refuge was established on December 12, 1973, when three tracts of tidal marsh were transferred from the Department of Defense to the Service. An additional tract of upland was added in 1996 after the closing of the Driver Naval Facility, also as excess lands from the Department of Defense. Nansemond NWR is a seasonal home for migratory waterfowl including American black ducks (*Anas rubripes*), mallards (*Anas platyrhynchos*), and canvasbacks (*Aythya valisineria*), as well as wading, marsh, and shorebirds The description, goals, and stressors were identified in the Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge CCP (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Stressors
Urbanization is a major stressor to the Refuge, as the region is continuing to develop rapidly. The cities of nearby Chesapeake and Suffolk have the highest growth rates in the region. The City of Suffolk, once a rural tidewater county, is now one of the fastest growing areas in the United States. Between July 2001 and July 2002, the population for the City of Suffolk grew at an astounding 4.8 percent, ranking it as the 33rd fastest growing city/county in the United States (U.S. Census, 2002).

In addition to the stress related to urbanization, much of the Refuge was contaminated by polychlorinated biphenyls (PCBs) in the past. Considerable remediation did occur before the base was closed; however, the former presence of contaminants on the Refuge will constrain future management options (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Additionally, leaking transformers previously stored on the Refuge, resulted in spilled PCBs near Star Creek. Historical reports indicate that oil in the transformers was drained into 55 gallon drums before being discarded into the marshy area. Results from soil sampling showed levels of PCBs up to 15,000 parts per million (ppm) in soil and 1 ppm in sediment, levels that are consistent with PCB clean-up goals at Superfund sites in the Environmental Protection Agency's Region 3. Clean fill was layered over site soils to minimize potential exposure of ecological receptors to remaining levels of PCBs in soils (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Site 1 restrictions prohibit the extraction of shallow groundwater and any disturbance of the surface and/or subsurface area without prior written approval of the Department of the Navy. Disturbance shall mean any intrusive activity that involves the penetration of the surface soil; such as excavation, trenching, tilling of the soil, and/or any mechanical or manual drilling. These prohibitions are intended to control the risk of direct contact with or consumption of water from the shallow aquifer and to control the risk of direct contact with or consumption of subsurface soils in contact with the groundwater in the shallow aquifer where contamination (124-trichlorobenzene) has been found to exceed the level for drinking water (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Site 7 restrictions prohibit disturbance of any surface or subsurface soils as above. The contaminant present in this case is low levels of polynuclear aromatic hydrocarbons (PAHs). Site 11 is adjacent to Site 5 and is designated as The Disposal Pits. In addition to the chemical contaminants, construction debris, including shingles, wood, and metal fascia, were found at a contamination site (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

In addition to issues related to contamination and urbanization, the invasive species phragmites (*Phragmites australis*) is present in the river's marshes (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Goals
The Refuge serves a unique role in preserving a remnant piece of habitat along the Nansemond River. Due to the small size and limited ability to contribute to management priorities for the Service, the goal is to aggressively pursue partnerships to support the management and stewardship of Nansemond NWR (Great Dismal Swamp National Wildlife Refuge and Nansemond National Wildlife Refuge, 2006).

Eastern Shore of Virginia National Wildlife Refuge (2004)

Eastern Shore of Virginia NWR was created in 1984 when 180 acres were transferred to the Service from the U.S. Air Force through the General Services Administration. In 1995 the Chesapeake Bay Bridge-Tunnel Authority (Bridge-Tunnel Authority) conveyed a 70-acre tract to the Service. This was done in compliance of mitigation for the parallel crossing of the Chesapeake Bay Bridge-Tunnel. In 1997 the Bridge-Tunnel Authority gave the Service a 66-foot wide abandoned railroad bed (19 acres) in return for a 4-acre parcel on Fisherman Island. The parcel on Fisherman Island was used to construct the abutments for the new Chesapeake Bay Bridge-Tunnel.

The Eastern Shore of Virginia NWR also includes Skidmore Island, sometimes called Long Point Island, and located approximately 1,000 feet off the mainland. The Service purchased the 108.5 acre-island from the Nature Conservancy in 1987 (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004).

Fisherman Island NWR was established in 1969, but it was not until 1973 that sole ownership rights were transferred to the Service by the Department of the Navy. Recent land acquisition activities include the purchase of Fisherman Island's eastern half (825 acres) in 1998 and transfer of the remaining 25 acres from the U.S. Navy in 2000 to complete the refuge. Total acreage for Fisherman Island Refuge is now estimated at 1,850 acres, though that number fluctuates with accretion and erosion events. The description, goals, and stressors were identified in the Eastern Shore of Virginia National Wildlife Refuge CCP (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004).

Stressors

Residential construction on the Eastern Shore of Virginia is on the rise. Personal communication with land use planners has revealed development trend in Northampton County emphasizing the construction of second homes for retirees, thus reflecting the demographic trend of an aging population. In the spring of 2000, construction of an Adult Community was beginning on a 2,000-acre tract of land. The development, located south of Cape Charles on the Chesapeake Bay has a 15-year build-out plan for up to 3,000 residences, plus 2 golf courses and other amenities. Additionally, a 224-slip marina is being constructed as part of this same development. Second home and recreational developments such as these pose the greatest threat to loss of valuable shoreline habitat on the Chesapeake Bay (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004).

The location of the Refuge relative to the Chesapeake Bay and Atlantic Ocean exposes the area to the effects of winds, waves, and currents, causing erosion and accretion of the shoreline. The Chesapeake Bay shoreline experiences moderate erosion, which is slightly greater near the south end (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004

Goals

The Refuge primary goal is to protect, restore, and enhance habitat for forest and shrub dependent neotropical and temperate migratory birds of conservation concern. To further protect essential habitat for these species, the Refuge will expand the approved land acquisition boundary on the Eastern Shore of Virginia NWR to include an additional 6,030 acres on the lower Delmarva Peninsula. In addition the Refuge plans to increase monitoring and surveying for federally listed species such as the threatened piping plover and northeastern beach tiger beetle, as well as beach-dependent nesting birds. Enhancing outreach programs and new infrastructure will provide opportunities for hunting and wildlife observation. Upgrading facilities at the Wise Point boat ramp will provide safe and improved access for recreational anglers and commercial watermen (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004).

The Chesapeake Bay Esturine complex, including the Virginia barrier island chain, ~~is~~ classified as "Wetlands of International Importance" under the RAMSAR Convention~~,~~ Protection goals stated herein have direct long term benefits in maintaining the RAMSAR designation (Eastern Shore Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge 2004).

ENDANGERED SPECIES

There are 22 threatened and endangered species in the Virginia portion of the Chesapeake Bay watershed. This section describes the life history and identifies the major stressor(s) that adversely affect these species. The section identifies two categories of threatened and endangered species for Virginia, those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats

Non-Aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they need to be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Shale Barren Rock Cress (*Arabis serotina*)

Shale barren rock cress (*Arabis serotina*), federally listed as endangered in 1989 (USFWS, 1989a), is a biennial herb in the mustard family that is typically found on steep exposed slopes with a south-westerly aspect (Platt, 1951). It is endemic to the community known as Appalachian shale barren and resides within a band occurring from southern Pennsylvania through Maryland into Virginia and West Virginia (USFWS, 2015). Plants typically grow to a height of 30 to 60 centimeters (cm) with compound inflorescence consisting of many whitish flowers, each approximately 2 to 3 millimeters (mm) long (USFWS, 1989a). The largest threats to the shale barren rock cress are nonnative invasive plant species and over browsing by white-tailed deer (*Odocoileus virginianus*). Additional negative impacts on the populations include quarrying for shale as well as road and railroad construction, which can disrupt the erosional processes that form the barrens (WVDNR, 2016).

Priority areas for shale barren rock cress in Virginia include Hydrologic Unit Codes (HUC): 0207000509 Hawksbill Creek-South Fork Shenandoah River, 0208020101 Upper Jackson River, 0208020105 Lower Jackson River, 0208020107 Middle Cowpasture River, 0208020108 Lower Cowpasture River, 0208020201 Calfpasture River, 0208020102 Back Creek-Middle Jackson River, 0208020103 Dunlap Creek, 0208020104 Potts Creek, and 0208020106 Upper Cowpasture River.

Smooth Coneflower (*Echinacea laevigata*)

Listed as federally endangered in 1992 (USFWS, 1992a), the smooth coneflower (*Echinacea laevigata*) is a rhizomatous perennial herb in the aster family. Habitat consists of open woods, cedar barrens, roadsides, clearcuts, dry limestone bluffs, and power line rights-of- way, in usually magnesium and calcium rich soils associated with amphibolite, dolomite, or limestone (Terwilliger, 1991; USFWS, 1995a). Community types are described as xeric hardpan forests and diabase glades or in Virginia dolomite woodlands or glades (Schafale and Weakly, 1990). The smooth coneflower is known to survive only in Virginia, North Carolina, South Carolina, and Georgia (USFWS, 1992a). Threats to smooth coneflower include habitat destruction and degradation, collection, fire suppression, urbanization, and (with half of remaining populations surviving along roadsides) highway right-of-way maintenance (USFWS, 1995a).

Priority areas for smooth coneflower in Virginia include Hydrologic Unit Codes (HUC): 208020105 Lower Jackson River, 0208020113 Catawba Creek, 0208020303 Harris Creek-James River, 0208020306 Buffalo River, 0208020707 Deep Creek, and 0208020103 Dunlap Creek.

Indiana Bat (*Myotis sodalis*)

The Indiana bat (*Myotis sodalis*) is an insectivorous species that spends its summer in wooded areas where it roosts in loose tree bark on dead or dying trees. During winter months, the Indiana bat migrates to caves and mines where it hibernates colonially (USFWS, 2007a). This species forages along rivers or upland lakes, with preferential foraging in woodland areas, where it consumes a variety of flying insects (Sparks et al., 2005).

Current winter distribution includes hibernacula found in 19 states: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. States where maternity colonies have been found, summer habitats, include: Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Missouri, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS, 2007a).

The Indiana bat was declared endangered in 1967. It suffered from large decreases in populations due to human disturbance during hibernation, habitat alteration through stream channelization, deforestation for agriculture, surface strip mining, and urban expansion (Garner and Gardner, 1992; Murry and Kurta, 2003).

Priority areas for Indiana bat in Virginia include Hydrologic Unit Codes (HUC): 0207000603 Linville Creek-North Fork Shenandoah River, 0208010402 Mill Creek-Rappahannock River, 0208020101 Upper Jackson River, 0208020107 Middle Cowpasture River, 0208020110 Upper Craig Creek, 0208020102 Back Creek-Middle Jackson River, 0208020104 Potts Creek, and 0208020106 Upper Cowpasture River.

Northern Long-Eared Bat (*Myotis septentrionalis*)

The northern long- eared bat (*Myotis septentrionalis*), listed as federally threatened in 2015 (USFWS, 2016a), is a medium-sized bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (Wisconsin Department of Natural Resources, 2013). The distribution range of the northern long- eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and in the United States from Maine to North Dakota , extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increased agricultural and household pesticide use, and hibernaculum disturbance (Wisconsin Department of Natural Resources, 2013).

Priority areas for northern long-eared bat in Virginia include Hydrologic Unit Codes (HUC): 0207000810 Difficult Run-Potomac River, 0207001001 Rock Creek-Potomac River, 0207000804 Tuscarora Creek-Potomac River, 0207000809 Broad Run-Potomac River, 0207000703 Bullskin Run-Shenandoah River, 0207000501 Upper Middle River, 0207000507 South River, 0207000508 Naked Creek-South Fork Shenandoah River, 0207000509 Hawksbill Creek- South Fork Shenandoah River, 0207000510 Gooney Run-South Fork Shenandoah River, 0208010307 Conway River-Rapidan River, 0208010402 Mill Creek-Rappahannock River, 0208010403 Occupacia Creek-Rappahannock River, 0208010501-Poni River, 0208010601 Upper South Anna River, 0208020101 Upper Jackson River, 0208020107 Middle Cowpasture River, 0208020201 Calfpasture River, 0208020302 Pedlar River, 0208020313 Upper Slate River, 0208020314 Lower Slate River, 0208020403 North Fork Rivanna River, 0208020404 Mechunk Creek-Rivanna River, 0208020702 Vaughans Creek-Appomattox River, 0208020709 Swift Creek, 0207000504 Upper North River, 0208020102 Back Creek-Middle Jackson River, 0208020104 Potts Creek, and 0208020106 Upper Cowpasture River.

Red-Cockaded Woodpecker (*Picoides borealis*)

The red-cockaded woodpecker (*Picoides borealis*) was federally listed as endangered in 1970, and is endemic to open, mature, and old growth pine ecosystems in the southeastern United States (USFWS, 2003). The red-cockaded woodpecker excavates roost and nest cavities within the heartwood of large, living pine trees (USFWS and Costa, 2002). Current populations of the red-cockaded woodpecker can be found in Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas with possible extirpation in Maryland and presumed extirpation in Kentucky, Tennessee, and Missouri (Ridgely et al., 2003). Degradation and loss of habitat has led to a rapid decline of red-cockaded woodpeckers (USFWS and Costa, 2002). The old growth pine savannahs that the woodpecker relies on only exist in a few small patches due to intense logging for lumber and agriculture, fire suppression, and detrimental silvicultural practices (USFWS, 2003).

Priority areas for red-cockaded woodpecker in Virginia include Hydrologic Unit Code (HUC) 0208020801 Nansemond River.

Virginia Big-Eared Bat (*Corynorhinus townsendii virginianus*)
Listed in 1979 as federally endangered (USFWS, 1979), the Virginia big-eared bat (*Corynorhinus townsendii virginianus*) is a medium-sized, brown bat that inhabits caves and mines in both summer and winter seasons. During the winter, they hibernate in clusters, and during the summer months, they use the caves for maternity sites and roosting (USFWS, 2009). Populations of Virginia big-eared bat are located in West Virginia, Virginia, Kentucky, and North Carolina (Patterson et al., 2003). The largest threats to Virginia big-eared bat populations are its limited distribution, small population size, extreme vulnerability to human disturbance, and white-nose syndrome (USFWS, 2009).

Priority areas for Virginia big-eared bat in Virginia include Hydrologic Unit Codes (HUC): 0207000603 Linville Creek-North Fork Shenandoah River, 0208020101 Upper Jackson River, 0207000103 Upper South Branch Potomac River, 0207000105 South Fork South Branch Potomac River, 0207000601 Shoemaker River-North Fork Shenandoah River, and 0208020106 Upper Cowpasture River.

Shenandoah Salamander (*Plethodon shenandoah*)
Listed as federally endangered in 1989 (USFWS, 1989b), the Shenandoah salamander (*Plethodon shenandoah*) is a small terrestrial salamander endemic to the Shenandoah National Park in Virginia. The salamander is generally found in forested conditions where the overstory promotes surface moisture, and tends to take cover under protective objects or in rock crevices (USFWS, 1994a). Threats to the species include forest defoliation due to introduction of the gypsy moth (*Lymantria dispar*) and hemlock woolly adelgid (*Adelges tsugae*), impacts associated with acid deposition and/or precipitation, and management activities such as road and trail maintenance as well as fire management (Carpenter et al., 2001).

Priority areas for Shenandoah salamander in Virginia include Hydrologic Unit Codes (HUC): 0207000509 Hawksbill Creek-South Fork Shenandoah River, 0208010304 Hazel River, and 0208010309 Robinson River.

Aquatic Species
Aquatic threatened and endangered species listed below are species have some or all of their life history tied directly to the aquatic systems.

Dwarf Wedgemussel (*Alasmidonta heterodon*)
Freshwater mussels have declined dramatically in diversity, abundance, and distribution within the last 200 years and are considered the most imperiled fauna in North America (Richter et al., 1997; Lydeard et al., 2004). In the genus Alasmidonta, 9 of 13 species are threatened,

endangered, or extinct (Williams et al., 1992). The dwarf wedgemussel (*Alasmidonta heterodon*) was once known in 70 locations throughout 15 major Atlantic coastal drainages from New Brunswick Canada to North Carolina. Now, populations are discontinuously distributed in selected drainages in Vermont, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia, and North Carolina with possible extirpation in Canada, Maine, Delaware, and Washington, D.C. The dwarf wedgemussel was listed as endangered by the Service in 1990 (USFWS, 1993a).

The dwarf wedgemussel is a small bivalve, rarely exceeding 45 mm in length. Clean young shells are usually greenish-brown with green rays. As the animal ages, the shell color becomes obscured by diatoms or mineral deposits and appears black or brown. The shell is thin but does thicken somewhat with age, especially toward the anterior end. The anterior end is rounded while the posterior end is angular forming a point near the posterior-ventral margin. The most distinctive shell characteristic of the dwarf wedgemussel is the arrangement of the lateral teeth. There are two lateral teeth in the right valve and one in the left valve. The typical arrangement for most freshwater mussel species consists of two lateral teeth in the left valve and one in the right valve. (Massachusetts Natural Heritage and Endangered Species Program, 2009).

The dwarf wedgemussel is a sedentary filter feeder that spends most of its life partially buried in the substrate of small streams to large rivers. Dwarf wedgemussel often have patchy distribution in rivers, and usually inhabit hydrologically stable areas. They can be found in a variety of substrate types including clay, sand, gravel, pebble, and sometimes silt depositional areas near banks. The species is a bradytictic breeder, meaning that females become gravid in the early fall and larvae called glochidia are released by mid-spring attaching to the gills of specific host fish. The tessellated darter (*Etheostoma olmstedi*), johnny darter (*Etheostoma nigrum*), and mottled sculpin (*Cottus bairdi*) have been identified as hosts for the dwarf wedgemussel, it is possible other fish will act as host as well (N.C. Natural Heritage Program, 2001).

Dwarf wedgemussels require unpolluted streams or rivers with high dissolved oxygen, moderate current, and stable substrate (Strayer, 1999). Some of the population instability of the dwarf wedgemussel can be attributed to its short lifespan; low fecundity; high degree of host specificity; limited dispersal ability of its primary host; and low population densities (McLean and Ross, 2005). However, stream fragmentation from dams, causeways, impoundments, and channelization, exacerbates population instability by causing inhospitable stream segments. This stream fragmentation results in spatially and genetically disjunctive populations, disrupting mussel life cycles, preventing host fish migration, blocking gene flow, and prohibiting recolonization (USFWS, 1993a).

Priority areas for dwarf wedgemussel in Virginia include Hydrologic Unit Codes (HUC): 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0208010305 Mountain Run, 0208010306 Marsh Run-Rappahannock River, 0208010308 Blue Run-Rapidan River, 0208010401 Massaponax Creek-Rappahannock River, 0208010501 Poni

River, 0208010602 Middle South Anna River, 0208010603 Lower South Anna River, and 0208020203 Middle Maury River.

James Spinymussel (*Pleurobema collina*)

Freshwater mussels are important components of aquatic ecosystems by serving as energy sources for many species as well as being indicators of ecosystem health (Wisniewski et al., 2005). With the increasing number of introduced species and extensive habitat alteration, freshwater mussels are the most imperiled faunal ground in North America with 60 percent of described species considered endangered or threatened and 12 percent presumed extinct (Ricciardi et al., 2002). The James spinymussel (*Pleurobema collina*), was listed in 1988 (USFWS, 1988a).

While the juveniles of the James spinymussel usually bear one to three short but prominent spines on each valve, the adults usually lack spines. The foot and mantle of the adult are orange in color with the mantle being darkly pigmented in a narrow band around the edges of the branchial and anal openings. The shell of juvenile James spinymussels is more rhombus-shaped and becomes increasingly more ovate or acute as it grows (USFWS, 1990b).

The James spinymussel is a tachytictic (short-term) brooder; fertilizing eggs in the spring and releasing the glochidia in spring and summer (USFWS, 1990b). Once released, these glochidia parasitize host fish species including: the common shiner (*Luxilus cornutus*), rosyside dace (*Clinostomus funduloides*), bluehead chub (*Nocomis leptocephalus*), pumpkinseed (*Lepomis gibbosus*), and fantail darter (*Etheostoma flabellare*) (Hove and Neves, 1994). The James spinymussel is endemic to the James River watershed is known to occupy sediments of cobble and sand in reaches with slow to moderate currents, and can be found in 1.5 to 20 m wide second and third order streams at water depth of 0.3 to 2 m (Hove and Neves, 1994).

There has been a rapid decline of populations that indicates a high vulnerability to extirpation. Much of this decline is due to siltation generated by agricultural and forestry activities. Because mussels are sedentary and unable to move long distances, they are susceptible to heavy silt that results from anthropogenic activities (USFWS, 1990b). Impoundments and habitat alteration also play a key role in the decline of mussel populations. Closure of dams changes habitat by increasing depth, decreasing flow, and enabling silt accumulation which can result in the change of fish communities and host availability (USFWS, 1990b). Habitat alteration allows the Asian clam (*Corbicula fluminea*) to expand into the habitat and compete with other mussel and clam species (Hove and Neves, 1994). Insecticide pollution from inland waters as a result of agricultural practices has been found to significantly affect mussel by reducing siphoning activity (Salanki and Varanka, 1977).

Priority areas for James spinymussel in Virginia include Hydrologic Unit Codes (HUC): 0208020110 Upper Craig Creek, 0208020112 Lower Craig Creek, 0208020113 Catawba Creek, 0208020114 Looney Creek-James River, 0208020115 Cedar Creek-James River, 0208020201 Calfpasture River, 0208020202 Little Calfpasture River-Upper Maury River, 0208020203 Middle Maury River, 0208020302 Pedlar River, 0208020305 Upper Type River, 0208020311 Ballinger

Creek-James River, 0208020312 Hardware River, 0208020401 Moormans River-Mechums River, 0208020402 South Fork Rivanna River, 0208020403 North Fork Rivanna River, 0208020405 Cunningham Creek-Rivanna River, 0208020505 Lickinghole Creek-James River, 0208020104-Potts Creek, 0208020106 Upper Cowpasture River, and 0208020111 Johns Creek.

Madison Cave Isopod (*Antrolana lira*)
The western hemisphere is home to 25 species of troglobitic (adapted for inhabiting subterranean habitats) cirolanid isopods, only 3 of which reside in the United States (Carpenter, 1994). Invertebrates dwelling in subterranean habitats are vulnerable due to their limited geographic range, low reproductive potential, long life span, and small population size (Hutchins et al., 2010). The Madison Cave isopod (*Antrolana lira*) is such an organism. Due to these vulnerabilities and threats from anthropogenic disturbance, the isopod was federally listed as threatened in 1982 (USFWS, 1982a).

The Madison Cave isopod is a crustacean having a small, dorso-ventrally flattened body with a pair of short first antennae and a pair of long second antennae. Like most troglobitic organisms, the Madison Cave isopod lack pigment and is eyeless. Males reach a length of approximately 15 mm and width of 5 mm, with females reach lengths of about 18 mm and widths of 6 mm (USFWS, 1996a). This species is endemic to the phreatic zone (below the water table) of groundwater aquifers underlying the Shenandoah Valley of Virginia and West Virginia (Hutchins et al., 2010). The Madison Cave isopod can be found in underground lakes or temporary pools, in shallow depressions on the floor of low-level caves passages, or low-gradient streams previously flooded by rising ground water (USFWS, 1996a).

Due to its subterranean habitat, threats to the Madison Cave isopod are loss and modification of habitat, ground water contamination, and groundwater draw down (Elliot, 2000). The surface environment is particularly important as it is their primary source of water and nutrients (Hutchins et al., 2010). Expanding urban development has increased the probability of pollutants entering the groundwater. Pollution from agricultural runoff is also a major threat to populations (USFWS, 1996a).

Priority areas for Madison Cove isopod in Virginia include Hydrologic Unit Codes (HUC): 0207000502 Christians Creek, 0207000507 South River, 0207000508 Naked Creek-South Fork Shenandoah River, 0207000510 Gooney Run-South Fork Shenandoah River, 0207000603 Linville Creek-North Fork Shenandoah River, 0207000701 Crooked Run-Shenandoah River, and 0208020203 Middle Maury River.

Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*)
Tiger beetles live in a variety of habitats including water edges, sandy flats, dunes, woodland paths, open patches in grasslands, and recently cleared areas. Although tiger beetles can be found in this range of habitats, each species has very specific habitat requirements (Knisley and Hill, 1992). The northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) inhabits sandy

beaches along the East Coast. Shoreline stabilization and/or elimination of updrift sand sources are stressors in that they prevent natural shoreline dynamics and induce beach erosion (USFWS, 2007) This species is now extirpated from much of its historic range and was federally listed as a threatened species in 1990 (Fenster et al., 2006; USFWS, 1990c).

The northeastern beach tiger beetle is a medium-sized (13 to 15.5 mm in length), beach dwelling tiger beetle that has white to light tan elytra with a bronze-green head and thorax. The northeastern beach tiger beetle is considered a subspecies of the eastern beach tiger beetle, and can be distinguished morphologically (USFWS, 1994b). The life cycle of the northeastern beach tiger beetle begins with the eggs which are oviposited by the female in burrows located in the upper foreshore to the lower backshore. The first instar larva hatches during the summer and digs a burrow at the site of oviposition. Development occurs in these burrows. The larvae are sedentary predators that use the burrows to capture small arthropods passing by. The adults then emerge from mid-June to August. Mating occurs throughout adulthood. The entire life cycle generally lasts 2 years (Fenster et al., 2006). Adult tiger beetles typically consume small beach amphipods and occasionally scavenge on dead amphipods, crabs, and fish (USFWS, 1994b).

Habitats preferred by the northeastern beach tiger beetle include beaches with low to moderate compaction, and medium- to coarse-grained sands to facilitate oviposition of females (Fenster et al., 2006). The historic range of the tiger beetle includes most of the coastal sandy beaches from New Jersey to Cape Cod and much of the eastern and western shorelines of the Chesapeake Bay from southern Maryland to Virginia (Knisley et al., 1987). With a dramatic decline in populations, the northeastern beach tiger beetle can be found in relative abundant amounts in Virginia (Knisley et al., 1998).

Threats to the northeastern beach tiger beetle are destruction and disturbance of natural beach habitat from shoreline developments, oil slicks, recreational use, and beach erosion (potentially contributed to with climate change). Larval recruitment and survival dramatically decreases in areas with development and high recreational use. Distributions of beetles that successfully emerged from the pupa stage, however, were much less affected by human activity (USFWS, 1994b). Beach erosion can also have serious effects on larval habitat. Tiger beetle larvae are typically not found at sites that have only narrow eroded beaches, and seem to be limited to areas where beaches are at least 5 m wide, with some sand above the high tide zone. Beach erosion is a natural process resulting from rising sea levels and prevailing currents (USFWS, 1994b). Climate change affects the rate of sea level rise and could be a major contributor in the increase of beach erosion and decrease in beach habitat in the future (Bosello et al., 2004).

Priority areas for northeastern beach tiger beetle in Virginia include Hydrologic Unit Codes (HUC): 0207001108 Nomini Creek-Potomac River, 0208010201 Great Wicomico River-Lower Chesapeake Bay, 0208011006 Lower Tangier Sound, 0208011105 Marumsco Creek-Pocomoke Sound, 0208011107 Deep Creek-Pocomoke Sound, 0208010203 Piankatank River-Lower Chesapeake Bay, 0208010204 Mobjack Bay-Lower Chesapeake Bay, 0208010407 Carrotoman

River-Rappahannock River, 0208010801 Back River-Lower Chesapeake Bay, 0208011106 Messongo Creek-Pocomoke Sound, 0208011108 Pungoteague Creek-Lower Chesapeake Bay, and 0208011109 Cherrystone Inlet-Lower Chesapeake Bay.

Harperella (*Ptilimnium nodosum*)

Harperella (*Ptilimnium nodosum*), listed as federally endangered in 1988 (USFWS, 1988b), is a semi-aquatic annual herb and includes two variates known as the pond and riverine forms (previously referred to as: pond, *H. nodosum*; riverine, *P. fluviatile*). These separate forms were not shown to be quantitatively distinct in morphology and phenology, and are thought to be the results of environmental factors – specifically variation due to the extent of flooding in the environment (USFWS, 1990d). Harperella flowers from late July to frost and reproduces both sexually and asexually through seeds or plantlets formed in the nodes typically being transported downstream to form new subpopulations (Wells, 2012).

Harperella generally prefers rocky riverbeds and has very specific water depth tolerances: neither too shallow nor too deep to impair completion of its life cycle. The riverine ecotype grows on rocky and sandy shoals and, rarely, on muddy banks of seasonally flooded and quickly moving streams with the largest subpopulations found in sunny sections of creeks (USFWS, 1990d). These harperella populations can be found in Maryland, West Virginia, Virginia, North Carolina, Alabama, and Arkansas (Frye and Tessel, 2012). The pond ecotype generally occupies the edges of the coastal plain ponds and granite flatrock sites (USFWS, 1990d) and can be found in South Carolina and Georgia, respectively (Frye and Tessel, 2012).

Frequent and minor flood events are typically beneficial to harperella populations as they scour cobble bars, preventing most competitors from becoming established, and remove algae, which can overgrow and shade out harperella that is still in the water (Wells, 2012). Although, these flood events are beneficial, manipulations of the water flow to increase or decrease flooding are the primary threat to the species. Manipulation of water flow upstream such as dams, reservoirs, or other water impoundments/diversions can destroy suitable habitat and threaten populations. P. fluviatile populations are also sensitive to siltation caused by development and agriculture (USFWS, 1990d).

Priority areas for harperella in Virginia include Hydrologic Unit Code (HUC) 0207001102 Potomac Creek-Potomac River.

Northeastern Bulrush (*Scirpus ancistrochaetus*)

Freshwater, seasonal ponds are important habitats to many endemic or rare animal and plant species. Northeastern bulrush (*Scirpus ancistrochaetus*) is a plant species that relies on the seasonal or temporary nature of these ponds (Lentz and Dunson, 1999) and was listed as federally endangered in 1991 (USFWS, 1991a).

Northeastern bulrush, a perennial emergent sedge, is found primarily in small vernal ponds (Lentz and Cipollini, 1998). It grows approximately 80-120 cm in height (Lentz and Dunson, 1999), with the lowermost leaves being much longer than they are wide and the uppermost leaves being narrower and somewhat shorter than the lower leaves. The bulrush flowers from mid-June to July and has an umbellate inflorescence that bears clusters of brown spikelets. Its fruit sets between July and September and has yellow-brown achenes that are obovate and thickened above the seed (USFWS, 1993b).

Northeastern bulrush is typically found in small, seasonal, palustrine wetlands which are frequently isolated (Lentz, 1999). The bulrush tends to grow in acidic to circumneutral areas, with sites varying geographically from sinkhole ponds in the southern portion of the range to a various other wetland types in the northern portions (USFWS, 1993b). The wetlands inhabited by the northeastern bulrush seem to be fed primarily from surface water, and can vary greatly within a season (Lentz and Dunson, 1998). Distribution is thought to be influenced by light availability. Northeastern bulrush can usually be found in areas with less than 60 percent canopy cover (Lentz and Cipollini, 1998). Populations of northeastern bulrush can be found in West Virginia, Virginia, Maryland, New York, Pennsylvania, Massachusetts, Vermont, and New Hampshire; with the majority of populations found in Pennsylvania (Lentz, 1999).

The most immediate threats to the northeastern bulrush are destruction or modification of habitat. Wetland filling, draining, and dredging for developmental, agricultural, and recreational purposes are the primary forms of habitat destruction (USFWS, 1993b). Logging, road construction, agricultural activities, and development also threaten population persistence (Lentz and Dunson, 1999). Little is known about life history, which makes conservation and management of this species more challenging.

Priority areas for northeastern bulrush in Virginia include Hydrologic Unit Codes (HUC): 0207000507 South River, 0207000508 Naked Creek-South Fork Shenandoah River, 0207000505 Dry River, 0208020102 Back Creek-Middle Jackson River, and 0208020104 Potts Creek.

Prairie Fringed Orchid (*Platanthera leucophaea*)

The eastern prairie fringed orchid (*Platanthera leucophaea*) was listed as federally threatened in 1989 (USFWS, 1989c). The eastern prairie fringed orchid is a long-lived, perennial member of Orchidaceae (Wallace, 2003). It is characterized by an upright leafy stem and flower cluster rising 20 to 100 cm from an underground tuber. The flowers are creamy white and have a three-parted fringed lip with a thickened nectar spur (USFWS, 1999). The orchid generally experiences fluctuations in the number of flowering individuals from year to year, partly due to its habitation of environments that are prone to disturbance. The eastern prairie fringed orchid is thought to be large and showy and is known to be pollinated by hawkmoths (*Sphingidae*) (USFWS, 1999).

The eastern prairie fringed orchid typically occurs in Midwestern prairies and prairie wetlands, in fens and sphagnum bogs in the eastern portion of its range, and in graminoid wetlands (Bowles et al., 2005). Throughout its historic range, there has been a dramatic decline of about 70 percent of the orchid's population. The remaining, isolated populations are only made up of approximately 50 to 100 plants, contributing to the fear of additional decline due to inbreeding (Zettler et al, 2001). Current populations can be found in Maine, Ohio, Michigan, Illinois, Wisconsin, Iowa, Missouri, and Ontario, Canada; possible extirpation in New York, New Jersey, Indiana, and Oklahoma; and presumed extirpation in Pennsylvania and Virginia (USFWS, 1999).

The major threat to the eastern prairie fringed orchid is wetland habitat conversion for cropland or pasture. The conversion of these wetlands requires them to be drained, which destroys the suitable habitat for this species. Other stressors include fire suppression, competition from nonnative plant species, and collection. The dependence of the eastern prairie fringed orchid on its pollinator, hawkmoth species, adds a complexity to the ability of populations to persist, making them vulnerable to changes in population of these insects (USFWS, 1999).

Priority areas for prairie fringed orchid in Virginia include Hydrologic Unit Code (HUC) 0207000507 South River.

Sensitive Joint-Vetch (*Aeschynomene virginica*)

Listed as federally threatened in 1992 (USFWS, 1992b), sensitive joint-vetch (*Aeschynomene virginica*) is an annual legume in the family Fabaceae. It usually grows to the height of 1 to 2 meters with single stems that sometimes branch near the top and have stiff or bristly hairs. Each leaf consists of 30 to 56 leaflets that fold slightly when touched and has yellow, irregular, legume-type flowers streaked with red that grow in racemes (elongated inflorescences with stalked flowers) (USFWS, 1995b). The fruits are pods that contain 4 to 10 seeds each and break along suture lines at maturity. Seeds generally disperse as single seed enclosed within their pod segment during October and November (Griffith and Forseth, 2002).

Sensitive joint-vetch generally grows along the East Coast in freshwater and slightly brackish tidal marshes (Baskin et al., 1998). The substrate may be sandy, muddy, peaty, or gravelly. It is usually found on substrates that are sparsely vegetated due to natural disturbances such as storms, ice scour, accreting sediments, or muskrat (*Ondatra zibethica*) eat outs. Nutrient deficiencies in the organic sediments may also result in sparse vegetation (USFWS, 1995b). Populations located in the tidal freshwater habitats are currently found in six river systems in Virginia, three in Maryland, and two in New Jersey. It is believed to be extirpated from Delaware and Pennsylvania.

Alterations to tidal marshes are the main threats to the remaining sensitive joint-vetch populations. Some of these alterations include dams, dredging and filling, commercial and residential development, water withdrawal, mining, agricultural practices, timber harvest, and sea level changes resulting from climate change (USFWS, 1995b). Some of these practices could potentially allow salinity levels to exceed the tolerance of the sensitive joint-vetch, affecting seed germination and retention of viability of nondormant seeds (Baskin et al., 1998). Disturbance of these habitats and excess nutrients can promote increases and spread of cattails(*Typha spp*.) and invasive species such as phragmites (*Phragmites australis)*, which tends to outcompete with many of the native freshwater tidal marsh plants (USFWS, 1995b).

Priority areas for sensitive joint-vetch in Virginia include Hydrologic Unit Codes (HUC): 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0208010403 Occupacia Creek-Rappahannock River, 0208010404 Cat Point Creek-Rappahannock River, 0208010505 Chapel Creek-Mattaponi River, 0208010506 Garnetts Creek- Mattaponi River, 0208010611 Lower Pamunkey River, 0208020601 Falling Creek-James River, 0208020602 Herring Creek-James River, 0208020603-Upper Chippokes Creek-James River, 0208020605 Middle Chickahominy River, 0208020606 Lower Chickahominy River, and 0208020607 Powhatan Creek-James River.

Small Whorled Pogonia (*Isotria medeoloides*)

Listed as federally endangered in 1982 (UFWS, 1982c) and reclassified as threatened in 1994 (USFWS, 1994c), the small whorled pogonia (*Isotria medeoloides*), is one species greatly affected by habitat destruction.

The small whorled pogonia is a perennial member of the Orchidaceae family and has slender, hairy, fibrous roots that radiate from the crown or rootstock (USFWS, 1992c). It is characterized by a whorl of five or six leaves at the top of a glabrous, pale-green, hollow stem and a single yellowish-green flower, occasionally two, that may bloom from the center of the leaf whorl (Sperduto and Congalton, 1996). The small whorled pogonia has four different states: vegetative, with an abortive flower bud, flowering, or dormant. Although insect pollination may take place, the species is primarily self-pollinating (USFWS, 1992c).

Habitat for the small whorled pogonia is in mixed deciduous or mixed deciduous/coniferous forests with common herbs, ferns, and occasionally other orchids (Sperduto and Congalton, 1996). Preferred habitats are forests in second- or third- growth successional stages (USFWS, 1992c). Populations are very isolated and typically very small, being made up of less than 20 plants, although some have been found to contain nearly 100 plants (Mehrhoff, 1989). The small whorled pogonia can be found in Maine and Ontario in the northern portion of its range, west to Michigan, Illinois, and Missouri, and south along the eastern seaboard to Georgia (Massachusetts Natural Heritage and Endangered Species Program, 2015).

The two main threats for the small whorled pogonia are habitat destruction and collection. This destruction is primarily a result of residential and commercial development. These activities directly destroy habitat and indirectly through the construction of roads, powerlines, and sewer mains forming barriers to seed dispersal. Heavy timbering and clear-cutting also threatens populations (USFWS, 1992c). The small whorled pogonia requires very specific habitat to persist and these anthropogenic activities are significantly reducing the amount of suitable habitat available (Massachusetts Natural Heritage and Endangered Species Program, 2015).

Priority areas for small whorled pogonia in Virginia include Hydrologic Unit Codes (HUC): 0207001008 Occoquan River-Potomac River, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001004 Pohick Creek, 0207001006 Cedar Run, 0208010204 Mobjack Bay-Lower Chesapeake Bay, 0208010309 Robinson River, 0208010401 Massaponax Creek-Rappahannock River, 0208010402 Mill Creek-Rappahannock River, 0208010403 Occupacia Creek-Rappahannock River, 0208010407 Corrotoman River-Rappahannock River, 0208010501 Poni River, 0208010502 Matta River-Mattaponi River, 0208010504-Maracossic Creek, 0208010610 Middle Pamunkey River, 0208010611 Lower Pamunkey River, 0208010701 Upper York River, 0208010702 Lower York River, 0208020304 Wreck Island Creek-James River, 0208020308 David Creek-James River, 0208020606 Lower Chickahominy River, 0208020607 Powhatan Creek-James River, 0208020608 Lawnes Creek-James River, 0208020710 Ashton Creek-Appomattox River, and 0208020111 Johns Creek.

Swamp Pink (*Helonias bullata*)

Listed as federally threatened in 1988 (USFWS, 1988c), swamp pink (*Helonias bullata*) is highly impacted by habitat destruction and fragmentation. Swamp pink is a perennial herb in the family Liliaceae that is characterized by a short stout rhizome, evergreen leaves that form a flat basal rosette, and a tall scape with a terminal raceme of pink flowers (Laidig et al., 2009). During the winter months, the leaves lie flat or slightly raised from the ground – typically reddish-brown in color – with new, bright green leaves appearing in spring. Swamp pink will bloom as early as March – often lasting until May – and seed production occurs in June (USFWS, 1991b).

Swamp pink is a wetland species and is associated with swamps and bogs of coastal plain and mountainous areas in the eastern United States (Laidig et al., 2009). These wetland habitats come in a variety of forms including: swampy forested wetlands bordering meandering streams; headwater wetlands; sphagnous, hummocky, dense, Atlantic white cedar swamps; Blue Ridge swamps; meadows; bogs; and spring seepage areas. The wetlands are groundwater-influenced and are perennially saturated (USFWS, 1991b). Swamp pink populations can historically be found from Staten Island and New Jersey to the Southern Appalachians (Sutter, 1984). Although, New York populations are now presumed extirpated, swamp pink is still known from New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia (NatureServe, 2015).

Habitat loss, fragmentation, and degradation are the main threats to swamp pink. Much of this habitat destruction occurs from development projects, draining and filling of wetlands, and silvicultural practices. The bogs that swamp pink inhabits are very sensitive as they are impossible to re-create once they are destroyed. Construction of trails and runoff from roads can pose a serious threat to these habitats. Populations are also impacted by collection and trampling (USFWS, 1991b).

Priority areas for swamp pink in Virginia include Hydrologic Unit Codes (HUC): 0207000507 South River, 0208010402 Mill Creek-Rappahannock River, 0208010403 Occupacia Creek-Rappahannock River, 0208010501 Poni River, 0208010502 Matta River-Mattaponi River, 0208010503 Polecat Creek-Mattaponi River, 0208010504 Maracossic Creek, 0208020204 South River, 0208020305 Upper Type River, 0208020601 Falling Creek-James River, and 0208020605 Middle Chickahominy River.

Virginia Sneezeweed (*Helenium virginicum*)

Sinkhole ponds in the Shenandoah Valley Sinkhole Pond system are home to a unique assemblage of animal and insect species as well as coastal plain and northern bog plant species. One species found in this habitat is Virginia sneezeweed (*Helenium virginicum*) (Buhlmann et al., 1999). Virginia sneezeweed was listed as federally threatened in 1998 (USFWS, 1998).

Virginia sneezeweed is a perennial herbaceous member of the Asteraceae family (Knox et al., 1999). It is approximately 7 to11 cm in height with basal leaves that are gland-dotted, toothed or untoothed, and widest in the upper half of the leaf clustered in a rosette. The flowers are golden yellow turning purplish at the base with age and the fruit is an achene with hairs on its nerves. Virginia sneezeweed typically blooms from early July through October with a peak in late July to early August and seed dispersal occurs in late fall (USFWS, 2000).

Virginia sneezeweed grows in a sinkhole pond habitat that is characterized by clay soils with low pH, low levels of boron, calcium, potassium, magnesium, and phosphorus, and high levels of aluminum (Knox et al., 1999). The soils are a matrix of sand, gravel, and cobble that overlies limestone bedrock. The erosion of this bedrock leads to the formation of shallow basins (Rimer and Summers, 2006). There is typically a dramatic, seasonal change in water depth with months of continuous flooding and periods of drawdown causing the basins to lack any standing water (Knox et al., 1999). Populations of Virginia sneezeweed have a very restricted range and can be found in two counties in the Shenandoah Valley of western Virginia. There is one other population that has been found in Missouri (USFWS, 2000).

Threats to Virginia sneezeweed include habitat loss and degradation as a result of anthropogenic activities resulting in changes in the hydrological regime of the sinkhole pond habitat. Some of these key wetlands have been deepened to create permanent ponds. Other detrimental activities are ditching and plowing, filling, and development for residential subdivisions. Withdrawals for wells use the groundwater that could potentially be an important source for the sinkhole ponds (USFWS, 2000).

Priority areas for Virginia sneezeweed in Virginia include Hydrologic Unit Codes (HUC): 0207000507 South River, 0207000508 Naked Creek-South Fork Shenandoah River, 0208020204 South River, and 0208020205 Lower Maury River.

Atlantic Sturgeon (*Acipenser oxyrinchus*)

Atlantic sturgeon (*Acipenser oxyrinchus*) is an anadromous species occurring on the Atlantic Coast of North America (Collins et al., 2000). This species has suffered dramatic declines for many reasons, including high demands for roe and flesh (Balazik, 2012). Because of these declines, the Atlantic sturgeon was listed as federally endangered in 2012 (USFWS, 2012b).

Atlantic sturgeons are long-lived, anadromous fish reported to reach lengths of 459 cm and body weights of 364.9 kg (Fisheries and Oceans Canada, 2013). The Atlantic sturgeon is a bottom-feeder without teeth and has four whiskers halfway between its snout and mouth. There are five rows of armor-like scales – called scutes – and the tail is longer on the top than on the bottom (Florida Fish and Wildlife Conservation Commission, 2013). The species tends to reach maturity at 16 and 17 years for males and females, respectively. The number of eggs that can be produced is about 25,000 eggs per kg of body weight and females are thought to spawn once every 2 to 6 years whereas males are thought to spawn every 1 to 5 years. (Fisheries and Oceans Canada, 2013).

Atlantic sturgeon grow in freshwater and then spend their adult life in saltwater. Juveniles tend to spend 1 to 3 years in freshwater before entering the marine environment. Spawning typically occurs in the spring over large gravel and other substrates when flow, pH, and other cues are optimal (Florida Fish and Wildlife Conservation Commission, 2013). Populations of Atlantic sturgeon can be found from Quebec, Canada down along the Atlantic Coast and Gulf Coast to Louisiana with possible extirpation in Rhode Island and presumed extirpation in Washington, D.C. (NatureServe, 2017).

The primary threats for this species include habitat degradation including alteration, urbanization, pollution, and fishery by-catch (Florida Fish and Wildlife Conservation Commission, 2013). Dam construction has also had a particularly detrimental effect on sturgeon populations (Balazik, 2012).

Priority areas for Atlantic sturgeon in Virginia include Hydrologic Unit Codes (HUC): 0208010100 Lower Chesapeake Bay, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0207001106 Machodoc Creek-Potomac River, 0207001108 Nomini Creek-Potomac River, 0207001110 Potomac River, 0208010100 Lower Chesapeake Bay, 0208011006 Lower Tangier Sound, 0208011103 Dividing Creek-Pocomoke River, 0208011105 Marumsco Creek-Pocomoke Sound, 0208011107 Deep Creek-Pocomoke Sound, 0208010801 Back River-Lower Chesapeake Bay, 0208020601 Falling Creek-James River, 0208020602 Herring Creek-James River, 0208020607 Powhatan Creek-James River, 0208020608 Lawnes Creek-James River, 0208020609 Pagan River-James River, 0208020710 Ashton Creek- Appomattox River, and 0208020803 Hampton Roads.

Piping Plover (*Charadirus melodus*)

Dependence of shorebirds on the availability of wetlands has led to a large decline in populations as wetlands have been lost (Howe et al., 1989). These wetlands, including intertidal beaches and tidal flats, serve as very important fueling points for long distance migrations from breeding grounds to wintering grounds (Morrison et al., 2004). One of these declining shorebird species is the piping plover (*Charadirus melodus*), listed as federally endangered in the Great Lakes watershed portion of their range and threatened throughout the entirety of their range in 1985 (USFWS, 1985b).

The piping plover is a small shorebird approximately 17 cm long with a wingspread of about 38 cm. Breeding birds have white underparts, light beige back and crown, white rump, and black upper tail with white edge. Breeding plumage has a single black breast and black bar across the forehead. Legs and bill are orange in the summer with a black tip on the bill (USFWS, 1996b). Piping plovers breed in three distinct ranges: coastal beaches along the Atlantic seaboard; sand and gravel shorelines of the Great Lakes; and sand, gravel, and alkaline shores and rivers of the

Great Plains (Gaines and Ryan, 1988). Plovers arrive at breeding grounds and by early April, males begin to establish territories. Nests are typically situated above the high tide line on coastal beaches, and eggs are typically present from mid-April to late July. Southward migration to wintering grounds then occurs in late July, August, and September (USFWS, 1996b).

Along the Atlantic Coast, wintering plovers are typically found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets. The species appears to prefer sandflats adjacent to inlets or passes, sandy mudflats, and overwash areas as foraging habitats. Piping plovers tend to consume invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks (USFWS, 1996b).

Piping plovers have declined causing extirpation in portions of its range, such as Illinois, Indiana, Pennsylvania, and New Hampshire. Such severe decline is primarily due to habitat disturbance and destruction (Gaines and Ryan, 1988). Much of this destruction of beach habitat is through development for residential, resort, and seawall development purposes. Loss of natural dynamic beach from shoreline armoring/stabilization and human disturbances are principal causes of loss of breeding plovers in the Mid-Atlantic region. These habitats rely on natural forces for maintenance and are particularly sensitive to anthropogenic activities (USFWS, 1996b).

Priority areas for piping plover in Virginia include Hydrologic Unit Codes (HUC): 0208010801 Back River-Lower Chesapeake Bay, 0208011109 Cherrystone Inlet-Lower Chesapeake Bay, and 0208020803 Hampton Roads.

Red Knot (*Calidris canutus rufa*)

Dependence of shorebirds on the availability of wetlands has led to a large decline in populations as wetlands have been lost (Howe et al., 1989). These wetlands including intertidal beaches and tidal flats serve as very important fueling points for long distance migrations from breeding grounds to wintering grounds (Morrison et al., 2004). One of the shorebird species that relies so heavily on these wetlands is the red knot (*Calidris canutus rufa*), listed as federally threatened in 2014 (USFWS, 2014).

The red knot is a medium sized, migratory shorebird. They have a long, straight, bill, with a small head, short neck, long legs, and long tapered wings. In breeding plumage, the red knot's face, neck, breast, and underparts are reddish-brown. Wings have a white stripe and upper parts are dark brown or black with some red or grey (Garland and Thomas, 2009). The red knot undergoes a long distance migration from their breeding grounds in the central Canadian Arctic to wintering grounds in the southern tip of South America (Morrison et al., 2004). At stopover sites along the North Atlantic Coast (such as the Delaware Bay), red knots feed almost exclusively on horseshoe crab eggs, and this area serves as a major fueling site for the red knot migration (Baker et al., 2004).

Habitat use by red knots varies among breeding, wintering, and migration periods, but habitat requirements during all periods include suitable sites near foraging areas that are free from predators and human disturbance. During the breeding season, red knots can be found in coastal areas with elevated tundra and barren habitats, such as slopes. This species tends to forage in damp or barren areas up to 10 m from the nest. During migrations and wintering periods, red knots tend to frequent coastal mudflats, sandflats, brackish areas, salt marshes, and mussel beds (Garland and Thomas, 2009).

The greatest threats to the red knot are habitat degradation and disturbance, through anthropogenic activities, in key stopover areas, such as the Delaware Bay, and decreases in horseshoe crab populations. Increases in take of horseshoe crabs, a commercial species, can drastically affect red knot populations (Garland and Thomas, 2009).

Priority areas for red knot in Virginia include Hydrologic Unit Code (HUC) 0208011109 Cherrystone Inlet-Lower Chesapeake Bay.

CBRA

In Virginia there are 64 CBRA Units identified. Of these, 52 units are located in the Chesapeake Bay watershed along Virginia's Eastern Shore (western side of the peninsula), parts of Smith and Tangier Islands, and numerous locations along the eastern most shorelines of Virginia's mainland that interface with the Chesapeake Bay (USFWS, 2017b).

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Shorebird Action Plan

The U.S. Shorebird Conservation Plan (Brown et al., 2001) provides a scientific framework to determine species, sites, and habitats that most urgently need conservation action. Main goals of the plan are to ensure that adequate quantity and quality of shorebird habitat is maintained at the local level and to maintain or restore shorebird populations at the continental and hemispheric levels. Technical assessments were developed for conservation, research needs, comprehensive monitoring strategy, and education and outreach. These national assessments were used to step down goals and objectives into 11 regional conservation plans. Many of the Migratory Bird Joint Venture Implementation Plans now address shorebird habitat needs and represent a second generation of regional plans for shorebird habitat conservation. The North Atlantic Planning Region, which is one of the above 11 regional conservations plans, encompasses the entire Chesapeake Bay region.

Habitats within the region range from rocky shorelines to sandy beaches to tidal mudflats. With the exception of rocky shorelines, most of the shorebird habitats described in the North Atlantic Planning Region are present within the Chesapeake Bay. The major habitat types are: beachfront, including high-energy beaches, sandy deltas, rock and gravel shorelines, and high beach/dune; intertidal mudflats lacking vegetation; vegetated intertidal marshes (dominated by *Spartina* cordgrasses); managed impoundments, both brackish and freshwater; and inland habitats (such as forested wetlands and peninsulas that concentrate migrants), as well as managed uplands (airport and pastures).

Shorebirds in the Chesapeake Bay region face potential impacts from recreational disturbances to foraging and nesting birds, oil spills, extraction of food resources (horseshoe crabs), habitat loss due to development, predators, contaminants, and habitat management that lacks integration with shorebird needs. Shoreline stabilization and armoring practices are important practices to reduce erosion and run-off, but must also addresss habitat suitability for shorebirds (USFWS, 2007b).

Greater than 50 shorebird species have been documented within the Chesapeake region with most shorebird species visiting the region during the spring and fall migration periods. However, at least seven shorebird species are known to nest in the region of which only five species would benefit from Corps restoration related activities, those species are: American oystercatcher, black-necked stilt, piping plover, , and willet.

American Oystercatcher (*Haematopus palliates*)
The American oystercatcher (*Haematopus palliates*) is a common coastal salt marsh and sandy beach shorebird. Its bright red-orange bill is sturdy and laterally flattened, built for opening mussels and oysters. In young birds the bill is a pinkish brown and dusky black toward the tip. It has a yellow eye and an orange-red eye ring. Breeding and non-breeding plumage is almost identical. They have black heads and necks, dark blackish-brown underparts, and white wing and upper-tail patches. Their legs are a tan or sand color. Males and females look alike but females are larger and heavier (Prince William Network, 2017).

American oystercatchers nest on marsh islands, upland dunes, or on the beach. Their nest is a simple scrape lined with tiny pebbles, bits of shell, and seaweed. A pair of oystercatchers may make up to five nests before deciding on which one to use. In marshy areas nests may be lined with reeds. Typically one to three eggs are laid and are well camouflaged. They are sand colored and marked with dark splotches that look like bits of shell and stone. As of 2006, the Chesapeake Bay had approximately 120 nesting pairs, most of which were confined to remote offshore islands. Confirmed nesting sites within the Chesapeake Bay include: Poplar Island, Tangier Island, Smith Island, and surrounding islands; and Fisherman Island NWR (Nol and Humphry, 1994; USGS, 2015).

Unlike other shorebirds, the number of American oystercatchers along the Atlantic Coast has grown in the last two decades. This is one of the few shorebirds that has expanded its range northward. Their success may have to do with the facts they are specialized feeders and attentive parents. They are strictly coastal birds that migrate only short distances if at all. Still, today's population of American oystercatchers is less than 10,000 birds. Coastal reserves in Virginia and North Carolina protect critical habitat where the largest groups of oystercatchers now live (USGS, 2015).

American oystercatchers are shy and intolerant of people. Since coastal property is always in demand for recreation and development, human disturbance is perhaps the greatest threat to breeding American oystercatchers. The American oystercatcher builds nests in open, sandy areas where they are vulnerable to predators like red fox (*Vulpes vulpes*), cats (*Felis catus*), dogs (*Canis lupus familiaris*), or other birds. Pollution is another threat to the oystercatcher population if the levels are high enough to affect the shellfish these shorebirds feed on (Prince William Network, 2017).

Priority areas for American oystercatcher in Virginia include Hydrologic Unit Codes (HUC): 0208011006 Lower Tangier Sound, 0208011105 Marumsco Creek-Pocomoke Sound, 0208011107 Deep Creek-Pocomoke Sound, 0208011109 Cherrystone Inlet-Lower Chesapeake Bay, and 0208020803 Hampton Roads.

Black-Necked Stilt (*Himantopus mexicanus*)

The black-necked stilt (*Himantopus mexicanus*) is one of the largest shorebirds, approximating the size of a crow. Stilts are tall, slim waders with pink or reddish-pink legs. Their long, needle-like bills are built to feed in water and also on the shore. The males are glossy black above with white underparts. Females are brownish- black above. Both males and females have a white forehead and spot over the eye and carry the same plumage all year (Prince William Network, 2017).

Black-necked stilts are commonly found on the edges of managed impoundments, salt and sewage ponds, and shallow inland wetlands. They eat aquatic invertebrates, fish, insects, and brine shrimp. Stilts always breed near water. Their nest is a shallow depression on an island or along the shores of a lake, pond, or stagnant pool. They sometimes line their nests with pebbles, bits of shells, and sticks. Black-necked stilts lay four buff-colored eggs that are well camouflaged by brown or black marks. Parents are monogamous, semi-colonial nesters, known for their aggressive displays against predators. Male and female stilts take turns incubating the eggs. Black-necked stilts are tolerant of other shorebirds nesting nearby. However, they can be very territorial and aggressive toward neighboring chicks (Prince William Network, 2017). Within the Chesapeake Bay, Poplar Island, Hart-Miller Island, and Craney Island are confirmed nesting sites for the species.

Black-necked stilts migrate to coastal areas in the southern United States, Central America, and northern South America. The most critical staging sites are central California, the Salton Sea, and the Great Salt Lake. An estimated 850,000 black-necked stilts can be found globally. Of these, about 150,000 are found in North America. Habitat loss is the primary threat facing black-necked stilts, however, this threat is counterbalanced in some areas by their use of managed impoundments, salt and sewage ponds, agricultural evaporation ponds, and rice fields (Prince William Network, 2017).

Priority areas for black-necked stilt in Virginia include Hydrologic Unit Code (HUC) 0208020803 Hampton Roads.

Piping Plover (*Charadrius melodus*)

The piping plover (*Charadrius melodus*) is a small shorebird that is found only in North America. Within the Chesapeake Bay region, piping plovers are listed as federally threatened. The piping plover has a pale, sand-colored back, short stout bill, and orange legs. During the breeding season, it also has a single black band across the breast, another black band across the forehead between the eyes, and a distinctive black tip on the orange bill. There are two subspecies. The interior subspecies breeds on the Canadian prairies, the Great Plains, and in the Great Lakes region and the eastern subspecies breeds along the Atlantic Coast of Canada and the United States (Prince William Network, 2017).

Individuals of the eastern subspecies breed in the Gulf of St. Lawrence on the Magdalen Islands of Quebec and on the coasts of New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Labrador, and the French islands of Saint Pierre and Miquelon. They are also found along the Atlantic Coast beaches of the United States. Piping plovers winter along the Gulf Coast of the United States and Mexico, southern Atlantic United States Coast, and the Caribbean, including the Bahamas and Cuba. While there is overlap among breeding populations, most Prairie/Great Plains birds winter along the coast of the Gulf of Mexico, most Great Lakes birds on the Atlantic Coast and Florida, and most Atlantic breeders on the Atlantic Coast and the Caribbean (Prince William Network, 2017). Known nesting areas within the Chesapeake Bay include: Craney Island, Fisherman Island NWR, Eastern Shore of Virginia NWR, Plum Tree Island NWR, and Grandview Nature Reserve, all of which are located in Virginia.

Across its breeding range, the piping plover nests on wide sandy beaches with little vegetation and a mix of substrates such as pebbles, gravel, shells, and sticks. On the Atlantic Coast, they are associated with sandy beaches on barrier islands, oceanfronts, bays, and sand bars (Prince William Network, 2017; Rhode Island Department Environmental Management, 2015). The beaches used by piping plovers, on both breeding and wintering grounds, are also of great value to people, so habitat has been lost to or degraded by development, resource extraction, recreation, and other disturbances (Prince William Network, 2017).

Adult piping plovers arrive on breeding grounds in mid-April to mid-May, often returning to the same nesting area in consecutive years. Nests are made by males, and are simple depressions or scrapes in the sand, often lined with pebbles, shells, or driftwood for camouflage. Four eggs are laid, and hatch after about 28 days. Both parents incubate the eggs and tend the chicks. Chicks are able to fly 18 to 35 days after hatching. Fledging success is highly variable and on average only one to two young per clutch fledge.

The key threats to piping plovers are predation (primarily of eggs and chicks), human disturbance, and habitat loss or degradation. Some natural predators have increased with increasing human presence, and domestic and feral animals also prey on piping plovers. Human disturbance directly affects piping plovers through the destruction of eggs or nests and indirectly through distracting birds from nesting and feeding activities and tire tracks on breeding beaches that make feeding difficult and can trap chicks. Development, recreation, and resource extraction reduce the amount and quality of habitat available to piping plovers on breeding grounds and wintering grounds (Prince William Network, 2017).

Climate change poses a growing threat, particularly on coastal breeding and wintering grounds, where an increase in severe storms and rising sea levels are expected to reduce the amount of available habitat. Other threats to the piping plover include extreme high tides, hurricanes (during migration and on the wintering grounds), pollution, and oil spills.

Priority areas for piping plover in Virginia include Hydrologic Unit Codes (HUC): 0208010801 Back River-Lower Chesapeake Bay, 0208011109 Cherrystone Inlet-Lower Chesapeake Bay, and 0208020803 Hampton Roads.

Willet (*Tringa semipalmata*)

Willets (*Tringa semipalmata*) are large shorebirds with grey-brown plumage and a long, thick, grey bill. They have a white rump, eyebrow, and wing stripe that is visible in flight. Willets also have long grey legs and slightly webbed toes. Plumage is similar for both sexes, but females are slightly larger. The eastern subspecies, the willets that can be seen in the Chesapeake Bay, are slightly smaller and darker than their western cousins (Ellison, 2010).

In the Chesapeake Bay, willets are commonly found on beaches, mudflats, and tidal salt marshes. Willets primarily breed in high marsh areas dominated by saltmeadow hay (*Spartina patens*) and in coastal dune areas dominated by beach grass (*Ammophila breviligulata*). Willets migrate south to winter on mudflats and beaches in northern South America. While willets are usually solitary, they may gather in flocks to migrate and roost (Ellison, 2010).

Willets feed by probing with their bills into mud and sand flats, searching for a wide variety of invertebrates. They eat insects, crustaceans, mollusks, worms, grasses, seeds, and occasionally fish. Aside from probing in the sand, willets also hunt by walking through shallow water and holding their bills open under the surface. (Ellison, 2010)

Willets breed from May to July. They are monogamous each season, and males will even reunite with their previous mate if he can find her at their breeding grounds. To attract females, the males will fly with their wings high above their heads and use their "pill-will-willet" call. Females fly beneath them and sing back, before the pair flies to the ground together. Once a pair has formed, the willets stop displaying, mate, and search for a nest site together. Nests are simple scrapes in the grass. Females lay three to four eggs over the course of six days. Both parents incubate the eggs for slightly less than a month. Within hours of hatching, willet chicks are able to walk and feed themselves, and can fly within 4 weeks. Like many other shorebirds, the male, rather than the female, stays with the chicks longer (Ellison, 2010).

There is no current conservation status for willets within the Chesapeake Bay region, as they have had no significant declines in population recently. However, habitat degradation in breeding, wintering, and migration areas may put this species at risk (Ellison, 2010).

Priority areas for willet in Virginia include Hydrologic Unit Codes (HUC): 0208011006 Lower Tangier Sound, 0208011105 Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Landscape Conservation - Black Duck Joint Venture

Established in 1989, the Black Duck Joint Venture (BDJV) is an international, partnership-based conservation program comprised of Federal, state, and provincial wildlife management agencies in the United States and Canada, as well as related non-governmental organizations (BDJV, 2017). As the first species joint venture under the North American Waterfowl Management Plan (NAWMP), the BDJV seeks to implement and coordinate a cooperative population monitoring, research, and communications program to provide information required to manage American black ducks (*Anas rubripes*) and restore numbers to the NAWMP goal of 640,000 breeding birds in the original breeding ground survey area (BDJV, 2017).

Priority areas for American black duck in Virginia include Hydrologic Unit Codes (HUC): 0207001008 Occoquan River-Potomac River, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0208011006 Lower Tangier Sound, 0208011104 Pitts Creek-Potomac River, 0208011105 Marumsco Creek-Pocomoke Sound, 0208011107 Deep Creek-Pocomoke Sound, 0208010401 Massaponax Creek-Rappahannock River, 0208010402 Mill Creek-Rappahannock River, 0208010403 Occupacia Creek-Rappahannock River, 0208010404 Cat Point Creek-Rappahannock River, 0208010506 Garnetts Creek-Mattaponi River, 0208010609 Upper Pamunkey River, 0208010610 Middle Pamunkey River, 0208010611 Lower Pamunkey River, 0208010701 Upper York River, 0208011106 Messongo Creek-Pocomoke Sound, 0208011108 Pungoteague Creek-Lower Chesapeake Bay, and 0208011109 Cherrystone Inlet-Lower Chesapeake Bay.

Landscape Conservation - Sea Duck Joint Venture

The Sea Duck Joint Venture (SDJV), endorsed by the NAWMP in 1998, works to ensure that sea duck populations are maintained at sustainable levels throughout their ranges. To do so, the SDJV promotes the conservation of all North American sea ducks through partnerships by providing greater knowledge and understanding for effective management (Sea Duck Joint Venture, 2017). Since the Joint Venture was endorsed, it has supported efforts to understand what habitats are most important for them. Today, emphasis is on obtaining information that will help ensure that harvest is sustainable and inform habitat conservation actions (Sea Duck Joint Venture, 2017).

There are 15 species of sea ducks as follows: common eider (*Somateria mollissima*), king eider (*Somateria spectabilis*), spectacled eider (*Somateria fischeri*), Steller's eider (*Polysticta stelleri*), black scoter (*Melanitta americana*), white-winged scoter (*Melanitta fusca*), surf scoter (*Melanitta perspicillata*), Barrow's goldeneye (*Bucephala islandica*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), long-tailed duck (oldsquaw) (*Clangula hyemalis*), harlequin duck (*Histrionicus histrionicus*), common merganser (*Mergus merganser*), red-breasted merganser (*Mergus serrator*), and hooded merganser (*Lophodytes cucullatus*). Of the sea duck species, surf scoter, black scoter, white-winged scoter, long-tailed duck, and common eider are species of highest importance (Sea Duck Joint Venture, 2017).

Virginia sea duck priority areas were determined based on the Chesapeake Bay Field Office's 2011-2016 Strategic Plan. The Strategic Plan indicates the priority areas to be the Lower Rappahannock, Chesapeake Oyster Reef, and Chesapeake Bay Islands Focus Areas (USFWS CBFO, 2011).

Priority areas for sea ducks in Virginia include Hydrologic Unit Codes (HUC): 0208010100 Lower Chesapeake Bay, 0208010201 Great Wicomico River-Lower Chesapeake Bay, 0208010406 Lancaster Creek-Rappahannock River, 0208010407 Corrotoman River-Rappahannock River, and 0208020608 Lawnes Creek-James River.

Landscape Conservation - Eastern Brook Trout Joint Venture
The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and Federal agencies, regional and local governments, businesses, conservation organizations, academia, scientific societies, and private citizens (EBTJV, 2017). The EBTJV is dedicated to protecting, restoring, and enhancing aquatic habitat within the eastern brook trout's (*Salvelinus fontinalis*) range, and is modeled after the joint ventures created in support of the North American Waterfowl Management Plan. Working at a variety of geographic and jurisdictional scales, the EBTJV works within a non-regulatory framework to secure adoption of policies that support protection of aquatic habitats and accomplish measurable conservation gains. The EBTJV seeks to secure populations of wild brook trout, aid in the restoration of watershed integrity, protect water quality, and enhance human connections to and stewardship of our natural environment through collaboration among its partners (EBTJV, 2017).

Virginia brook trout priority 10-digit HUCs were determined with assistance from Trout Unlimited. Trout Unlimited advised that areas currently considered strongholds for brook trout and areas that have persistent populations that are adjacent to strongholds should be prioritized. Trout Unlimited's Eastern Brook Trout Conservation Portfolio, Range-wide Assessment, and Focal Area Tools were used to determine strongholds and persistent populations (Trout Unlimited, 2017).

Priority areas for brook trout in Virginia include Hydrologic Unit Codes (HUC): 0207000507 South River, 0207000508 Naked Creek-South Fork Shenandoah River, 0207000509 Hawksbill Creek-South Fork Shenandoah River, 0207000510 Gooney Run-South Fork Shenandoah River, 0207000602 Smith Creek, 0207000701 Crooked Run-Shenandoah River, 0208010307 Conway River-Rapidan River, 0208020101 Upper Jackson River, 0208020105 Lower Jackson River, 0208020107 Middle Cowpasture River, 0208020108 Lower Cowpasture River, 0208020109 Mill Creek-James River, 0208020112 Lower Craig Creek, 0208020115 Cedar Creek-James River, 0208020201 Calfpasture River, 0208020202 Little Calfpasture River-Upper Maury River, 0208020204 South River, 0208020205 Lower Maury River, 0208020302 Pedlar River, 0208020305 Upper Tye River, 0207000101 North Fork South Branch Potomac River, 0207000103 Upper South Branch Potomac River, 0207000105 South Fork South Branch Potomac River, 0207000305 Lost River, 0207000307 Cacapon River, 0207000402 Sleepy Creek, 0207000504 Upper North River, 0207000505 Dry River, 0207000601 Shoemaker River-North Fork Shenandoah River, 0207000604 Stony Creek, 0207000606 Cedar Creek, 0208020102 Back

Creek-Middle Jackson River, 0208020103 Dunlap Creek, 0208020104 Potts Creek, 0208020106 Upper Cowpasture River, and 0208020111 Johns Creek.

Landscape Conservation - Pollinator Initiative

Pollinators are a diverse group of animals and insects (including bees, butterflies, birds, and moths) that assist in the reproductive success of nearly 75 percent of the world's crop species and flowering plants. In the United States, native pollinators are vital to food security and are estimated to add a $3 billion per year to the economy in ecological services (Xerces Society, 2015). Wild pollinator populations, though, are in decline worldwide due to stressors like habitat loss, pesticide use, and introduction of disease in response to this decline. A Federal Interagency Task Force was assigned the job of creating a plan to combat population loss and to promote overall pollinator health. The Task Force's plan includes three overarching goals: reduce honey bee (*Apis mellifera*) losses to economically sustainable levels; increase monarch butterfly (*Danaus plexippus*) numbers to protect the annual migration; and restore or enhance millions of acres of land for pollinators through combined public and private action (Holdren, 2015).

Restoring degraded habitat or planting open patches of land with native plants provides habitat and forage for pollinators as well as other native wildlife. Native wildflowers are attractive to pollinators, provide the nectar that pollinators eat, and provide vital relationships with specific pollinators. For example, the monarch butterfly's only apparent larval host plant is milkweed (*Asclepias sp.*). The monarch butterfly's success is contingent on the health and abundance of the native wildflower (Xerces Society, 2015). Native grasses and wildflowers are adapted both to an area's climate conditions and serve the specific needs of wildlife (Holdren, 2015). HUCS were not assigned to Pollinator Initiative as this is prioritized throughout the entire State.

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and Federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia. Work to assess road-stream crossings in Virginia has been focused on streams and rivers where roads are fragmenting habitat alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), brook trout (*Salvelinus fontinalis*), and imperiled freshwater mussels including the endangered dwarf wedgemussel (*Alasmidonta heterodon*). Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcontinuity.org (NAACC, 2017). There is also an effort to remove low head dams. HUCS were not assigned to Aquatic Connectivity as this is prioritized throughout the entire State.

At-Risk Species

Kenk's Amphipod (*Stygobromus kenki*)

There are an estimated 1,870 amphipod species and subspecies recognized from fresh or inland waters constituting 20 percent of the total amphipod diversity. These amphipods often play critical roles in aquatic food webs, acting as a source of nutrients and energy to higher trophic levels (Vainola et al., 2008). The genus Stygobromus is made up of some of these inland species, which tend to occur in caves or areas where there are permanent groundwater habitats that contain lower levels of organic matter such as decomposing leaf litter and dead insects (Center for Biological Diversity, 2014). Members of this genus include Hay's spring amphipod (*Stygobromus hayi*), listed as federally endangered in 1982 (USFWS, 1982b), and Kenk's amphipod (*Stygobromus kenki*), proposed for federal listing of endangered species.

Kenk's amphipod is a small, eyeless, unpigmented crustacean that grows no larger than a quarter of an inch in size (3.7-5.5 millimeters for the largest male and female specimens). Kenk's amphipod is closely related to Hay's spring amphipod, but can be differentiated morphologically by their appendages (USFWS, 2016b). Little is known of the amphipod species, but like Hay's spring amphipod, Kenk's amphipod lives underground deep within the cracks and crevasses of small freshwater springs and can sometimes be found in the fine soils or dead leaves within those springs (USFWS, 2016b) The habitat is described as hypotelminorheic with a perched aquifer fed by subsurface water that creates a persistent wet spot and is underlain by clay or other impermeable layer typically 5 to 50 centimeters below the surface and is rich in organic matter compared with other aquatic subterranean habitats (USFWS, 2016b).

Kenk's amphipod has been found in a number of places along Rock Creek and its tributaries inhabiting springs that are generally in forested areas along steep slopes (Culver, 2014). Within Maryland and the District of Columbia, ideal springs have been located in areas overlying the Wissahickon geologic formation within the Piedmont physiographic region. Populations have also been found in Virginia at Fort A. P. Hill where the amphipod has been known to occur in the Calvert formation just above the Nanjemoy geologic formation in the upper Coastal Plain (USFWS, 2016b). These geologic characteristics lead to the formation of the shallow groundwater springs where Kenk's amphipod lives and feeds on decomposing leaf litter and dead insects (Center for Biological Diversity, 2014).

Because of their limited range, habitat loss and degradation pose immediate danger to Kenk's amphipod. The groundwater-fed springs where they live are greatly impacted by alterations of groundwater flows and pollution within the watershed (Center for Biological Diversity, 2014). Kenk's amphipod requires good water quality to persist and is very sensitive to pollutants from urban development or agricultural practices. Some of the main threats include sewer leaks and pesticides within the watershed (USFWS, 2016b).

Priority areas for Kenk's amphipod in Virginia include Hydrologic Unit Codes (HUC): 0207001001 Rock Creek-Potomac River, 0208010402 Mill Creek-Rappahannock River, and 0208010403 Occupacia Creek-Rappahannock River.

Bald Eagle (*Haliaeetus leucocephalus*)

The bald eagle (*Haliaeetus leucocephalus*) is a species found throughout the United States, usually occupying habitats close to large water bodies where they primarily forage for fish. Bald eagles nest in mature trees within a half mile of their foraging areas, preferring to nest in the tallest canopy tree or along an open forest edge. Eagle nest sites and communal roost areas require natural protection buffers to avoid being disturbed from commercial and residential development and other associated human activities. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA) from a variety of human induced conditions and activities.

In 2007, the Service removed the bald eagle from the list of federally threatened and endangered species , created National Bald Eagle Management Guidelines, and promulgated new rules under BGEPA (in 2012) to permit incidental take of eagles during activities of otherwise, lawful projects.

The guidelines advise landowners and land managers with measures on how to avoid and minimize disturbance to nesting eagles on private and Federal land. A variety of human actions can potentially interfere with bald eagles, affecting their ability to forage, nest, roost, breed, or successfully raise young. The guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute "disturbance," which is prohibited by the BGEPA. All bald eagle nest trees, including the 660-foot concentric circular forest buffer surrounding the nest, are federally protected and therefore considered as areas restricted from development unless authorized by issuance of an BGEPA Permit. Proposed projects in the Chesapeake Bay watershed region must consider the protection standards for bald eagles which includes: time-of-year restriction from activities (December-June); habitat/nest protection buffers (330-foot and 660-foot zones); and Important High Eagle Use Areas (communal roosts/concentration areas).

Priority areas for bald eagle in Virginia include Hydrologic Unit Codes (HUC): 0207001008 Occoquan River-Potomac River, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0208011103 Dividing Creek-Potomac River, 0208011104-Pitts Creek-Potomac River, 0208011105 Marumsco Creek-Pocomoke Sound, 0207000703-Bullskin Run-Shenandoah River, 0207001004-Pohick Creek, 0208010402 Mill Creek-Rappahannock River, 0208010403 Occupacia Creek-Rappahannock River, 0208010404 Cat Point Creek-Rappahannock River, 0208020601 Falling Creek-James River, 0208020602 Herring Creek-James River, 0208020603 Upper Chippokes Creek-James River, 0208020606 Lower Chickahominy River, 0208020607 Powhatan Creek-James River, 0208020608 Lawnes Creek-James River, 0208020710 Ashton Creek-Appomattox River, 0207000101 North Fork South Branch Potomac River, 0207000103 Upper South Branch Potomac River, 0207000105 South Fork South Branch Potomac River, 0207000305 Lost River, 0207000307 Cacapon River, and 0207000402 Sleepy Creek.

Saltmarsh Sparrow (Ammodramus caudacutus)

The saltmarsh sparrow (Ammodramus caudacutus) is an obligate tidal-marsh specialist, and as such, is unique among passerines in North America and elsewhere. It chiefly breeds in dense, supratidal Spartina patens–Juncus romerianus salt meadows, but in some marshes, it readily uses smooth cordgrass (Spartina alterniflora) in the upper intertidal, which it often shares with its close relative, the seaside sparrow (A. maritimus), in more southern areas. Its breeding range is narrowly linear along the north-central Atlantic Coast of the United States, in localized and discontinuous populations, where it extends from coastal Maine, south to Chesapeake Bay and the Delmarva Peninsula (Greenlaw and Rising, 1994).

Within the Chesapeake Bay, the extensive saltmarshes of the lower Delmarva Peninsula counties (Dorchester, Wicomico, and Somerset in MD; Accomack and Northampton in VA) are the species last strongholds within the Bay. The saltmarsh systems located in the western shore counties of Virginia that include Northumberland, Gloucester, Mathews, and Middlesex also provide high quality breeding habit for the species. Periodic tidal flooding in many, perhaps most, salt marshes is the chief source of nest mortality in this species. Selection arising from such events has molded several adaptations that mitigate flooding risk, including nest placement, nest-repair and egg retrieval behaviors, and rapid post-flood renesting. Flooding of vulnerable nests early in the breeding season often results in synchronization of subsequent nests to a tidal cycle in marshes subject to a monthly pattern of a single highest (spring) tide.

This species is a ground feeder that forages in dense wet grasses, wrack, and the edges of saltmarsh pools. For the most part their diet is comprised mostly of insects and other small invertebrates. During the fall migrations, grass seeds become an important part of their diet (Greenlaw and Rising, 1994; Ellison, 2010).

Priority areas for saltmarsh sparrow in Virginia includeinclude Hydrologic Unit Code (HUC) 0208010204 Mobjack Bay-Lower Chesapeake Bay, 0208011107, Deep Creek-Pocomoke Sound, 0208011106 Messongo Creek-Pocomoke Sound.

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Chapter 2. Maryland

Seven states and the District of Columbia directly impact the health of the Chesapeake Bay. Maryland falls in the middle of the watershed and has 1,726 square miles in the Chesapeake Bay watershed. Many rivers flow into the Chesapeake Bay, and three of the largest are the Potomac, the Patapsco, and the Patuxent. The Potomac River flows east and creates a natural border between Maryland and Virginia, while the Patapsco flows south/southeast through Baltimore to the Bay. Located between the Patapsco and the Potomac, the Patuxent River covers over 957 square miles, and bears the distinction of being the longest river exclusive to Maryland (Maryland, 2017). Through strategic planning, HUC 10 Priority Areas have been identified by the Service to protect ecologically sensitive terrestrial and aquatic species and to maintain or restore their habitats in Maryland. These watershed areas are essential to a variety of aquatic and terrestrial species, including endangered and threatened plants and animals.

REFUGES

There are 16 refuges in the watershed, including those in the Chesapeake Marshlands National Wildlife Refuge Complex and Patuxent Research Refuge which are located in Maryland. Each of these refuges may have individual refuge units within the Refuge Complex. Both complex and refuge units are described in detail in this section.

Chesapeake Marshlands National Wildlife Refuge Complex

The Chesapeake Marshlands National Wildlife Refuge Complex is located on the Eastern Shore of Maryland and Virginia and includes Blackwater National Wildlife Refuge (NWR); Eastern Neck NWR; and the Chesapeake Island Refuges which includes Martin NWR, Susquehanna NWR, and Blackwater NWR's Barren Island, Watts Island, Bishops Head and Spring Island Divisions. Each refuge/division is discussed in more detail below. The Chesapeake Marshlands National Wildlife Refuge Complex seeks to create the most complete network of protected lands within the Chesapeake Bay watershed. The major stressors for the Complex are sea level rise, due to climate change and subsidence, and urbanization. The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge Comprehensive Conservation Plan (USFWS, 2006; USFWS, 2010a).

Blackwater National Wildlife Refuge (2006)

Blackwater National Wildlife Refuge was officially established under the authority of the Migratory Bird Conservation Act on January 23, 1933 for use as a sanctuary or other management purpose for migratory birds. Since that time, the Refuge has acquired additional land to protect endangered and threatened species, conserve other natural resources, including wetland ecosystems, and provide fish and wildlife-oriented recreation. The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Blackwater's extensive marshes, moist-soil impoundments, and variety of croplands form the favorable trio of habitats most essential to thousands of migrating and wintering waterfowl. Its forests provide unique and important habitat for a variety of migratory birds, including bald eagles, and Delmarva fox squirrels (*Sciurus niger cinereus*) (USFWS, 2006).

Goals

The primary goal of Blackwater NWR is to protect and enhance Service trust resources and habitats of special concern. This includes providing habitats to sustain 10 percent of each of Maryland's wintering waterfowl populations of Atlantic Population Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), and dabbling ducks. Additionally, this goal includes providing habitats that support neotropical migratory songbirds, emphasizing forest interior dwelling (FID) species (USFWS, 2006).

Blackwater NWR also seeks to provide habitats to support a diversity of raptors, migrating shorebirds, marsh, and water birds, as well as a diversity of brackish marsh nesting birds including rails, sparrows, and other marsh bird species. This goal includes accomplishing applicable recovery plan objectives and other management activities for federally listed species and restoring, protecting, and enhancing habitats for anadromous and interjurisdictional fish species (USFWS, 2006).

An additional goal of Blackwater NWR is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuge will control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore natural diversity of communities, sensitive species, and associated ecosystem processes in the Blackwater and Nanticoke watersheds (USFWS, 2006).

Eastern Neck National Wildlife Refuge (2010)

The purpose of Eastern Neck NWR is to serve as a sanctuary or other management purpose for migratory birds. Established by executive order on December 27, 1962, this 2,286-acre island is strategically located at the confluence of the Chester River and the Chesapeake Bay to serve resting and feeding migrating and wintering waterfowl on Maryland's upper Eastern Shore. Habitat on the Refuge includes marsh, woodland, grassland, cropland, and open water. The Refuge provides habitat for more than 240 bird species, including bald eagles and transitory peregrine falcons (*Falco peregrinus*). It hosts a large variety of migrating waterfowl as well as staging and overwintering areas for tundra swans (*Cygnus columbianus*). It is also one of only four benchmark sites for recently delisted Delmarva fox squirrel. The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2010).

Goals

Eastern Neck NWR's primary goal is to protect and enhance Service trust resources and species and habitats of special concern. This includes maintaining and restoring the integrity of the

Refuge shoreline and nearshore environments to sustain diverse natural communities. The Refuge manages habitats to sustain wintering populations of migratory waterfowl in the lower Chester River basin. The Refuge also manages a variety of upland habitats to support the rich diversity of songbirds, raptors, butterflies, and other native wildlife; and manages, protects, and monitors interjurisdictional fish and other aquatic species on the Refuge and in surrounding waters. Consistent with the full extent of Service trust responsibilities, the Refuge also protects and restores archeological and historic resources on Refuge land (USFWS, 2010).

An additional goal of Eastern Neck NWR is to maintain a healthy and diverse complex of natural community types comprised of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuge seeks to protect, enhance, and restore the natural diversity, integrity, and health of community types and associated native plants and animals and sensitive species on the Refuge, and to protect the integrity of federally designated Research and Public Use Natural Areas (USFWS, 2010).

Susquehanna National Wildlife Refuge (2006)

Susquehanna NWR serves as a refuge and breeding ground for migratory birds and other wildlife. It is long renowned for its outstanding aquatic habitat, where large numbers of diving ducks, primarily canvasback ducks (*Aythya valisineria*), concentrate. President Franklin D. Roosevelt, under the authority of the Migratory Bird Treaty Act of July 3, 1918, designated a certain part of the Chesapeake Bay as the “Susquehanna Migratory Waterfowl Closed Area.” The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Goals

Chesapeake Island Refuges, which includes Susquehanna NWR, were established to protect and enhance Service trust resources and other species and habitats of special concern. This includes providing habitats to sustain five percent of each of the following waterfowl wintering in Maryland: Atlantic Population (AP) Canada geese and dabbling duck population, as measured by the Midwinter Waterfowl Inventory. The Refuges intend to restore, protect, and enhance habitats for American black duck production by creating an American Black Duck Initiative for the island refuges. Additionally, the Refuges seeks to restore, protect, and enhance habitats for designated species of neotropical migrants identified for protection in the Partners in Flight Plan and protect, enhance, and create island habitats for colonial waterbirds. The Refuges provide habitats to support a diversity of migrating and nesting shorebirds, gulls, terns, and allied species as well as estuarine habitat associated raptors. Additionally, the Refuges seeks to accomplish applicable recovery objectives for federally listed species as outlined in recovery plans and restore, protect, and enhance habitats for anadromous and interjurisdictional fish species and blue crab (USFWS, 2006).

An additional goal of the Chesapeake Island Refuges is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuges aim to control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore submerged aquatic vegetation (SAV) habitats and the natural diversity of communities and associated ecosystem processes on Chesapeake Island Refuges (USFWS, 2006).

Martin National Wildlife Refuge (2006)
Martin NWR is for use as a sanctuary, or for any other management purpose, for migratory birds. The late Glenn L. Martin established Martin NWR by donating 2,482 acres of his private hunting preserve to the United States. In May 1957, his estate offered the Federal government 1,377 acres at $27.06 per acre (USFWS, 2006). The Migratory Bird Conservation Commission, under the authority of the Migratory Bird Treaty Act, subsequently approved the acquisition of those and other lands. Today, Martin NWR is comprised of the Barren Island Division, Bishops Head Division, and Watts Island Division. The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Goals
Chesapeake Island Refuges, which includes Martin NWR, were established to protect and enhance Service trust resources and other species and habitats of special concern. This includes providing habitats to sustain five percent of each of the following waterfowl wintering in Maryland: Atlantic Population (AP) Canada geese and dabbling duck population, as measured by the Midwinter Waterfowl Inventory. The Refuges intend to restore, protect, and enhance habitats for American black duck production by creating an American Black Duck Initiative for the island refuges. Additionally, the Refuges seeks to restore, protect, and enhance habitats for designated species of neotropical migrants identified for protection in the Partners in Flight Plan and protect, enhance, and create island habitats for colonial waterbirds. The Refuges provide habitats to support a diversity of migrating and nesting shorebirds, gulls, terns, and allied species as well as estuarine habitat associated raptors. Additionally, the Refuges seeks to accomplish applicable recovery objectives for federally listed species as outlined in recovery plans and restore, protect, and enhance habitats for anadromous and interjurisdictional fish species and blue crab (USFWS, 2006).

An additional goal of the Chesapeake Island Refuges is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuges aim to control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore submerged aquatic vegetation (SAV) habitats and the natural diversity of communities and associated ecosystem processes on Chesapeake Island Refuges (USFWS, 2006).

Barren Island Division (2006)
The Barren Island Division, approximately 177 acres, was established on December 24, 1991 under the authority of the Migratory Bird Conservation Act. The purpose of the refuge is for use as a sanctuary, or for any other management purpose, for migratory birds. The islands are

located in the Chesapeake Bay, west of Hooper's Island, and serve as a major rookery for colonial bird species. They also have been noted as the only black skimmer (*Rynchops niger*)nesting area in the Maryland portion of the Chesapeake Bay, and a major nesting site for least terns (*Sternula antillarum*). The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Goals

Chesapeake Island Refuges, which includes Barren Island Division of Martin NWR, were established to protect and enhance Service trust resources and other species and habitats of special concern. This includes providing habitats to sustain five percent of each of the following waterfowl wintering in Maryland: Atlantic Population (AP) Canada geese and dabbling duck population, as measured by the Midwinter Waterfowl Inventory. The Refuges intend to restore, protect, and enhance habitats for American black duck production by creating an American Black Duck Initiative for the island refuges. Additionally, the Refuges seeks to restore, protect, and enhance habitats for designated species of neotropical migrants identified for protection in the Partners in Flight Plan and protect, enhance, and create island habitats for colonial waterbirds. The Refuges provide habitats to support a diversity of migrating and nesting shorebirds, gulls, terns, and allied species as well as estuarine habitat associated raptors. Additionally, the Refuges seeks to accomplish applicable recovery objectives for federally listed species as outlined in recovery plans and restore, protect, and enhance habitats for anadromous and interjurisdictional fish species and blue crab (*Callinectes sapidus*)(USFWS, 2006).

An additional goal of the Chesapeake Island Refuges is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuges aim to control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore submerged aquatic vegetation (SAV) habitats and the natural diversity of communities and associated ecosystem processes on Chesapeake Island Refuges (USFWS, 2006).

Bishops Head Division (2006)

The Bishops Head Division, comprising the 380-acre Bishops Head Tract and 52-acre Spring Island, was established on December 30, 1992, under the authority of the Migratory Bird Conservation Act. The purpose of the Bishops Head Division is for use as a sanctuary, or for any other management purpose, for migratory birds. These lands protect the largest brown pelican rookery in the Chesapeake Bay. The description, goals, and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Goals

Chesapeake Island Refuges, which includes Bishops Head Division of Martin NWR, were established to protect and enhance Service trust resources and other species and habitats of special concern. This includes providing habitats to sustain five percent of each of the following waterfowl wintering in Maryland: Atlantic Population (AP) Canada geese and dabbling duck population, as measured by the Midwinter Waterfowl Inventory. The Refuges intend to restore, protect, and enhance habitats for American black duck production by creating an American Black Duck Initiative for the island refuges. Additionally, the Refuges seek to restore, protect, and enhance habitats for designated species of neotropical migrants identified for protection in the Partners in Flight Plan and protect, enhance, and create island habitats for colonial waterbirds. The Refuges provide habitats to support a diversity of migrating and nesting shorebirds, gulls, terns, and allied species as well as estuarine habitat associated raptors. Additionally, the Refuges seeks to accomplish applicable recovery objectives for federally listed species as outlined in recovery plans and restore, protect, and enhance habitats for anadromous and interjurisdictional fish species and blue crab (USFWS, 2006).

An additional goal of the Chesapeake Island Refuges is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuges aim to control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore submerged aquatic vegetation (SAV) habitats and the natural diversity of communities and associated ecosystem processes on Chesapeake Island Refuges (USFWS, 2006).

Watts Island Division (2006)
The Watts Island Division was established on May 2, 1995, with the purpose of protecting, enhancing, restoring, and managing wetland ecosystems and other habitats for migratory birds, threatened and endangered species, and other wildlife. Located about 15 miles southeast of Martin NWR, the island supports a least tern nesting colony, and is noted as one of the largest colonial bird rookeries in Maryland. The description, goals and stressors in this section were identified in the Chesapeake Island National Wildlife Refuge Complex Comprehensive Conservation Plan and the Eastern Neck National Wildlife Refuge CCP (USFWS, 2006).

Goals
Chesapeake Island Refuges, which includes Watts Island Division of Martin NWR, were established to protect and enhance Service trust resources and other species and habitats of special concern. This includes providing habitats to sustain five percent of each of the following waterfowl wintering in Maryland: Atlantic Population (AP) Canada geese and dabbling duck population, as measured by the Midwinter Waterfowl Inventory. The Refuges intend to restore, protect, and enhance habitats for Americanblack duck production by creating an American Black Duck Initiative for the island refuges. Additionally, the Refuges seek to restore, protect, and enhance habitats for designated species of neotropical migrants identified for protection in the Partners in Flight Plan and protect, enhance, and create island habitats for colonial waterbirds. The Refuges provide habitats to support a diversity of migrating and nesting shorebirds, gulls, terns, and allied species as well as estuarine habitat associated raptors. Additionally, the Refuges seeks to accomplish applicable recovery objectives for federally listed

species as outlined in recovery plans and restore, protect, and enhance habitats for anadromous and interjurisdictional fish species and blue crab (USFWS, 2006).

An additional goal of the Chesapeake Island Refuges is to maintain a healthy and diverse ecosystem with a full range of natural processes, natural community types, and the full spectrum of native plants and animals to pass on to future generations of Americans. To accomplish this goal, the Refuges aim to control, eradicate, or manage injurious, invasive, and exotic species, and protect, enhance, and restore submerged aquatic vegetation (SAV) habitats and the natural diversity of communities and associated ecosystem processes on Chesapeake Island Refuges (USFWS, 2006).

Stressors

Sea level rise, resulting from a combination of climate change and land subsidence, is one of the greatest threats to the Refuge Complex. Unquestionably, the rate of sea level rise has accelerated in the Chesapeake Bay, and this appears to be the norm rather than the exception. The future of the ecosystem, and certainly the Refuge Complex, revolve around understanding, coping with, and more importantly, planning for an ongoing dynamic Earth process like sea level rise (USFWS, 2006).

In addition to sea level rise, effects of expanding human population and changing demographics are some of the greatest stressors to the future of the Refuge Complex. By 2020, the population within the Chesapeake Bay watershed is expected to increase almost 33 percent, causing substantial changes in land use (USFWS, 2006). The available open space is declining (farms, fields, forests, wetlands, and other wildlife habitats), and the areas that remain are becoming more and more fragmented. Lands within the Nanticoke protection area are under intense development pressure, since easily developable waterfront property is the rarest commodity in the present-day Eastern Shore real estate market (USFWS, 2006).

Population growth, fragmentation, and other land use changes affect Refuge Complex management, since these forces ultimately result in elemental changes to fish, wildlife, and plant populations and to ecosystem processes. They affect land acquisition efforts, create logistical problems in land management, maintenance, and law enforcement, and produce significant recreational demands and pressures on the Refuge Complex (USFWS, 2006).

Patuxent Research Refuge (2013)

The Patuxent Research Refuge mission is, “To help protect and conserve the Nation’s wildlife and habitat through research on critical environmental problems and issues.” Patuxent Research Refuge was established on December 16, 1936, to serve as a sanctuary or other management purposes for migratory birds and to serve as a wildlife experiment and research refuge. The description, goals, and stressors in this section were identified in Patuxent Research Refuge CCP (USFWS, 2013a).

Dedicated on June 3, 1939, Secretary of Agriculture Henry A. Wallace stated that, “The chief purpose of this refuge is to assist in the restoration of wildlife - one of our greatest natural resources." Patuxent Research Refuge was established to explore how wildlife and agriculture could co-exist, to develop wildlife-friendly agricultural practices, and to return marginal cropland back to wildlife habitat (USFWS, 2013a).

Goals

Patuxent Research Refuge serves as the first national wildlife refuge established for both wildlife and research and is the home of the U.S. Geological Survey's Patuxent Wildlife Research Center. Staff and partners are able to conduct cutting-edge wildlife research and interpretation of the natural world in the shadows of protected historic and cultural resources. Situated near the center of the Baltimore-Washington Corridor, Patuxent Research Refuge is an island of green. This large contiguous block of forest, meadows, and wetlands provides habitat for resident and migratory species, and improved air and water quality for the surrounding areas, while fostering a sense of wonder and connectedness to natural areas (USFWS, 2013a).

Patuxent Research Refuge seeks to maintain and actively promote the Refuge as an outdoor laboratory, providing a diversity of wildlife and natural resource research opportunities on the Refuge in such areas as landscape conservation, habitat fragmentation, climate change, and other emerging issues, as well as the more traditional types of wildlife research, including inventory and monitoring techniques, land management, and understanding ecological processes. Research that supports the overall Service mission and evaluates the best methods for protecting natural resources throughout the Refuge System and other land management agencies is a priority (USFWS, 2013a).

Additionally, Patuxent aims to protect, maintain, and restore, where practicable, the biological integrity, diversity, and environmental health of forested ecological communities to provide habitat for species of conservation concern including migratory birds, mammals, amphibians, reptiles, and invertebrates (USFWS, 2013a).

Patuxent also seeks to protect, maintain, and restore, where practicable, the biological integrity, diversity, and environmental health of refuge aquatic habitats located within the Patuxent, Little Patuxent, and Anacostia River watersheds and impoundments, and to provide habitat for species of conservation concern, including fish, invertebrates, and plants (USFWS, 2013a).

An additional goal of Patuxent Research Refuge is to manage refuge non-forested upland communities to provide ecological structure, composition, and function to support native plants and wildlife, including species of conservation concern. Where appropriate, the Refuge seeks to restore the biological integrity and diversity of these habitats (USFWS, 2013a).

With its close proximity to both Washington D.C. and Baltimore, Patuxent Research Refuge provides high-quality recreation, environmental education, and interpretive programs to enhance Refuge visitors' understanding and appreciation of fish and wildlife conservation (USFWS, 2013a).

Stressors

With its close proximity to Washington D.C. and Baltimore, urbanization continues to be a stressor for Patuxent Research Refuge, including issues with contamination. Contamination on the North Tract includes solvents, lead, pesticides, polychlorinated biphenyls, heavy metals, waste fuels, waste oils, and unexploded ordnance associated with activities that took place when the land was part of Fort Meade (URS, 2010).

The largest rivers on the Refuge are identified as impaired water bodies on Maryland's 303(d) list likely, in part, due to urbanization in the area. The Patuxent and Little Patuxent Rivers have excessive nutrients and sediment, while the Little Patuxent may have excessive mercury in its waters. The Little Patuxent, Midway Branch, and Lake Allen are all identified as having impaired aquatic biota populations (Wurster, 2010).

In addition to issues associated with urbanization and contamination, invasive species, both plants and animals, are also a stressor to the Refuge. These invasives include phragmites (*Phragmites australis*), Japanese honeysuckle (*Lonicera japonica*), European starlings (*Sturnus vulgaris*), red swamp crayfish (*Procambarus clarkia*), and feral cats (*Felis catus*), among others. In addition to the species that are currently considered invasive, other nonnative species are poised to create challenges in the near future (USFWS, 2013a).

Baltimore Rivers to Harbor Urban Wildlife Refuge Partnership

What began as the restoration of an abandoned area near Baltimore Harbor grew into a nationally recognized partnership connecting the city's residents to the outdoors. The Service designated Masonville Cove as the Nation's first Urban Wildlife Refuge Partnership (UWRP) on September 26, 2013. Given the successes at Masonville Cove, the network of partners involved grew and the Urban Wildlife Refuge Partnership expanded beyond Masonville Cove to further connect Baltimore residents to the outdoors; this broader vision for the efforts of the Baltimore is captured in its new name: Baltimore Rivers to Harbor Urban Wildlife Refuge Partnership (USFWS 2017a).

With over 600,000 residents, Baltimore is the commercial, residential, and industrial heart of Maryland. Maryland is a state that is physically and politically wrapped around the Chesapeake Bay. However, people in urban areas, like Baltimore, are becoming increasingly disconnected from the lands and waters on which they depend. The broadened Baltimore Rivers to Harbor UWRP will connect one harbor, two sub-watersheds, three rivers, a multitude of unique neighborhoods, eight state, local, and federal public lands, and several trails into one coordinated program that offers a revitalized trail system, enhanced and accessible programming that is relevant to diverse urban audiences, and a more beautiful and resilient ecosystem that benefits the people of Baltimore (USFWS 2017a).

Over the course of the next 10 years, the Baltimore Rivers to Harbor UWRP will grow from the neighborhoods and communities around the Middle Branch and Masonville Cove into the key tributary watersheds of Jones Falls, Gwynns Falls, and the Patapsco River (USFWS 2017a).

Collaborating with community-based organizations, government agencies and other institutions, the Service will work to connect residents with green corridors and Bay waters. Building stronger connections to nature and wildlife will enhance the social and economic vitality of Baltimore communities and will provide the foundation for a shared regional ethic of environmental stewardship (USFWS 2017a).

Priority HUCS for the Baltimore Rivers to Harbor Urban Wildlife Refuge Partnership include 0206000312 Patapsco River, 0206000309 Gwynns Falls, and 0206000311 West Branch Patapsco River.

ENDANGERED SPECIES

There are 18 endangered and threatened species in the Maryland portion of the Chesapeake Bay watershed. This section describes the life history and stressors associated with these Species. The section identifies two categories of threatened and endangered species for Maryland, those that are directly associated with aquatic habitats and those that are not directly associated to aquatic habitat. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats.

Non-Aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they need to be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Sandplain Gerardia (*Agalinis acuta*)

Listed as endangered in 1988, the sandplain gerardia (*Agalinis acuta*) is an annual herb that grows in dry, open areas such as the sandplain grassland as well as openings in pine-oak forest on nutrient poor soils where vegetation is sparse (Neel, 2002). Populations occur at sites in Cape Cod, Massachusetts; Long Island, New York; Washington County, Rhode Island; and Baltimore County, Maryland (USFWS, 1989). Major threats include habitat loss due to conversion of the coastal plain to agricultural, residential, industrial, and commercial development (USFWS, 1988a).

Priority areas for sandplain gerardia in Maryland include Hydrologic Unit Codes (HUC): 0206000308 North Branch Patapsco River and 0206000309 Gwynns Falls.

Indiana Bat (*Myotis sodalis*)

The Indiana bat (*Myotis sodalis*) is an insectivorous species that spends its summer in wooded areas where it roosts in loose tree bark on dead or dying trees. During winter months, the Indiana bat will migrate to caves and mines where it hibernates colonially (USFWS, 2007). This species forages along rivers or upland lakes, with preferential foraging in woodland areas, where it consumes a variety of flying insects (Sparks et al., 2005).

Current winter distribution includes hibernacula found in 19 states: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. States were maternity colonies have been found, summer habitats, include: Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Missouri, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS, 2007).

The Indiana bat was listed as federally endangered in 1967. It suffered from large decreases in populations because of threats such as human disturbance during hibernation, habitat alteration through stream channelization, deforestation for agriculture, surface strip-mining, and urban expansion. (Garner and Gardner, 1992; Murry and Kurta, 2003).

Priority areas for Indiana bat in Maryland include Hydrologic Unit Codes (HUC): 0207000201 Savage River, 0207000904 Double Pipe Creek, 0205030601 South Branch Conewago Creek, 0205030607 Codorus Creek, 0206000303 Upper Gunpowder Falls, 0207000205 Wills Creek, 0207000206 Evitts Creek, 0207000405 Little Tonoloway Creek-Potomac River, 0207000202 Stony River-North Branch Potomac River, and 0207000308 Long Hollow Run-Potomac River.

Northern Long-Eared Bat (*Myotis septentrionalis*)
The northern long-eared bat (*Myotis septentrionalis*), listed as federally threatened in 2015 (USFWS, 2016a), is a medium-sized bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (WDNR, 2013). The distribution range of the northern long-eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and the United States from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increased agricultural and household pesticide use, and hibernaculum disturbance (WDNR, 2013).

Priority areas for northern long-eared bat in Maryland include Hydrologic Unit Codes (HUC): 0207001002 Anacostia River, 0207000810 Difficult Run-Potomac River, 0207001001 Rock Creek-Potomac River, 0207000201 Savage River, 0207000907 Lower Monocacy River, 0207000205 Wills Creek, 0207000206 Evitts Creek, 0207000410 Antietam Creek, 0207000905 Upper Monocacy River, 0207000405 Little Tonoloway Creek-Potomac River, 0207000411 Rocky Marsh Run-Potomac River, 0207000804 Tuscarora Creek-Potomac River, 0207000809 Broad Run-Potomac River, 0207000703 Bullskin Run-Shenandoah River, 0207000208 Trading Run-North Branch Potomac River, and 0207000308 Long Hollow Run-Potomac River.

Aquatic Threatened and Endangered Species

Aquatic threatened and endangered species listed below are species have some or all of their life history tied directly to the aquatic systems.

Dwarf Wedgemussel (*Alasmidonta heterodon*)
Freshwater mussels have declined dramatically in diversity, abundance, and distribution within the last 200 years and are considered the most imperiled fauna in North America (Richter et al., 1997; Lydeard et al., 2004). In the genus Alasmidonta, 9 of 13 species are threatened, endangered, or extinct (Williams et al., 1992). The dwarf wedgemussel (*Alasmidonta heterodon*) was once known in 70 locations throughout 15 major Atlantic coastal drainages from New Brunswick Canada to North Carolina. Now, populations are discontinuously distributed in selected drainages in Vermont, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia, and North Carolina with possible extirpation in Canada, Maine, Delaware and Washington, D.C. The dwarf wedgemussel was listed as endangered by the Service in 1990 (USFWS, 1993a).

The dwarf wedgemussel is a small bivalve, rarely exceeding 45 mm in length. Clean young shells are usually greenish-brown with green rays. As the animal ages, the shell color becomes obscured by diatoms or mineral deposits and appears black or brown. The shell is thin but does thicken somewhat with age, especially toward the anterior end. The anterior end is rounded while the posterior end is angular forming a point near the posterior-ventral margin. The most distinctive shell characteristic of the dwarf wedgemussel is the arrangement of the lateral teeth. There are two lateral teeth in the right valve and one in the left valve. The typical arrangement for most freshwater mussel species consists of two lateral teeth in the left valve and one in the right valve (MDNR, 2009).

The dwarf wedgemussel is a sedentary filter feeder that spends most of its life partially buried in the substrate of small streams to large rivers. Dwarf wedgemussels often have patchy distribution in rivers, and usually inhabit hydrologically stable areas. They can be found in a variety of substrate types including clay, sand, gravel, pebble, and sometimes silt depositional areas near banks. The species is a bradytictic breeder, meaning that females become gravid in the early fall and larvae called glochidia are released by mid-spring attaching to the gills of specific host fish. The tessellated darter (*Etheostoma olmstedi*), johnny darter (*Etheostoma nigrum*), and mottled sculpin (*Cottus bairdi*) have been identified as hosts for the dwarf wedgemussel, it is possible other fish will act as host as well (N.C. Natural Heritage Program, 2001).

Dwarf wedge mussels require unpolluted streams or rivers with high dissolved oxygen, moderate current, and stable substrate (Strayer, 1999). Some of the population instability of the dwarf wedgemussel can be attributed to its short lifespan; low fecundity; high degree of host specificity; limited dispersal ability of its primary host; and low population densities (McLean and Ross, 2005). However, stream fragmentation from dams, causeways, impoundments, and channelization, exacerbates population instability by causing inhospitable stream segments. This stream fragmentation results in spatially and genetically disjunctive populations, disrupting mussel life cycles, preventing host fish migration, blocking gene flow, and prohibiting recolonization (USFWS, 1993a).

Priority areas for dwarf wedgemussel in Maryland include Hydrologic Unit Codes (HUC): 0206000204-Chester River, 0206000502-Upper Choptank River, 0206000501-Tuckahoe Creek, 0207001107-Saint Clements Bay-Potomac River, 0207001102-Potomac Creek-Potomac River, and 0207001103-Nanjemoy Creek-Potomac River.

Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*)
Tiger beetles live in a variety of habitats including water edges, sandy flats, dunes, woodland paths, open patches in grasslands, and recently cleared areas. Although tiger beetles can be found in this range of habitats, each species has very specific habitat requirements (Knisley and Hill, 1992). The northeastern beach tiger beetle (Cicindela dorsalis dorsalis) inhabits sandy beaches along the East Coast. Shoreline stabilization and/or elimination of updrift sand sources are stressors in that they prevent natural shoreline dynamics and induce beach erosion (USFWS, 2007) This species is now extirpated from much of its historic range and was federally listed as a threatened species in 1990 (Fenster et al., 2006; USFWS, 1990c).

The northeastern beach tiger beetle is a medium-sized (13 to 15.5 mm in length), beach dwelling tiger beetle that has white to light tan elytra with a bronze-green head and thorax. The northeastern beach tiger beetle is considered a subspecies of the eastern beach tiger beetle, and can be distinguished morphologically (USFWS, 1994b). The life cycle of the northeastern beach tiger beetle begins with the eggs which are oviposited by the female in burrows located in the upper foreshore to the lower backshore. The first instar larva hatches during the summer and digs a burrow at the site of oviposition. Development occurs in these burrows. The larvae are sedentary predators that use the burrows to capture small arthropods passing by. The adults then emerge from mid-June to August. Mating occurs throughout adulthood. The entire life cycle generally lasts 2 years (Fenster et al., 2006). Adult tiger beetles typically consume small beach amphipods and occasionally scavenge on dead amphipods, crabs, and fish (USFWS, 1994b).

Habitats preferred by the northeastern beach tiger beetle include beaches with low to moderate compaction, and medium- to coarse-grained sands to facilitate oviposition of females (Fenster et al., 2006). The historic range of the tiger beetle includes most of the coastal sandy beaches from New Jersey to Cape Cod and much of the eastern and western shorelines of the Chesapeake Bay from southern Maryland to Virginia (Knisley et al., 1987). With a dramatic decline in populations, the northeastern beach tiger beetle can be found in relative abundant amounts in Virginia (Knisley et al., 1998).

Threats to the northeastern beach tiger beetle are destruction and disturbance of natural beach habitat from shoreline developments, oil slicks, recreational use, and beach erosion (potentially contributed to with climate change). Larval recruitment and survival dramatically decreases in areas with development and high recreational use. Distributions of beetles that successfully emerged from the pupa stage, however, were much less affected by human activity

(USFWS, 1994b). Beach erosion can also have serious effects on larval habitat. Tiger beetle larvae are typically not found at sites that have only narrow eroded beaches, and seem to be limited to areas where beaches are at least 5 m wide, with some sand above the high tide zone. Beach erosion is a natural process resulting from rising sea levels and prevailing currents (USFWS, 1994b). Climate change affects the rate of sea level rise and could be a major contributor in the increase of beach erosion and decrease in beach habitat in the future (Bosello et al., 2004).

Priority areas for northeastern beach tiger beetle in Maryland include Hydrologic Unit Codes (HUC): 0206000404 Herring Bay-Chesapeake Bay, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, 0207001108 Nomini Creek-Potomac River, 0208010201-Great Wicomico River-Lower Chesapeake Bay, 0208011006 Lower Tangier Sound, 0208011105-Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Puritan Tiger Beetle (*Cicindela puritana*)

Tiger beetles are an ecologically important group of insects generally being the dominant invertebrate predator in their habitats. Tiger beetles have become model organisms for testing ecological theories on community structure, competition, food limitation, thermoregulation, and predator defense (USFWS, 1994). Tiger beetles live in a variety of habitats including water edges, sandy flats, dunes, woodland paths, open patches in grasslands, and recently cleared areas. Although tiger beetles can be found in this range of habitats, each species has very specific habitat requirements (Knisley and Hill, 1992). The puritan tiger beetle (*Cicindela puritana*) is one such species that can be found in shoreline habitat along the Connecticut River in New England and the Chesapeake Bay in Maryland (USFWS, 1993b). This species has suffered a major decline in populations and was federally listed as threatened in 1990 (USFWS, 1990a).

The puritan tiger beetle is a medium-sized (average length 11.5 to 12.4 mm) species of tiger beetle that is characterized by elytra with a background color of dark bronze-brown to bronze-green with cream-colored markings. Habitat requirements for the puritan tiger beetle vary with locality. In Maryland, larvae live in deep burrows dug in sandy deposits on non-vegetated portions of the bluff face or at the base of the bluffs in erosion driven sediment deposits. In Connecticut, larvae generally do not use the low bluffs; instead their burrows are found among herbaceous vegetation on the upper portions of sandy beaches and occasionally near the water's edge (USFWS, 1993b). Similar to other tiger beetles, the puritan tiger beetle typically undergoes a 2-year larval period before emergence. Larvae hatch in late July or August as first instars and generally overwinter as second instars before molting into the third instar. During the larval stage, they inhabit their burrows feeding off small arthropods passing by. After emergence, the adults tend to predate smaller invertebrates for the bulk of their diet (USFWS, 1993b).

The current range for the puritan tiger beetle has drastically decreased from its historic occurrences. The presence of the tiger beetle has not been recorded from the Connecticut River since the 1930s, and remaining populations in the Chesapeake Bay are threatened. There are no known occurrences between these two locations (Vogler et al., 1993). Reasons for this decline are mainly due to flood control dams (Knisley, 2011). The change in water flow had greatly altered the river's hydrologic cycle and likely reduced the amount of beach habitat available for foraging (USFWS, 1993b). Urban development disturbing habitat also poses a risk to the puritan tiger beetle. This can greatly affect the recruitment rates and survival of tiger beetle larvae (USFWS, 1993b).

Priority areas for puritan tiger beetle in Maryland include Hydrologic Unit Codes (HUC): 0206000203 Sassafras River, 0206000202 Elk River, 0206000205 Upper Chesapeake Bay, 0206000402 Severn River-Chesapeake Bay, and 0206000404 Herring Bay-Chesapeake Bay.

Canby's Dropwort (*Oxypolis canbyi*)

Nearly 25 percent of the world's vascular plant species are in danger of becoming extinct within the next 50 years (Raven, 1987), and 22 percent of the vascular plant species in the United States are currently of conservation concern (Falk, 1992). Forested wetlands represent one of the many communities that are negatively affected by anthropogenic activities and serve as habitat for many rare species of vascular plants (Ernst and Brown, 1988). Listed as federally endangered in 1986 (USFWS, 1986), Canby's dropwort (*Oxypolis canbyi*) is one of these plants within these largely impacted communities.

Originally described as a variety of *O. filiformis* (water dropwort), Canby's dropwort was elevated to a full species based on differences in leaf and fruit characters (USFWS, 1990b). Canby's dropwort is a member of the Apiaceae family and is a perennial herb that stands 0.8 to 1.2 m tall (USFWS, 1990b). The dropwort has slender leaves that are hollow and small five-parted flowers on compound umbrels with white petals and pale green sepals, some of which are tinged with red (USFWS, 2010b). The fruit of Canby's dropwort is a schizocarp that is ellipsoidal in shape and compressed dorsoventrally; the dropwort has also been known to reproduce asexually through rhizomes (USFWS, 1990b).

Canby's dropwort is found to grow in Coastal Plain habitats including pond cypress savannas, wet pineland savannas, wet meadows, Carolina bays, sloughs, and around the edges of cypress-pine ponds. The healthiest populations generally occur in open savannas, bays, or ponds that are wet most of the year and have a sparse or non-existent canopy (USFWS, 2010b). Preferred soils are generally sandy loams or acidic peat-mucks underlain by clay layers resulting in the retention of water (USFWS, 1990b). Habitats for the dropwort can be found in Maryland, North Carolina, South Carolina, and Georgia, with presumed extirpation from Delaware (NatureServe, 2015).

The most significant threat to the remaining populations of Canby's dropwort is loss and alteration of wetland habitat. Primary loss is due to ditching and draining of the wetland areas, and is generally done for agricultural and silvicultural purposes. These practices reduce the frequency, depth, and duration of surface water, lower the groundwater table, and change vegetative composition (USFWS, 2010b). Due to the proximity of some Canby dropwort populations to agricultural fields and pine plantations, some damage of plants could potentially be a result of herbicide drift (USFWS, 1990b). Another threat to the species could be the occurrence of sea level rise resulting from climate change. Due to changes in environmental conditions, the current vegetative composition could be altered causing optimum habitat to be lost (Daniels et al., 1993).

Priority areas for Canby's dropwort in Maryland include Hydrologic Unit Codes (HUC) 0206000204 Chester River.

Harperella (*Ptilimnium nodosum*)

Harperella (*Ptilimnium nodosum*), listed as federally endangered in 1988 (USFWS, 1988b), is a semi-aquatic annual herb and includes two variates known as the pond and riverine forms (previously referred to as: pond, *H. nodosum*; riverine*, P. fluviatile*). These separate forms were not shown to be quantitatively distinct in morphology and phenology, and are thought to be the results of environmental factors – specifically variation due to the extent of flooding in the environment (USFWS, 1990c). Harperella flowers from late July to frost and reproduces both sexually and asexually through seeds or plantlets formed in the nodes typically being transported downstream to form new subpopulations (Wells, 2012).

Harperella generally prefers rocky riverbeds and has very specific water depth tolerances: neither too shallow nor too deep to impair completion of its life cycle. The riverine ecotype grows on rocky and sandy shoals and, rarely, on muddy banks of seasonally flooded and quickly moving streams with the largest subpopulations found in sunny sections of creeks (USFWS, 1990c). These harperella populations can be found in Maryland, West Virginia, Virginia, North Carolina, Alabama, and Arkansas (Frye and Tessel, 2012). The pond ecotype generally occupies the edges of the coastal plain ponds and granite flatrock sites (USFWS, 1990c) and can be found in South Carolina and Georgia, respectively (Frye and Tessel, 2012).

Frequent and minor flood events are typically beneficial to harperella populations as they scour cobble bars, preventing most competitors from becoming established, and remove algae which can overgrow and shade out harperella that is still in the water (Wells, 2012). Although, these flood events are beneficial, manipulations of the water flow to increase or decrease flooding are the primary threat to the species. Manipulation of water flow upstream such as dams, reservoirs, or other water impoundments/diversions can destroy suitable habitat and threaten populations. P. fluviatile populations are also sensitive to siltation caused by development and agriculture (USFWS, 1990c).

Priority areas for harperella in Maryland include Hydrologic Unit Codes (HUC): 0207000303 Fifteenmile Creek, 0207000304 Sideling Hill Creek, and 0207001102 Potomac Creek-Potomac River.

Northeastern Bulrush (*Scirpus ancistrochaetus*)

Freshwater, seasonal ponds are important habitats to many endemic or rare animal and plant species. Northeastern bulrush (*Scirpus ancistrochaetus*) is a plant species that relies on the seasonal or temporary nature of these ponds (Lentz and Dunson, 1999) and was listed as federally endangered in 1991 (USFWS, 1991).

Northeastern bulrush, perennial emergent sedge, is found primarily in small vernal ponds (Lentz and Cipollini, 1998). It grows approximately 80-120 cm in height (Lentz and Dunson, 1999), with the lowermost leaves being much longer than they are wide and the uppermost leaves being narrower and somewhat shorter than the lower leaves. The bulrush flowers from mid-June to July and has an umbellate inflorescence that bears clusters of brown spikelets. Its fruit sets between July and September and has yellow-brown achenes that are obovate and thickened above the seed (USFWS, 1993c).

Northeastern bulrush is typically found in small, seasonal, palustrine wetlands which are frequently isolated (Lentz, 1999). The bulrush tends to grow in acidic to circumneutral areas, with sites varying geographically from sinkhole ponds in the southern portion of the range to a various other wetland types in the northern portions (USFWS, 1993c). The wetlands inhabited by the northeastern bulrush seem to be fed primarily from surface water, and can vary greatly within a season (Lentz and Dunson, 1998). Distribution is thought to be influenced by light availability. Northeastern bulrush can usually be found in areas with less than 60 percent canopy cover (Lentz and Cipollini, 1998). Populations of northeastern bulrush can be found in West Virginia, Virginia, Maryland, New York, Pennsylvania, Massachusetts, Vermont, and New Hampshire; with the majority of populations found in Pennsylvania (Lentz, 1999).

The most immediate threats to the northeastern bulrush are destruction or modification of habitat. Wetland filling, draining, and dredging for development, agriculture, and recreation are the primary forms of habitat destruction (USFWS, 1993b). Logging, road construction, agricultural activities, and development also threaten population persistence (Lentz and Dunson, 1999). Little is known about life history, which makes conservation and management of this species more challenging.

Priority areas for northeastern bulrush in Maryland include Hydrologic Unit Codes (HUC) 0207000403 Licking Creek.

Sensitive Joint-Vetch (*Aeschynomene virginica*)

Listed as federally threatened in 1992 (USFWS, 1992), sensitive joint-vetch (*Aeschynomene virginica*) is an annual legume in the family Fabaceae. It usually grows to the height of 1 to 2 meters with single stems that sometimes branch near the top and have stiff or bristly hairs. Each leaf consists of 30 to 56 leaflets that fold slightly when touched and has yellow, irregular, legume-type flowers streaked with red that grow in racemes (elongated inflorescences with stalked flowers) (USFWS, 1995). The fruits are pods that contain 4 to 10 seeds each and break along suture lines at maturity. Seeds generally disperse as single seed enclosed within their pod segment during October and November (Griffith and Forseth, 2002).

Sensitive joint-vetch generally grows along the East Coast in freshwater and slightly brackish tidal marshes (Baskin et al., 1998). The substrate may be sandy, muddy, peaty, or gravelly. It is usually found on substrates that are sparsely vegetated due to natural disturbances such as storms, ice scour, accreting sediments, or muskrat (*Ondatra zibethica*) eat outs. Nutrient deficiencies in the organic sediments may also result in sparse vegetation (USFWS, 1995). Populations located in the tidal freshwater habitats are currently found in six river systems in Virginia, three in Maryland, and two in New Jersey. It is believed to be extirpated from Delaware and Pennsylvania.

Alterations to tidal marshes are the main threats to the remaining sensitive joint-vetch populations. Some of these alterations include dams, dredging and filling, commercial and residential development, water withdrawal, mining, agricultural practices, timber harvest, and sea level changes resulting from climate change (USFWS, 1995). Some of these practices could potentially allow salinity levels to exceed the tolerance of the sensitive joint-vetch affecting seed germination and retention of viability of nondormant seeds (Baskin et al., 1998). Disturbance of these habitats can also facilitate the spread of invasive species such as phragmites (*Phragmites australis*), which tends to outcompete many of the native freshwater tidal marsh plants (USFWS, 1995).

Priority areas for sensitive joint-vetch in Maryland include Hydrologic Unit Codes (HUC): 0206000605 Middle Patuxent River, 0208011004 Manokin River, 0207001101 Quantico Creek-Potomac River, and 0207001102 Potomac Creek-Potomac River.

Swamp Pink (*Helonias bullata*)

Listed as federally threatened in 1988 (USFWS, 1988c), swamp pink (*Helonias bullata*) is highly impacted by habitat destruction and fragmentation. Swamp pink is a perennial herb in the family Liliaceae that is characterized by a short stout rhizome, evergreen leaves that form a flat basal rosette, and a tall scape with a terminal raceme of pink flowers (Laidig et al., 2009). During the winter months, the leaves lie flat or slightly raised from the ground – typically reddish-brown in color – with new, bright green leaves appearing in spring. Swamp pink will bloom as early as March – often lasting until May – and seed production occurs in June (USFWS, 1991a).

Swamp pink is a wetland species and is associated with swamps and bogs of coastal plain and mountainous areas in the eastern United States (Laidig et al., 2009). These wetland habitats come in a variety of forms including: swampy forested wetlands bordering meandering streams; headwater wetlands; sphagnous, hummocky, dense, Atlantic white cedar swamps; Blue Ridge swamps; meadows; bogs; and spring seepage areas. The wetlands are groundwater-influenced and are perennially saturated (USFWS, 1991a). Swamp pink populations can historically be found from Staten Island and New Jersey to the Southern Appalachians (Sutter, 1984). Although, New York populations are now presumed extirpated, swamp pink is still known from New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia.

Habitat loss, fragmentation, and degradation are the main threats to swamp pink. Much of this habitat destruction occurs from development projects, draining and filling of wetlands, and silvicultural practices. The bogs that swamp pink inhabits are very sensitive as they are impossible to re-create once they are destroyed. Construction of trails and runoff from roads can pose a serious threat to these habitats. Populations are also impacted by collection and trampling (USFWS, 1991a).

Priority areas for swamp pink in Maryland include Hydrologic Unit Codes (HUC): 0206000311 Patapsco River, 0206000312 Patapsco River Chesapeake Bay, 0206000401 Magothy River-Chesapeake Bay, 0206000505 Lower Choptank River, and 0206000201 North East River-Upper Chesapeake Bay.

Atlantic Sturgeon (*Acipenser oxyrinchus*)
There are two anadromous or semianadromus sturgeon species that occur on the Atlantic Coast of North America; shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus*) (Collins et al., 2000). Both of these species have suffered dramatic declines in their populations for many reasons including high demands for roe and flesh (Balazik, 2012). Because of these declines, both species have been federally listed, with shortnose sturgeon being listed as federally endangered in 1967 (USFWS, 1967).

Atlantic sturgeon is an anadromous species occurring on the Atlantic Coast of North America (Collins et al., 2000). This species has suffered dramatic declines for many reasons, including high demands for roe and flesh (Balazik, 2012). Because of these declines, the Atlantic sturgeon was listed as federally endangered in 2012 (USFWS, 2012).

Atlantic sturgeon are long-lived, anadromous fish reported to reach lengths of 459 cm and body weights of 364.9 kg (Fisheries and Oceans Canada, 2013). The Atlantic sturgeon is a bottom-feeder without teeth and has four whiskers halfway between its snout and mouth. There are five rows of armor-like scales – called scutes – and the tail is longer on the top than on the bottom (Florida Fish and Wildlife Conservation Commission, 2013). The species tends to reach maturity at 16 and 17 years for males and females, respectively. The number of eggs that can be produced is about 25,000 eggs per kg of body weight and females are thought to spawn once every 2 to 6 years whereas males are thought to spawn every 1 to 5 years. (Fisheries and Oceans Canada, 2013).

Atlantic sturgeon grow in freshwater and then spend their adult life in saltwater. Juveniles tend to spend 1 to 3 years in freshwater before entering the marine environment. Spawning typically occurs in the spring over large gravel and other substrates when flow, pH, and other cues are optimal (Florida Fish and Wildlife Conservation Commission, 2013). Populations of Atlantic sturgeon can be found from Quebec, Canada down along the Atlantic Coast and Gulf Coast to Louisiana with possible extirpation in Rhode Island and presumed extirpation in Washington, D.C. (NatureServe, 2017).

The primary threats for this species include habitat degradation including alteration, urbanization, pollution, and fishery by-catch (Florida Fish and Wildlife Conservation Commission, 2013). Dam construction has also had a particularly detrimental effect on sturgeon populations (Balazik, 2012).

Priority areas for Atlantic sturgeon in Maryland include Hydrologic Unit Codes (HUC): 0206000204 Chester River, 02080109050 Lower Nanticoke River, 0206000100 Upper Chesapeake Bay, 0206000205 Upper Chesapeake Bay, 0206000206 Eastern Bay, 0206000307 Back River-Chesapeake Bay, 0206000312 Patapsco River-Chesapeake Bay, 0206000402 Severn River-Chesapeake Bay, 0206000403 South River-Chesapeake Bay, 0206000404 Herring Bay-Chesapeake Bay, 0206000504 Little Choptank River, 0206000505 Lower Choptank River, 0206000506 Honga River-Chesapeake Bay, 0207001105 Wicomico River, 0208011002 Blackwater River, 0208011005 Upper Tangier Sound, 0208010100 Lower Chesapeake Bay, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0207001106 Machodoc Creek-Potomac River, 0207001108 Nomini Creek-Potomac River, 0207001110 Potomac River, 0208010100 Lower Chesapeake Bay, 0208011006 Lower Tangier Sound, 0208011103 Dividing Creek-Pocomoke River, 0208011105 Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Shortnose Sturgeon (*Acipenser brevirostrum*)
The shortnose sturgeons typically reach a length of 4 feet and have a shorter and blunter snout than the Atlantic sturgeon. Unlike the Atlantic sturgeon, the shortnose sturgeon does not have a row of bony plates along the anal fin. The shortnose sturgeon is anadromous, spawning at or above the head-of-tide in most rivers. Although it has some seasonal migrations to estuarine waters, it rarely occurs in the marine environment (NMFS, 1998). Shortnose sturgeons live along the bottom of large rivers and estuaries and as water temperatures rise in the spring, they migrate to the swift moving upstream reaches of the river. Spawning season ranges from February to May depending on their location. When water temperatures begin to cool in fall to early winter, they travel to overwintering sites within the river (USFWS, 2003). Populations of shortnose sturgeon can be found from New Brunswick, Canada south along the Atlantic Coast to Florida with possible extirpation in New Hampshire, Rhode Island, and Virginia and presumed extirpation in Washington, D.C (NatureServe, 2017).

The primary threats for this species include habitat degradation – including alteration, urbanization, and point source/non-point source pollution – poor water quality, and fishery by-catch (Florida Fish and Wildlife Conservation Commission, 2013). Dam construction has also had a particularly detrimental effect on sturgeon populations (Balazik 2012).

Priority areas for shortnose sturgeon in Maryland include Hydrologic Unit Codes (HUC): 0206000203 Sassafras River, 0208010905 Lower Nanticoke River, 0206000202 Elk River, 0206000100 Upper Chesapeake Bay, 0206000205 Upper Chesapeake Bay, 0206000302 Romney Creek-Chesapeake Bay, 0206000307 Back River-Chesapeake Bay, 0206000312 Patapsco River-Chesapeake Bay, 0208011002 Blackwater River, 0208011005 Upper Tangier Sound, 0205030617 Susquehanna River, 0206000201 North East River-Upper Chesapeake Bay, 0207001008 Occoquan River-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001110 Potomac River, and 0208011105 Marumsco Creek-Pocomoke Sound.

Bog Turtle (*Glyptemys muhlenbergii*)

The bog turtle (*Glyptemys muhlenbergii*) was listed as federally threatened in 1997 (USFWS, 1997). The bog turtle is one of North America's smallest turtles with New England specimens measuring less than 100 mm in carapace length and specimens from more southern populations reaching sizes up to 115 mm in carapace length (USFWS, 2001). The turtles are dark in color and have large yellow to orange markings on both sides of the head. The markings on juveniles and hatchlings are lighter, whereas older adults have more intense color blotches (NRCS, 2006). The carapace is usually black or brown, somewhat domed, and has a slight mid-dorsal keel (Pennsylvania Fish and Boat Commission, 2011). The carapace may be marked with yellowish rays of color, and the plastron is usually black with varying amounts of white or pale yellow patches (NRCS, 2006). Bog turtles in the northern populations typically emerge from hibernation in late March through April and return to hibernacula in October. Breeding occurs from late April to early June and nesting occurs 21 to 31 days after copulation. Hatchlings then emerge from mid-August to September and overwinter at or near the nest site (Pennsylvania Fish and Boat Commission, 2011).

Bog turtles typically inhabit shallow wetland habitats such as sphagnum bogs, marshes, and wet meadows (Chase et al., 1989). These wetland habitats are seepages or spring-fed emergent freshwater wetlands, are associated with streams, and are bordered by wooded areas. The wetlands generally have a variety of microhabitats for the bog turtles to use for foraging, nesting, basking, hibernation, shelter, and other needs (NRCS, 2006). Populations of bog turtles can be found in New York, Massachusetts, Connecticut, New Jersey, Pennsylvania, Delaware, and Maryland with some populations located further to the south in Virginia, North Carolina, South Carolina, Tennessee, and Georgia (USFWS, 2001).

Bog turtles are very sensitive to changes in habitat and have declined greatly due to habitat degradation and loss from activities such as wetland filling, fragmentation, and drainage (NRCS, 2006). The creation of farm ponds, reservoirs, and other impoundments inundate the shallow, open wet meadows and fens required for bog turtles. Because bog turtles are sustained by groundwater regimes, they are particularly sensitive to changes in subsurface water supplies. Construction and development has the ability to alter subsurface flow as well as drilling under wetlands, which can fracture bedrock and significantly impact small wetland systems (USFWS, 2001).

HUCs for bog turtle were not included in this report as the information was deemed too sensitive and would risk the species recovery. One of the greatest threats to bog turtle recovery is collection of the species. Providing the HUC locations would allow collectors to know where bog turtles are currently located. Bog turtle must be coordinated with the Service on a project specific basis.

Maryland Darter (*Etheostoma sellare*)

Rates of extinction tend to be considerably higher for aquatic species when compared to terrestrial species. For Maryland, in particular, 88 percent of freshwater mussels, 41 percent of native fish species are imperiled, and nearly 10 percent of the native freshwater fishes are presumed extirpated or extinct (Stranko et al., 2010). One species that is included in the 41 percent of Maryland imperiled species is the Maryland darter (*Etheostoma sellare*), which was listed as federally endangered in 1967 (USFWS, 1967).

The Maryland darter is a small fish growing to just under 3 inches in size with a life span of approximately 3 years (USFWS, 2011). The Maryland darter is paler in color with four dark brown to black saddle markings along the body and a small dark spot behind each eye. The species inhabits fast rocky riffles of creeks with rubble to gravel substrate and an abundance of rooted aquatic plants. It likely spawns in the gravel riffles, but little is known about its life history (NatureServe, 2013). Historically, this species is only known from a limited area in Harford County, Maryland in the Susquehanna River drainage basin (USFWS, 2011).

Threats to the Maryland darter include habitat loss and degradation from residential development, and damming of the Susquehanna River. Agricultural runoff has also had a negative effect on water quality within the darter's range (USFWS, 2011; NatureServe, 2013). A combination of range reduction from damming and decreased water quality has resulted in drastic decline in the population leading to a listing of federally endangered with the possibility of extinction as a specimen has not been found since 1986 – there was also a report of an unverified specimen found in 1988 (NatureServe, 2013).

Priority areas for Maryland darter in Maryland include Hydrologic Unit Codes (HUC) 0205030616 Deer Creek.

CBRA

In Maryland there are 49 CBRA units. Of these, 47 units are found within the Chesapeake Bay watershed. Most are located on the Chesapeake Bay side of Maryland's Eastern Shore peninsula and the remaining occur along the confluence of the Patuxent and Potomac Rivers on Maryland's Western Shore (USFWS, 2017b).

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Shorebird Action Plan

The U.S. Shorebird Conservation Plan (Brown et al., 2001) provides a scientific framework to determine species, sites, and habitats that most urgently need conservation action. Main goals of the plan are to ensure that adequate quantity and quality of shorebird habitat is maintained at the local level and to maintain or restore shorebird populations at the continental and hemispheric levels. Technical assessments were developed for conservation, research needs, comprehensive monitoring strategy, education, and outreach. These national assessments were used to step down goals and objectives into 11 regional conservation plans. Many of the Migratory Bird Joint Venture Implementation Plans now address shorebird habitat needs and represent a second generation of regional plans for shorebird habitat conservation. The North Atlantic Planning Region, which is one of the above 11 regional conservations plans, encompasses the entire Chesapeake Bay region (Brown et al., 2001).

Habitats within the region range from rocky shorelines to sandy beaches to tidal mudflats. With the exception of rocky shorelines, most of the described shorebird habitats described in the North Atlantic Planning Region are present within the Chesapeake Bay. The major habitat types are: beachfront, including high-energy beaches, sandy deltas, rock and gravel shorelines, and high beach/dune; intertidal mudflats lacking vegetation; vegetated intertidal marshes (dominated by Spartina cordgrasses); managed impoundments, both brackish and freshwater; and inland habitats (such as forested wetlands and peninsulas that concentrate migrants), as well as managed uplands (airport and pastures) (Brown et al., 2001).

Shorebirds in the Chesapeake Bay region face potential impacts from recreational disturbances, oil spills, extraction of food resources (horseshoe crabs), habitat loss due to development and potentially armoring /shoreline stabilization, predators, contaminants, and habitat management that lacks integration with shorebird needs (USFWS, 2008).

Greater than 50 shorebird species have been documented within the Chesapeake region with most shorebird species visiting the region during the spring and fall migration periods. However, at least seven shorebird species are known to nest in the region of which only five species would benefit from Corps restoration related activities, those species are: American oystercatcher, black-necked stilt, piping plover, and willet (USFWS, 2008).

American Oystercatcher (*Haematopus palliates*)

The American oystercatcher (*Haematopus palliates*) is a common coastal salt marsh and sandy beach shorebird. Its bright red-orange bill is sturdy and laterally flattened, built for opening mussels and oysters. In young birds the bill is a pinkish brown and dusky black toward the tip. It has a yellow eye and an orange-red eye ring. Breeding and non-breeding plumage is almost identical in American oystercatchers. They have black heads and necks, dark blackish-brown underparts, and white wing and upper-tail patches. Their legs are a tan or sand color. Males and females look alike but females are larger and heavier (Prince William Network, 2017).

American oystercatchers nest on marsh islands, upland dunes, or on the beach. Their nest is a simple scrape lined with tiny pebbles, bits of shell, and seaweed. A pair of oystercatchers may make up to five nests before deciding on which one to use. In marshy areas nests may be lined with reeds. Typically one to three eggs are laid and are well camouflaged. They are sand colored and marked with dark splotches that look like bits of shell and stones. As of 2006, the Chesapeake Bay had approximately 120 nesting pairs, most of which were confined to remote offshore islands. Confirmed nesting sites within the Chesapeake Bay include: Poplar Island, Tangier Island, Smith Island, and surrounding islands; and Fisherman Island NWR (USFWS, 2008).

Unlike other shorebirds, the numbers of American oystercatchers along the Atlantic Coast has grown in the last two decades. This is one of the few shorebirds that has expanded its range northward. Their success may have to do with the facts they are specialized feeders and attentive parents. They are strictly coastal birds that migrate only short distances if at all. Still, today's population of American oystercatchers is less than 10,000 birds. Coastal reserves in

Virginia and North Carolina protect critical habitat where the largest groups of oystercatchers now live (USFWS, 2008).

American oystercatchers are shy and intolerant of people. Since coastal property is always in demand for recreation and development, human disturbance is perhaps the greatest threat to breeding American oystercatchers. The American oystercatcher builds nests in open, sandy areas where they are vulnerable to predators like red fox, cats, dogs, or other birds (Prince William Network, 2017). Pollution is another threat to the oystercatcher population if the levels are high enough to affect the shellfish these shorebirds feed on (Prince William Network, 2017).

Priority areas for American oystercatcher in Maryland include Hydrologic Unit Codes (HUC): 0206000505 Lower Choptank River, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, 0208011006 Lower Tangier Sound, 0208011105 Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Black-necked Stilt (*Himantopus mexicanus*)

The black-necked stilt (*Himantopus mexicanus*) is one of the largest shorebirds, approximating the size of a crow. Stilts are tall, slim waders with pink or reddish-pink legs. Their long, needle-like bills are built to feed in water and also on the shore. The males are glossy black above with white underparts. Females are brownish- black above. Both males and females have a white forehead and spot over the eye and carry the same plumage all year (Prince William Network, 2017).

Black-necked stilts are commonly found on the edges of managed impoundments, salt and sewage ponds, and shallow inland wetlands. They eat aquatic invertebrates, fish, insects, and brine shrimp. Black-necked stilts always breed near water. Their nest is a shallow depression on an island or along the shores of a lake, pond, or stagnant pool. They sometimes line their nests with pebbles, bits of shell, and sticks. Black-necked stilts lay four buff-colored eggs that are well camouflaged by brown or black marks. Parents are monogamous, semi-colonial nesters, known for their aggressive displays against predators. Male and female stilts take turns incubating the eggs. Black-necked stilts are tolerant of other shorebirds nesting nearby. However, they can be very territorial and aggressive toward neighboring chicks (Prince William Network, 2017). Within the Chesapeake Bay, Poplar Island, Hart-Miller Island, and Craney Island are confirmed nesting sites for the species.

Black-necked stilts migrate to coastal areas in the southern United States, Central America and northern South America. The most critical staging sites are central California, the Salton Sea, and the Great Salt Lake. An estimated 850,000 black-necked stilts can be found globally. Of these about 150,000 are found in North America. Habitat loss is the primary threat facing black-necked stilts, however, this threat is counterbalanced in some areas by their use of managed impoundments, salt and sewage ponds, agricultural evaporation ponds, and rice fields (Prince William Network, 2017).

Priority areas for black-necked stilt in Maryland include Hydrologic Unit Codes (HUC): 0208010905 Lower Nanticoke River, 0206000307 Black River-Chesapeake Bay, 0206000505 Lower Choptank River, 0208011002 Blackwater River, and 0208011005 Upper Tangier Sound.

Willet (*Tringa semipalmata*)

Willets (*Tringa semipalmata*) are large shorebirds with grey-brown plumage and a long, thick, grey bill. They have a white rump, eyebrow, and wing stripe that is visible in flight. Willets also have long grey legs and slightly webbed toes. Plumage is similar for both sexes, but females are slightly larger. The eastern subspecies, the willets that can be seen in the Chesapeake Bay, are slightly smaller and darker than their western cousins (Ellison, 2010).

In the Chesapeake Bay, willets are commonly found on beaches, mudflats, and tidal salt marshes. Willets primarily breed in high marsh areas dominated by saltmeadow hay (*Spartina patens*) and in coastal dune areas dominated by beach grass (*Ammophila breviligulata*). Willets migrate south to winter on mudflats and beaches in northern South America. While willets are usually solitary, they may gather in flocks to migrate and roost (Ellison, 2010).

Willets feed by probing with their bills into mud and sand flats, searching for a wide variety of invertebrates. They eat insects, crustaceans, mollusks, worms, grasses, seeds, and occasionally fish. Aside from probing in the sand, willets also hunt by walking through shallow water and holding their bills open under the surface (Ellison, 2010).

Willets breed from May to July. They are monogamous each season, and males will even reunite with their previous mate if he can find her at their breeding grounds. To attract females, the males will fly with their wings high above their heads and use their "pill-will-willet" call. Females fly beneath them and sing back, before the pair flies to the ground together. Once a pair has formed, the willets stop displaying, mate, and search for a nest site together. Nests are simple scrapes in the grass. Females lay three to four eggs over the course of 6 days. Both parents incubate the eggs for slightly less than a month. Within hours of hatching, willet chicks are able to walk and feed themselves, and can fly within 4 weeks. Like many other shorebirds, the male, rather than the female, stays with the chicks longer (Ellison, 2010).

There is no current conservation status for willets within the Chesapeake Bay region, as they have had no significant declines in population recently. However, habitat degradation in willets' breeding, wintering, and migration areas may put this species at risk (Ellison, 2010).

Priority areas for willet in Maryland include Hydrologic Unit Codes (HUC): 0208010905 Lower Nanticoke River, 0208011003 Wicomico River, 0206000504 Little Choptank River, 0206000505 Lower Choptank River, 0206000506 Honga River-Chesapeake Bay, 0208011002 Blackwater River, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, 0208011006 Lower Tangier Sound, 0208011105 Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Landscape Conservation - Black Duck Joint Venture
Established in 1989, the Black Duck Joint Venture (BDJV) is an international, partnership-based conservation program comprised of federal, state, and provincial wildlife management agencies in the United States and Canada, as well as related non-governmental organizations. As the first species joint venture under the North American Waterfowl Management Plan (NAWMP), the BDJV seeks to implement and coordinate a cooperative population monitoring, research, and communications program to provide information required to manage American black ducks (*Anas rubripes*) and restore numbers to the NAWMP goal of 640,000 breeding birds in the original breeding ground survey area (BDJV, 2017).

Priority areas for American black duck in Maryland include Hydrologic Unit Codes (HUC): 0206000203 Sassafras River, 0206000204 Chester River, 0208010904 Upper Nanticoke River, 0208010905 Lower Nanticoke River, 0208011003 Wicomico River, 0206000205 Upper Chesapeake Bay, 0206000506 Honga River-Chesapeake Bay, 0206000605 Middle Patuxent River, 0206000606 Lower Patuxent River, 0208011001- Transquaking River, 0208011002-Blackwater River, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, 0207001008 Occoquan River-Potomac River, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0208011006 Lower Tangier Sound, 0208011104 Pitts Creek-Potomac River, 0208011105 Marumsco Creek-Pocomoke Sound, and 0208011107 Deep Creek-Pocomoke Sound.

Landscape Conservation - Sea Duck Joint Venture
The Sea Duck Joint Venture (SDJV), officially endorsed by the NAWMP in 1998, works to ensure that sea duck populations are maintained at sustainable levels throughout their ranges. To do so, the SDJV promotes the conservation of all North American sea ducks through partnerships by providing greater knowledge and understanding for effective management (Sea Duck Joint Venture, 2017). Since the Joint Venture was endorsed, it has supported efforts to understand what habitats are most important for them. Today, emphasis is on obtaining information that will help ensure that harvest is sustainable and inform habitat conservation actions (Sea Duck Joint Venture, 2017).

There are 15 species of sea ducks as follows: common eider *(Somateria mollissima*), king eider (*Somateria spectabilis*), spectacled eider (*Somateria fischeri*), Steller's eider (*Polysticta stelleri*), black scoter (*Melanitta americana*), white-winged scoter (*Melanitta fusca*), surf scoter (*Melanitta perspicillata*), Barrow's goldeneye (*Bucephala islandica*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), long-tailed duck (oldsquaw) (*Clangula hyemalis*), harlequin duck (*Histrionicus histrionicus*), common merganser (*Mergus merganser*), red-breasted merganser (*Mergus serrator*), hooded merganser (Lophodytes cucullatus). Of the sea duck species, surf scoter, black scoter, white-winged scoter, long-tailed duck, and common eider are species of highest importance (Sea Duck Joint Venture, 2017).

Maryland sea duck priority areas were determined based on the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office's 2011 to 2016 Strategic Plan. The Strategic Plan indicates the priority areas to be the Lower Rappahannock, Chesapeake Oyster Reef, and Chesapeake Bay Islands focus areas (USFWS, CBFO 2011).

Priority areas for sea ducks in Maryland include Hydrologic Unit Codes (HUC): 0206000204 Chester River, 0208010905 Lower Nanticoke River, 0206000100 Upper Chesapeake Bay, 0206000205 Upper Chesapeake Bay, 0206000206 Eastern Bay, 0206000401 Magothy River-Chesapeake Bay, 0206000404 Herring Bay-Chesapeake Bay, 0206000501 Tuckahoe Creek, 0206000504 Little Choptank River, 0206000505 Lower Choptank River, 0206000605 Middle Patuxent River, 0206000606 Lower Patuxent River, 0207001105 Wicomico River, 0207001107 Saint Clements Bay-Potomac River, 0207001109 Saint Marys River, 0208011004 Manokin River, 0208010100 Lower Chesapeake Bay, and 0208010201 Great Wicomico River-Lower Chesapeake Bay.

Landscape Conservation - Eastern Brook Trout Joint Venture
The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and federal agencies, regional and local governments, businesses, conservation organizations, academia, scientific societies, and private citizens (TU, 2017). The EBTJV is dedicated to protecting, restoring, and enhancing aquatic habitat within the eastern brook trout's (*Salvelinus fontinalis*) range, and is modeled after the joint ventures created in support of the North American Waterfowl Management Plan. Working at a variety of geographic and jurisdictional scales, the EBTJV works within a non-regulatory framework to secure adoption of policies that support protection of aquatic habitats and accomplish measurable conservation gains. The EBTJV seeks to secure populations of wild brook trout, aid in the restoration of watershed integrity, protect water quality, and enhance human connections to and stewardship of our natural environment through collaboration among its partners (TU, 2017).

Maryland Brook Trout priority 10-digit HUCs were determined with assistance from Trout Unlimited. Trout Unlimited advised areas currently considered strongholds for brook trout and areas that have persistent populations adjacent to strongholds should be prioritized. Trout Unlimited's Eastern Brook Trout Conservation Portfolio, Range-wide Assessment, and Focal Area Tools were used to determine strongholds and persistent populations.

Priority areas for brook trout in Maryland include Hydrologic Unit Codes (HUC): 0207000201 Savage River, 0207000203 Georges Creek, 0207000205 Wills Creek, 0207000406 West Branch Conococheague Creek, 0207000408 Conococheague Creek, 0207000410 Antietam Creek, 0207000106 Lower South Branch Potomac River, 0207000202 Stony River-North Branch Potomac River, 0207000204 New Creek-North Branch Potomac River, and 0207000308 Long Hollow Run-Potomac River.

Landscape Conservation - Pollinator Initiative
Pollinators are a diverse group of animals and insects (including bees, butterflies, birds, and moths) that assist in the reproductive success of nearly 75 percent of the world's crop species and flowering plants (Xerces Society, 2015). When pollinators are near and eating from flowering plants, they pick up pollen and transport it to other plants, facilitating floral

reproduction. In the United States, native pollinators are vital to food security and are estimated to add a $3 billion per year to the economy in ecological services (Xerces Society, 2015). Wild pollinator populations, though, are in decline worldwide due to stressors like habitat loss, pesticide use, and introduction of disease. A Federal Interagency Task Force was assigned the job of creating a plan to combat population loss and to promote overall pollinator health. The Task Force's plan includes three overarching goals: reduce honey bee (*Apis mellifera*) losses to economically sustainable levels; increase monarch butterfly (*Danaus plexippus*) numbers to protect the annual migration; and restore or enhance millions of acres of land for pollinators through combined public and private action (Holdren, 2015).

Restoring a degraded habitat or planting an open patch of land with native plants will provide habitat and forage for pollinators as well as other native wildlife as to reestablish wild populations in line with federal goals. Native wildflowers, in particular, are attractive to pollinators, provide the nectar that pollinators eat, and some even boast vital relationships with specific pollinators. For example, the monarch butterfly's only apparent larval host plant is milkweed, its success contingent on the health and abundance of the native wildflower (Xerces Society, 2016). Native grasses and wildflowers are adapted both to an area's climate conditions and to better serve the specific needs of native wildlife than are nonnative plants.

Because native plants tend to thrive well together, they stave off invasions of nonnative and invasive plants, limiting the need for pesticide and herbicide use (Xerces Society, 2013). In addition to these services, native plants stabilize soil, store carbon, and help to reduce runoff. They do not normally require the use of fertilizer and do not need constant maintenance in the form of watering and mowing, proving to be generally low maintenance and less costly in their long term management. HUCS were not assigned to Pollinator Initiative as this is prioritized throughout the entire State.

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia. Work to assess road-stream crossings has been focused on streams and rivers where roads are fragmenting habitat of alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), brook trout (*Salvelinus fontinalis*), and imperiled freshwater mussels including the endangered dwarf wedgemussel (*Alasmidonta heterodon*). Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcontinuity.org (NAACC, 2017). There is also an effort to remove low head dams. HUCS were not assigned to Aquatic Connectivity as this is prioritized throughout the entire State.

At-Risk Species

Kenk's Amphipod (*Stygobromus kenki*)

There are an estimated 1,870 amphipod species and subspecies recognized from fresh or inland waters constituting 20 percent of the total amphipod diversity. These amphipods often play critical roles in aquatic food webs acting as a source of nutrients and energy to higher trophic levels (Vainola et al., 2008). The genus Stygobromus is made up of some of these inland species, which tend to occur in caves or areas where there are permanent groundwater habitats that contain lower levels of organic matter such as decomposing leaf litter and dead insects (Center for Biological Diversity, 2014). Members of this genus include Hay's spring amphipod (*Stygobromus hayi*), listed as federally endangered in 1982 (USFWS, 1982b), and Kenk's amphipod (*Stygobromus kenki*), proposed for federal listing of endangered.

Kenk's amphipod is a small, eyeless, unpigmented crustacean that grows no larger than a quarter of an inch in size (3.7-5.5 millimeters for the largest male and female specimens). Kenk's amphipod is closely related to Hay's spring amphipod, but can be differentiated morphologically by their appendages (USFWS, 2016b). Little is known of the amphipod species, but like Hay's spring amphipod, Kenk's amphipod lives underground deep within the cracks and crevasses of small freshwater springs and can sometimes be found in the fine soils or dead leaves within those springs USFWS, 2016b) The habitat is described as hypotelminorheic with a perched aquifer fed by subsurface water that creates a persistent wet spot and is underlain by clay or other impermeable layer typically 5 to 50 centimeters below the surface and is rich in organic matter compared with other aquatic subterranean habitats (USFWS, 2016b).

Kenk's amphipod has been found in a number of places along Rock Creek and its tributaries inhabiting springs that are generally in forested areas along steep slopes (Culver, 2014). Within Maryland and the District of Columbia, ideal springs have been located in areas overlying the Wissahickon geologic formation within the Piedmont physiographic region. Populations have also been found in Virginia at Fort A. P. Hill where the amphipod has been known to occur in the Calvert formation just above the Nanjemoy geologic formation in the upper Coastal Plain (USFWS, 2016b). These geologic characteristics lead to the formation of the shallow groundwater springs where Kenk's amphipod lives and feeds on decomposing leaf litter and dead insects (Center for Biological Diversity, 2014).

Because of their limited range, habitat loss and degradation pose immediate danger to Kenk's amphipod. The groundwater-fed springs where they live are greatly impacted by alterations of groundwater flows and pollution within the watershed (Center for Biological Diversity, 2014). Kenk's amphipod requires good water quality to persist and is very sensitive to pollutants from urban development or agricultural practices. Some of the main threats include sewer leaks and pesticides within the watershed (USFWS, 2016b).

Priority areas for Kenk's amphipod in Maryland include Hydrologic Unit Codes (HUC) 0207001002 Anacostia River and 0207001001 Rock Creek-Potomac River.

Bald Eagle (*Haliaeetus leucocephalus*)
The bald eagle (*Haliaeetus leucocephalus*) is a species found throughout the United States usually occupying habitats close to large water bodies where they primarily forage for fish. Bald eagles nest in mature trees within a half mile of their foraging areas preferring to nest in the tallest canopy tree or along an open forest edge. Eagle nest sites and communal roost areas

require natural protection buffers to avoid being disturbed from commercial and residential development and other associated human activities. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA) from a variety of human induced conditions and activities.

In 2007, the Service removed the species from the list of threatened and endangered species, created National Bald Eagle Management Guidelines, and promulgated new rules under BGEPA (in 2012) to permit incidental take of eagles during activities of otherwise, lawful projects.

The guidelines advise landowners and land managers with measures on how to avoid and minimize disturbance to nesting eagles on private and federal lands. A variety of human actions can potentially interfere with bald eagles, affecting their ability to forage, nest, roost, breed, or successfully raise young. The guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute “disturbance,” which is prohibited by the BGEPA. All bald eagle nest trees including the 660-foot concentric circular forest buffer surrounding the nest, are federally protected and therefore considered as areas restricted from development unless authorized by issuance of a BGEPA Permit. Proposed projects in the Chesapeake Bay watershed region must consider the protection standards for bald eagles which includes: time-of-year restriction from activities (December-June); habitat/nest protection buffers (330-foot and 660-foot zones); and Important High Eagle Use Areas (communal roosts/concentration areas).

Priority areas for bald eagle in Maryland include Hydrologic Unit Codes (HUC): 0206000203 Sassafras River, 0208010905 Lower Nanticoke River, 0206000202 Elk River, 0206000301 Winters Run-Bush River, 0206000302 Romney Creek-Chesapeake Bay, 0206000306 Gunpowder River-Chesapeake Bay, 0205030617 Susquehanna River, 0206000201 North East River-Upper Chesapeake Bay, 0207000411 Rocky Marsh Run-Potomac River, 0207001008 Occoquan River-Potomac River, 0207001101 Quantico Creek-Potomac River, 0207001102 Potomac Creek-Potomac River, 0207001103 Nanjemoy Creek-Potomac River, 0208011103 Dividing Creek-Potomac River, 0208011104 Pitts Creek-Potomac River, 0208011105 Marumsco Creek-Pocomoke Sound, 0207000703 Bullskin Run-Shenandoah River, 0207000106 Lower South Branch Potomac River, and 0207000202 Stony River-North Branch Potomac River.

Saltmarsh Sparrow (*Ammodramus caudacutus*)

The saltmarsh sparrow (*Ammodramus caudacutus*) is an obligate tidal-marsh specialist, and as such, is unique among passerines in North America and elsewhere. It chiefly breeds in dense, supratidal *Spartina patens–Juncus* salt meadows, but in some marshes, it readily uses smooth cordgrass (*Spartina alterniflora*) in the upper intertidal, which it often shares with its close relative, the seaside sparrow (*A. maritimus*), in more southern areas. Its breeding range is narrowly linear along the north-central Atlantic Coast of the United States, in localized and discontinuous populations, where it extends from coastal Maine, south to Chesapeake Bay and the Delmarva Peninsula (Greenlaw and Rising, 1994).

Within the Chesapeake Bay, the extensive saltmarshes of the lower Delmarva Peninsula counties (Dorchester, Wicomico, and Somerset in MD; Accomack and Northampton in VA) are the species last strongholds within the Bay. The saltmarsh systems located in the western shore counties of Virginia that include Northumberland, Gloucester, Mathews, and Middlesex also provide high quality breeding habit for the species. Periodic tidal flooding in many, perhaps most, salt marshes is the chief source of nest mortality in this species. Selection arising from such events has molded several adaptations that mitigate flooding risk, including nest placement, nest-repair and egg retrieval behaviors, and rapid post-flood renesting. Flooding of vulnerable nests early in the breeding season often results in synchronization of subsequent nests to a tidal cycle in marshes subject to a monthly pattern of a single highest (spring) tide.

This species is a ground feeder that forages in dense wet grasses, wrack, and the edges of saltmarsh pools. For the most part their diet is comprised mostly of insects and other small invertebrates. During the fall migrations, grass seeds become an important part of their diet (Greenlaw and Rising, 1994; Ellison, 2010).

Priority areas for saltmarsh sparrow in Maryland include Hydrologic Unit Codes (HUC): 0208010905 Lower Nanticoke River, 0206000506 Honga River-Chesapeake Bay, 0208011001-Transquaking River, 0208011002 Blackwater River, 0208011005 Upper Tangier Sound, and 0208011105 Marumsco Creek-Pocomoke Sound.

Seaside Sparrow (*Ammodramus maritimus)*

The seaside sparrow (*Ammodramus maritimus)* is a relatively common species found within its limited range in the Chesapeake Bay. Similar to its close relative, the saltmarsh sparrow, the seaside sparrow is a tidal-marsh specialist found only in small localized populations (Post and Greenlaw, 2009). Within the Chesapeake Bay, the extensive tidal saltmarshes of the lower Delmarva Peninsula counties (Dorchester, Wicomico, and Somerset in MD; Accomack and Northampton in VA) provide high quality nesting habitat for the species, as does Tangier Island. The saltmarsh systems located in the western shore counties of Virginia which include Northumberland, Gloucester, Mathews, and Middlesex also provide high quality breeding habit for the species. Contraction of the species range within the Chesapeake Bay in has been associated with habitat degradation and loss (Ellison 2010).

The primary nesting habitat is at the summer high tide mark within saltmarshes, nesting close to the ground, typically in a clump of smooth cordgrass (*Spartina alterniflora*) or black needle rush (*Juncus roemerianus*). Periodic tidal flooding in many, perhaps most, salt marshes is the chief source of nest mortality in this species in our region. This species is a ground feeder that prefers to feed in open areas of vegetation and mud where it forages mostly for insects and other small invertebrates (Ellison, 2010; Post and Greenlaw, 2009). During the winter, when invertebrates are less available, seeds make up a good portion of their. Most seaside sparrows within the Chesapeake Bay typically migrate to saltmarsh systems located south of the Bay, returning in April to breed; however, a few individuals do over winter, mixing in with migrants from the north (Ellison, 2010).

Priority areas for seaside sparrow in Maryland include Hydrologic Unit Codes (HUC): 0208010905 Lower Nanticoke River, 0208011003 Wicomico River, 0206000506 Honga River-Chesapeake Bay, 0208011001 Transquaking River, 0208011002 Blackwater River, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, 0208011006 Lower Tangier Sound, and 0208011105 Marumsco Creek-Pocomoke Sound.

Colonial Nesting Waterbirds

In this document, colonial waterbirds refers to species such as terns, herons, egrets, cormorants, gulls, and pelicans which nest in dense colonies ranging from small numbers of single-species pairs to many thousands in mixed species colonies. The major stressor on the success of colonial nesting waterbirds in Maryland is sea level rise coupled with glacial subsidence.

Sea level rise and glacial subsidence is rapidly causing colonial nesting waterbirds habitat in the Chesapeake Bay to disappear. Geologic evidence indicates that for the past 2,000 years up to the late 1800s or early 1900s the sea level was rising slowly at rates less than 1 millimeter/year (mm/yr) (Kemp et al., 2011). Since that time the sea level has been rising at an increasing rate. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2013), reviews the history of sea level rise and makes projections out to the end of this century. Between 1901 and 2010, the mean rate of globally averaged sea level rise (also termed the eustatic rate) was 1.7 mm/yr. However, toward the end of that period, between 1993 and 2010, the rate of sea level rise accelerated to 3.2 mm/yr. Global sea level rise is a result of thermal expansion of the oceans and melting of glaciers and ice sheets induced by atmospheric warming. The IPCC predicts that global mean sea level will continue to rise at an increasing rate during the 21st century. The amount of rise will vary depending on number of factors such as the amount of greenhouse gas emissions. However, the IPCC has “medium confidence” that the rise by 2100 relative to 1986 to 2005 would be in the range of 0.52 to 0.98 meters (m), with a rate of 8 to 16 mm/yr during 2081 to 2100. The current prediction is more than 50 percent higher than the prediction that the IPCC made in their Fourth Assessment Report in 2007, mostly due to inclusion of a larger contribution from ice sheet melting. Ongoing Glacial Isostatic Adjustment (GIA) or subsidence adds to the threat of sea level rise. Boon et al., 2010 suggests that this rate will add another 0.16 m of sea level rise to the Maryland portion of the Chesapeake Bay by 2100. The net effect of sea level rise and subsidence is that the low lying islands used by colonial waterbirds for nesting is rapidly disappearing. Below is a summary of the priority species in Maryland’s Chesapeake Bay and the habitats they use.

Terns

Terns are seabirds in the family Sternidae that have a worldwide distribution and are normally found near the sea, rivers, or wetlands. They are slender, lightly built birds with long, forked tails, narrow wings, long bills, and relatively short legs. Most species are pale grey above and white below, with a contrasting black cap to the head. From late April to August, terns use barren to sparsely vegetated sandbars along shorelines for nesting. Terns feed in a variety of ways, including capture of prey while in-flight or by diving to the water’s surface. Prey items include small fish, shrimp, and insects. Pairs generally occupy and defend a feeding territory which may be more than 20 km away from the breeding colony. Terns are colonial breeders that often associate with gulls or other tern species. Nests are simple depressions in the sand or shallow cups of dead grass formed on beaches or open rocky areas. Typical clutch size is two to three eggs. One study found that 90 percent of terns observed had returned to the territory occupied the previous year. While many tern species forage in the Bay during migration, only the common tern (*Sterna hirundo*), Forester's tern (*Sterna forsteri*), and least tern (*Sternula antillarum*) nest in the Maryland portion of the Bay. These terns are found at only two sites. The first site is the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island. The second site is an abandoned barge in the Patapsco River near the Masonville Cove mitigation site. Both of these projects are habitat enhancement projects that have been designed to enhance and promote wildlife (USFWS, 2008, USFWS 2013b). In addition to Poplar Island and Masonville Cove in the Patapsco River, other priority areas for terns include the outer islands in Dorchester County and Somerset County from Tangier Sound to the Choptank River (MDDNR, 2013).

Priority areas for terns in Maryland include Hydrologic Unit Codes (HUC): 0206000312 Patapsco River-Chesapeake Bay, 0206000505 Lower Choptank River, 0206000506 Honga River-Chesapeake Bay, 0208011004 Manokin River, 0208011005 Upper Tangier Sound, and 0208011006 Lower Tangier Sound.

Black Skimmer

The black skimmer (*Rynchops niger*) is the only American representative of the skimmer family Rynchopidae. The bill of the black skimmer sets it apart from all other American birds. The large red and black bill is knife-thin and the lower mandible is longer than the upper. The bird drags the lower bill through the water as it flies along, hoping to catch small fish. Although the black skimmer is active throughout the day, it is largely crepuscular (active in the dawn and dusk) and even nocturnal. Its use of touch to catch fish lets it be successful in low light or darkness. Black skimmers historically nested in Dorchester and Somerset County with the last known nesting colony occurring in 2012. Priority areas are in the outer islands Dorchester County and Somerset County from Tangier Sound to the Choptank River (MDDNR, 2013).

Priority areas for black skimmer in Maryland include Hydrologic Unit Codes (HUC) 0206000506 Honga River-Chesapeake Bay and 0208011005 Upper Tangier Sound.

Herons and Egrets

Great blue heron (*Ardea herodias*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violacea*), tricolor heron (*Egretta tricolor*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*) great egret (*Ardea alba*), green heron (*Butorides virescens*) cattle egret (*Bubulcus ibis*), and glossy ibis (*Plegadis falcinellus*) can all be found nesting in single species colonies or mixed heronry throughout the Chesapeake Bay in Maryland. Herons nest in trees or shrubs close to waterways. They are all primarily fish eaters, but will also eat invertebrates, benthic organisms, reptiles and amphibians. Great blue herons rookeries are found abundantly throughout the Bay watershed, many of the other species are found sporadically around the watershed with the highest densities of rookeries occurring on upland hummocks within islands that are relatively free of human intervention or predators

(USFWS 2008, USFWS 2013b). Priority areas for herons and egrets are Poplar Island and the outer islands in Dorchester County and Somerset County from Tangier Sound to the Choptank River (MDDNR, 2013).

Priority areas for herons and egrets in Maryland include Hydrologic Unit Codes (HUC): 0206000505 Lower Choptank River, 0206000506 Honga River-Chesapeake Bay, 0208011005 Upper Tangier Sound, and 0208011006 Lower Tangier Sound.

Brown Pelican

Brown pelicans (*Pelecanus occidentalis*) are huge, stocky seabirds. They have thin necks and very long bills with a throat pouch used for capturing fish. Their wings are very long and broad and are often noticeably bowed when the birds are gliding. Adult brown pelicans are gray-brown birds with yellow heads and white necks. In breeding plumage, the back and sides of the neck turn a rich, dark reddish-brown. Immature brown pelicans are gray-brown above (including the head and neck) with pale whitish belly and breast. Brown pelicans feed by plunging into the water, stunning small fish with the impact of their large bodies and scooping them up in their expandable throat pouches. When not foraging, pelicans stand around fishing docks, jetties, and beaches or cruise the shoreline. In flight, lines of pelicans glide on their broad wings, often surfing updrafts along wave faces or cliffs. Their wing beats are slow, deep, and powerful. Pelicans nest in colonies, often on isolated islands free of land predators. They are typically found in the Tangier Sound Islands in the Maryland portion of the Chesapeake Bay with the largest colony on Smith Island (MDDNR, 2013).

Priority areas for brown pelican in Maryland include Hydrologic Unit Codes (HUC) 0208011005 Upper Tangier Sound and 0208011006 Lower Tangier Sound.

Gulls and Double-Crested Cormorant

Gulls (Family Laridae) and double-crested cormorant (*Phalacrocorax auritus*) are common colonial nesting waterbirds throughout the Maryland portion of the Chesapeake watershed, and are often thought of as nuisance species because of their abundance and ability to adapt to the human environment. Nesting cormorants compete with other priority colonial nesting birds and displace them. In addition, concentrated guano kills vegetation and exacerbates island erosion.

Herring and Shad (*Alosa sp.*)

Herring and shad (*Alosa sp.*) are anadromous, pelagic, highly migratory, schooling species (Colette and Klein-MacPhee, 2002). American shad (*Alosa sapidissima*) spend most of their lives in marine waters, with adults migrating into coastal rivers and tributaries to spawn (Greene et al., 2009). On average, American shad spend 4 to 5 years at sea, and some individuals from the southernmost range may travel over 20,000 km during this time period (Dadswell et al., 1987). Researchers believe that the historical spawning range of American shad included all accessible rivers and tributaries along the Atlantic Coast (MacKenzie et al., 1985). Over the past 170 years, declines in American shad stocks have been attributed to overfishing, pollution, and habitat loss due to dams, upland development, and other factors (Limburg et al., 2003).

The American shad population drastically declined when in 1928, a large hydroelectric dam was built in the lower Susquehanna River, near the Town of Conowingo, Maryland. Specifically, declines in Susquehanna River shad can be attributed to poor efficiency of fish passage measures and facilities; low hatchery production in recent years; low numbers of spawning fish accessing quality upstream habitat; poor young-of-year recruitment upstream of Conowingo Dam; excessive ocean fishery mortality; and potentially high predation mortality (SRAFRC, 2010). In more recent decades, overharvest by commercial fishing industry are also contributing factors. The shad cohort includes American shad, blueback herring (*Alosa aestivalis*), hickory shad (*Alosa mediocris*), and alewife (*Alosa psuedoharengus*).

Priority areas for American shad, alewife, and blueback herring in Maryland include Hydrologic Unit Codes (HUC) 0205030617 Susquehanna River.

American Eel (*Anguilla rostrata*)
American eels were once abundant in estuaries and freshwater tributaries in much of the eastern United States and Canada (Eyler, 2014). American eels spawn in the Sargasso Sea, where newly-hatched larvae (leptocephali) begin their migration to coastal streams where they transform and move upstream, some travelling thousands of kilometers. Because they are migratory, they inhabit multiple habitats at different times during their lives.

The American eel population drastically declined when in 1928, a large hydroelectric dam was built in the lower Susquehanna River, near the Town of Conowingo, Maryland. Once completed, eels were no longer able to migrate upstream (SRAFRC, 2010). The dam was later retrofitted with a fish lift and can pass American shad and other anadromous fish however it is not able to pass migrating eels (SRAFRC, 2010).

The Service has been stocking eels from 2008 to 2016 in the Susquehanna River and transferring eels over dams in an effort to increase the population of eels in the upper watershed. A third party began managing this effort in 2017, with oversight from the Service (Mangold 2017 personal communication).

Priority areas for American eel in Maryland include Hydrologic Unit Codes (HUC): 0207000810 Difficult Run-Potomac River, 0207000201 Savage River, 0205030617 Susquehanna River, 0207000411 Rocky Marsh Run-Potomac River, 0207000202 Stony River-North Branch Potomac River, and 0207000204 New Creek-North Branch Potomac River.

Coastal Resiliency
The U.S. Fish and Wildlife Service received $65 million in recovery funding and $102 million in resilience funding from the Department of the Interior through the Disaster Relief Appropriations Act of 2013 (Hurricane Sandy), for a total of more than 70 proposed projects in the Northeast. In the Maryland portion of the Chesapeake Bay, funds were used to restore habitat in the Nanticoke River basin, along Fog Point at Glenn Martin National Wildlife Refuge, and along Hail Cove at Eastern Neck National Wildlife Refuge. The Service's priorities for

Maryland Chesapeake Bay are Eastern Bay near Poplar Island; Chester River near Eastern Bay; Tangier Sound and the Islands of the Chesapeake Marshlands National Wildlife Refuge; the Nanticoke River; the Pocomoke River; and the Patuxent River below the Patuxent Research Refuge (USFWS, 2017c).

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Chapter 3. Delaware

Delaware's portion of the Chesapeake Bay watershed includes headwater areas and contains 702 square miles or about 1 percent of the 64,000-acre Chesapeake Bay watershed. Almost 140,000 residents (16 percent) of the Delaware total population of 885,000—live in the Chesapeake watershed. More than 41,800 people (11 percent) of Delaware’s total employment work in the Delaware portion of the watershed (University of Delaware, 2017).

REFUGES

There are no National Wildlife Refuges in the Delaware portion of the Chesapeake Bay.

ENDANGERED SPECIES

There are three threatened and endangered species in the Delaware portion of the Chesapeake Bay watershed. This section describes the life history and identifies the major stressor(s) that adversely affect these species. The section identifies two categories of threatened and endangered species for Delaware, those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats.

Non-Aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they should be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Northern Long-Eared Bat (*Myotis septentrionalis*)

The northern long-eared bat (*Myotis septentrionalis*), listed as federally threatened in 2015 (USFWS, 2016a), is a medium-size bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (WDNR, 2013). The distribution range of the northern long-eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and the U.S. from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increased agricultural and household pesticide use, and hibernaculum disturbance (WDNR, 2013). Although the northern long-eared bat occurs in Delaware, there are no specific priority HUCs identified.

Aquatic Threatened and Endangered Species

Aquatic threatened and endangered species listed below are species that have some or all of their life history tied directly to the aquatic systems.

Small Whorled Pogonia (*Isotria medeoloides*)
Listed as federally endangered in 1982 (UFWS, 1982) and reclassified as threatened in 1994 (USFWS, 1994), the small whorled pogonia (*Isotria medeoloides*), is one species greatly affected by habitat destruction.

The small whorled pogonia is a perennial member of the Orchidaceae family and has slender, hairy, fibrous roots that radiate from the crown or rootstock (USFWS, 1992). It is characterized by a whorl of five or six leaves at the top of a glabrous, pale-green, hollow stem and a single yellowish-green flower, occasionally two, that may bloom form the center of the leaf whorl (Sperduto and Congalton, 1996). The small whorled pogonia has four different states: vegetative, with an abortive flower bud, flowering, or dormant. Although insect pollination may take place, the species is primarily self-pollinating (USFWS, 1992).

Habitat for the small whorled pogonia is in mixed deciduous or mixed deciduous/coniferous forests with common herbs, ferns, and occasionally other orchids (Sperduto and Congalton, 1996). Preferred habitats are forests in second or third growth successional stages (USFWS, 1992). Populations are very isolated and typically very small, being made up of less than 20 plants, although some have been found to contain close to 100 plants (Mehrhoff, 1989). The small whorled pogonia can be found in Maine and Ontario in the northern portion of its range, west to Michigan, Illinois, and Missouri, and south along the eastern seaboard to Georgia (Massachusetts Natural Heritage and Endangered Species Program, 2015).

The two main threats for the small whorled pogonia are habitat destruction and collection. This destruction is primarily a result of residential and commercial development. These activities directly destroy habitat and indirectly destroy habitat through the construction of roads, powerlines, and sewer mains as well as forming barriers to seed dispersal. Heavy timbering and clear-cutting also threatens populations (USFWS, 1992). The small whorled pogonia requires very specific habitat to persist and these anthropogenic activities are significantly reducing the amount of suitable habitat available (Massachusetts Natural Heritage and Endangered Species Program, 2015).

Priority areas for small whorled pogonia in Delaware include Hydrologic Unit Code (HUC) 0206000204 Chester River.

Bog Turtle (*Glyptemys muhlenbergii*)
The bog turtle (*Glyptemys muhlenbergii*) was listed as federally threatened in 1997 (USFWS, 1997). The bog turtle is one of North America's smallest turtles with New England specimens measuring less than 100 mm in carapace length and specimens from more southern populations reaching sizes up to 115 mm in carapace length (USFWS, 2001). The turtles are dark in color and have large yellow to orange markings on both sides of the head. The markings on juveniles and hatchlings are lighter, whereas older adults have more intense color blotches (NRCS, 2006). The carapace is usually black or brown, somewhat domed, and has a slight mid-dorsal keel (Pennsylvania Fish and Boat Commission, 2011). The carapace may be marked with yellowish rays of color, and the plastron is usually black with varying amounts of white or pale

yellow patches (NRCS, 2006). Bog turtles in the northern populations typically emerge from hibernation in late March through April and return to hibernacula in October. Breeding occurs from late April to early June and nesting occurs 21 to 31 days after copulation. Hatchlings then emerge from mid-August to September and overwinter at or near the nest site (Pennsylvania Fish and Boat Commission, 2011).

Bog turtles typically inhabit shallow wetland habitats such as sphagnum bogs, marshes, and wet meadows (Chase et al., 1989). These wetland habitats are seepages or spring-fed emergent freshwater wetlands, are associated with streams, and are bordered by wooded areas. The wetlands generally have a variety of microhabitats for the bog turtles to use for foraging, nesting, basking, hibernation, shelter, and other needs (NRCS, 2006). Populations of bog turtles can be found in New York, Massachusetts, Connecticut, New Jersey, Pennsylvania, Delaware, and Maryland with some populations located further to the south in Virginia, North Carolina, South Carolina, Tennessee, and Georgia (USFWS, 2001).

Bog turtles are very sensitive to changes in habitat and have declined greatly due to habitat degradation and loss from activities such as filling, fragmentation, and drainage (NRCS, 2006). The creation of farm ponds, reservoirs, and other impoundments inundate the shallow, open wet meadows and fens required for bog turtles. Because bog turtles are sustained by groundwater regimes, they are particularly sensitive to changes in subsurface water supplies. Construction and development has the ability to alter subsurface flow as well as drilling under wetlands, which can fracture bedrock and significantly impact small wetland systems (USFWS, 2001).

HUCs for bog turtle were not included in this report as the information was deemed too sensitive and would risk the species recovery. One of the greatest threats to bog turtle recovery is collection of the species. Providing the HUC locations would allow collectors to know where bog turtles are currently located. Bog turtle must be coordinated with the Service on a project specific basis.

CBRA

There are no CBRA resources in Delaware's portion of the Chesapeake Bay watershed.

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Pollinator Initiative

Pollinators are a diverse group of animals and insects (including bees, butterflies, birds, and moths) that assist in the reproductive success of nearly 75 percent of the world's crop species and flowering plants. In the United States, native pollinators are vital to food security and are estimated to add $3 billion per year to the economy in ecological services (Xerces Society, 2015). Wild pollinator populations, though, are in decline worldwide due to stressors like habitat loss, pesticide use, and introduction of disease in response to this decline. A Federal Interagency Task Force was assigned the job of creating a plan to combat population loss and to promote overall pollinator health. The Task Force's plan includes three overarching goals:

reduce honey bee (*Apis mellifera*) losses to economically sustainable levels; increase monarch butterfly (*Danaus plexippus*) numbers to protect the annual migration; and restore or enhance millions of acres of land for pollinators through combined public and private action (Holdren, 2015).

Restoring degraded habitat or planting open patches of land with native plants provides habitat and forage for pollinators as well as other native wildlife. Native wildflowers are attractive to pollinators, provide the nectar that pollinators eat, and provide vital relationships with specific pollinators. For example, the monarch butterfly's only apparent larval host plant is milkweed (*Asclepias sp*.). The monarch butterfly's success is contingent on the health and abundance of the native wildflower (Xerces Society, 2015). Native grasses and wildflowers are adapted both to an area's climate conditions and serve the specific needs of wildlife (Holdren, 2015). HUCS were not assigned to Pollinator Initiative as this is prioritized throughout the entire State.

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia. Work to assess road-stream crossings has been focused on streams and rivers where roads are fragmenting habitat of alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), brook trout (*Salvelinus fontinalis*), and imperiled freshwater mussels, including the endangered dwarf wedgemussel (*Alasmidonta heterodon*). Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcontinuity.org (NAACC, 2017). There is also an effort to remove low head dams. HUCS were not assigned to Aquatic Connectivity as this is prioritized throughout the entire State.

At-Risk Species

Saltmarsh Sparrow (*Ammodramus caudacutus*)

The saltmarsh sparrow (*Ammodramus caudacutus*) is an obligate tidal-marsh specialist, and as such, is unique among passerines in North America and elsewhere. It chiefly breeds in dense, supratidal *Spartina patens–Juncus romerianus* salt meadows, but in some marshes, it readily uses smooth cordgrass (*Spartina alterniflora*) in the upper intertidal, which it often shares with its close relative, the seaside sparrow (*A. maritimus*), in more southern areas. Its breeding range is narrowly linear along the north-central Atlantic Coast of the United States, in localized and discontinuous populations, where it extends from coastal Maine, south to Chesapeake Bay and the Delmarva Peninsula (Greenlaw and Rising, 1994).

Within the Chesapeake Bay, the extensive saltmarshes of the lower Delmarva Peninsula counties (Dorchester, Wicomico, and Somerset in MD; Accomack and Northampton in VA) are the species last strongholds within the Bay. The saltmarsh systems located in the western shore counties of Virginia that include Northumberland, Gloucester, Mathews, and Middlesex also provide high quality breeding habit for the species. Periodic tidal flooding in many, perhaps most, salt marshes is the chief source of nest mortality in this species. Selection arising from such events has molded several adaptations that mitigate flooding risk, including nest placement, nest-repair and egg retrieval behaviors, and rapid post-flood renesting. Flooding of vulnerable nests early in the breeding season often results in synchronization of subsequent nests to a tidal cycle in marshes subject to a monthly pattern of a single highest (spring) tide.

This species is a ground feeder that forages in dense wet grasses, wrack, and the edges of saltmarsh pools. For the most part their diet is comprised mostly of insects and other small invertebrates. During the fall migrations, grass seeds become an important part of their diet (Greenlaw and Rising, 1994; Ellison, 2010).

Priority areas for saltmarsh sparrow in Delaware include Hydrologic Unit Code (HUC) 0208010905 Lower Nanticoke River.

Seaside Sparrow (*Ammodramus maritimus*)
The seaside sparrow (*Ammodramus maritimus*) is a relatively common species found within its limited range in the Chesapeake Bay. Similar to its close relative, the saltmarsh sparrow, the seaside sparrow is a tidal-marsh specialist found only in small localized populations (Post and Greenlaw, 2009).

Within the Chesapeake Bay, the extensive tidal saltmarshes of the lower Delmarva Peninsula counties (Dorchester, Wicomico, and Somerset in MD; Accomack and Northampton in VA) provide high quality nesting habitat for the species, as does Tangier Island. The saltmarsh systems located in the western shore counties of Virginia which include: Northumberland, Gloucester, Mathews and Middlesex counties, also provide high quality breeding habit for the species. Contraction of the species range within the Chesapeake Bay in has been associated with habitat degradation and loss (Ellison, 2010).

The primary nesting habitat is at the summer high tide mark within saltmarshes, nesting close to the ground, typically in a clump of smooth cordgrass (*Spartina alterniflora*) or black needle rush (*Juncus roemerianus*). Periodic tidal flooding in many, perhaps most, salt marshes is the chief source of nest mortality in this species in our region. This species is a ground feeder that prefers to feed in open areas of vegetation and mud where it forages mostly for insects and other small invertebrates (Ellison, 2010; Post and Greenlaw, 2009). During the winter, when invertebrates are less available, seeds make up a good portion of their diet. Most Seaside sparrows within the Chesapeake Bay typically migrate to saltmarsh systems that are located south of the Bay, returning in April to breed, however, a few individuals do over winter, mixing in with migrants from the north (Ellison, 2010).

Priority areas for seaside sparrow in Delaware include Hydrologic Unit Codes (HUC) 0208010905 Lower Nanticoke River and 0208011003 Wicomico River.

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Chapter 4. Washington D.C.

Washington, D.C., has a geographical area of 68.3 square miles. All the landmass as well as the entire population of 681,171 people is located within the Chesapeake Bay watershed (Census Bureau, 2016). Washington is surrounded by the states of Virginia (on its southwest side) and Maryland (on its southeast, northeast, and northwest sides). It interrupts those states' common border, which is the south shore of the Potomac River both upstream and downstream from the District. The portion of the Potomac River that passes Washington is entirely within the District's border, as the District extends to the south bank.

REFUGES

There are no National Wildlife Refuges in the Washington D.C. portion of the Chesapeake Bay.

ENDANGERED SPECIES

There are two endangered and threatened species in the Washington D.C. portion of the Chesapeake Bay watershed. This section describes the life history and identifies the major stressor(s) that adversely affect these species. The section identifies two categories of threatened and endangered species for Washington D.C., those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats.

Non-Aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they should be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Northern Long-Eared Bat

The northern long-eared bat (*Myotis septentrionalis*), listed as federally threatened in 2015 (USFWS, 2016a), is a medium-size bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (Wisconsin Department of Natural Resources, 2013). The distribution range of the northern long-eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and the U.S. from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). Some of the main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increased agricultural and household pesticide use, and hibernaculum disturbance (Wisconsin Department of Natural Resources, 2013).

Priority areas for northern long-eared bat in the District of Columbia include Hydrologic Unit Codes (HUC): 0207001002 Anacostia River, 0207000810 Difficult Run-Potomac River, and 0207001001 Rock Creek-Potomac River.

Aquatic Threatened and Endangered Species

Aquatic endangered and threatened species listed below are species that have some or all of their life history tied directly to the aquatic systems.

Hay's Spring Amphipod

There are an estimated 1,870 amphipod species and subspecies recognized from fresh or inland waters, constituting 20 percent of the total amphipod diversity. Some of this diversity is comprised of endemic species, meaning the species are restricted to a certain area (Vainola et al., 2008). The Hay's spring amphipod (*Stygobromus hayi*) is one such species, being known to exist in only a few springs in Washington D.C. and Washington County, Maryland (Center for Biological Diversity, 2014). Hay's spring amphipod was listed as endangered by the Service in 1982 (USFWS, 1982).

The Hay's spring amphipod is a small, aquatic crustacean measuring approximately 5-10 millimeters in length with a body shape that resembles that of a tiny shrimp. It is colorless and blind as it lives most of its life underground (Center for Biological Diversity, 2014). Much of the life history of Hay's spring amphipod is unknown, but it is thought to spend its life in a shallow groundwater zone. Portions of the amphipod's life may also be spent within the flooded fractures of metamorphic rock or in the saturated soil above the bedrock, potentially using both underground habitats (Pavek, 2002). Small hairs on the amphipod's body allow it to sense water currents to help it search for food that generally consists of small pieces of leaf litter and dead insects within the shallow groundwater zone (Center for Biological Diversity, 2014).

The Hay's spring amphipod is only known in Rock Creek Park and a single spring in the National Zoological Park, both heavily used recreational areas and surrounded by urbanization (USFWS, 2007). This narrow distribution and specialized habitat is especially vulnerable to groundwater pollution from the surrounding urbanized areas. Toxic spills, sewer leaks, and storm water flows may adversely affect groundwater and degrade amphipod habitat (Pavek, 2002).

Priority areas for Hay's spring amphipod in the District of Columbia include Hydrologic Unit Codes (HUC) 0207001001 Rock Creek-Potomac River.

CBRA

There are no CBRA resources in Washington D.C.

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Pollinator Initiative

Pollinators are a diverse group of animals and insects (including bees, butterflies, birds, and moths) that assist in the reproductive success of nearly 75 percent of the world's crop species and flowering plants. In the United States, native pollinators are vital to food security and are estimated to add $3 billion per year to the economy in ecological services (Xerces Society, 2015). Wild pollinator populations, though, are in decline worldwide due to stressors like habitat loss, pesticide use, and introduction of disease in response to this decline. A Federal Interagency Task Force was assigned the job of creating a plan to combat population loss and to promote overall pollinator health. The Task Force's plan includes three overarching goals: reduce honey bee (*Apis mellifera*) losses to economically sustainable levels; increase monarch butterfly (*Danaus plexippus*) numbers to protect the annual migration; and restore or enhance millions of acres of land for pollinators through combined public and private action (Holdren, 2015).

Restoring degraded habitat or planting open patches of land with native plants provides habitat and forage for pollinators as well as other native wildlife. Native wildflowers are attractive to pollinators, provide the nectar that pollinators eat, and provide vital relationships with specific pollinators. For example, the monarch butterfly's only apparent larval host plant is milkweed (*Asclepias sp.*). The monarch butterfly's success is contingent on the health and abundance of the native wildflower (Xerces Society, 2015). Native grasses and wildflowers are adapted both to an area's climate conditions and serve the specific needs of wildlife (Holdren, 2015). HUCS were not assigned to Pollinator Initiative as this is prioritized throughout the entire District.

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia. Work to assess road-stream crossings has been focused on streams and rivers where roads are fragmenting habitat of alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), brook trout (*Salvelinus fontinalis*), and imperiled freshwater mussels including the endangered dwarf wedgemussel (*Alasmidonta heterodon*). Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcommunity.org (NAACC, 2017). There is also an effort to remove low head dams. HUCS were not assigned to Aquatic Connectivity as this is prioritized throughout entire states.

At-Risk Species

Kenk's Amphipod (Stygobromus kenki)

There are an estimated 1,870 amphipod species and subspecies recognized from fresh or inland waters constituting 20 percent of the total amphipod diversity. These amphipods often play critical roles in aquatic food webs acting as a source of nutrients and energy to higher trophic levels (Vainola et al., 2008). The genus Stygobromus is made up of some of these inland species, which tend to occur in caves or areas where there are permanent groundwater habitats that contain lower levels of organic matter such as decomposing leaf litter and dead insects (Center for Biological Diversity, 2014). Members of this genus include Hay's spring amphipod (Stygobromus hayi), listed as federally endangered in 1982 (USFWS, 1982b), and Kenk's amphipod (*Stygobromus kenki*), proposed for federal listing as endangered.

Kenk's amphipod is a small, eyeless, unpigmented crustacean that grows no larger than a quarter of an inch in size (3.7-5.5 millimeters for the largest male and female specimens). Kenk's amphipod is closely related to Hay's spring amphipod, but can be differentiated morphologically by their appendages (USFWS, 2016b). Little is known of the amphipod species, but like Hay's spring amphipod, Kenk's amphipod lives underground deep within the cracks and crevasses of small freshwater springs and can sometimes be found in the fine soils or dead leaves within those springs USFWS, 2016b). The habitat is described as hypotelminorheic with a perched aquifer fed by subsurface water that creates a persistent wet spot and is underlain by clay or other impermeable layer typically 5 to 50 centimeters below the surface and is rich in organic matter compared with other aquatic subterranean habitats (USFWS, 2016b).

Kenk's amphipod has been found in a number of places along Rock Creek and its tributaries, inhabiting springs that are generally in forested areas along steep slopes (Culver, 2014). Within Maryland and the District of Columbia, ideal springs have been located in areas overlying the Wissahickon geologic formation within the Piedmont physiographic region. Populations have also been found in Virginia at Fort A. P. Hill where the amphipod has been known to occur in the Calvert formation just above the Nanjemoy geologic formation in the upper Coastal Plain (USFWS, 2016b). These geologic characteristics lead to the formation of the shallow groundwater springs where Kenk's amphipod lives and feeds on decomposing leaf litter and dead insects (Center for Biological Diversity, 2014).

Because of their limited range, habitat loss and degradation pose immediate danger to Kenk's amphipod. The groundwater-fed springs where they live are greatly impacted by alterations of groundwater flows and pollution within the watershed (Center for Biological Diversity, 2014). Kenk's amphipod requires good water quality to persist and is very sensitive to pollutants from urban development or agricultural practices. Some of the main threats include sewer leaks and pesticides within the watershed (USFWS, 2016b).

Priority areas for Kenk's amphipod in the District of Columbia include Hydrologic Unit Codes (HUC) 0207001002 Anacostia River and 0207001001 Rock Creek-Potomac River.

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CHAPTER 5. WEST VIRGINIA

The state of West Virginia lies inland from the Chesapeake Bay, surrounded by Ohio to the northwest, Pennsylvania and Maryland to the northeast, Virginia to the east and southeast, and Kentucky to the southwest. The only portion of West Virginia within the Chesapeake Bay watershed is the eastern panhandle (Grant, Pendleton, Hardy, Mineral, Hampshire, Morgan, Berkeley, and Jefferson Counties), and one watershed in Monroe County. The West Virginia eastern panhandle contains the headwaters of the Potomac River, and this region is considered a priority for the WVFO.

REFUGES

Although West Virginia has two refuges within the state (Ohio River Islands National Wildlife Refuge and Canaan Valley National Wildlife Refuge), neither of them reside within the Chesapeake Bay watershed.

CBRA

There are no CBRA resources in West Virginia.

ENDANGERED SPECIES

There are 10 endangered and threatened species in the West Virginia portion of the Chesapeake Bay watershed. This section describes the life history of these species and identifies the major stressor(s) that are adversely affecting them. The section identifies two categories of threatened and endangered species for Maryland, those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats.

Non-aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they need to be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Indiana Bat (*Myotis sodalis*)

The Indiana bat (Myotis sodalis) is an insectivorous species that spends its summer in wooded areas where it roosts in loose tree bark on dead or dying trees. During winter months, the Indiana bat will migrate to caves and mines where it hibernates colonially (USFWS, 2007). This species forages along rivers or upland lakes, with preferential foraging in woodland areas, where it consumes a variety of flying insects (Sparks et al., 2005).

Current winter distribution includes hibernacula found in 19 states: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. States were maternity colonies have been found, summer habitats, include: Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Missouri, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS, 2007).

The Indiana bat was declared endangered in 1967 (USFWS, 1967). It suffered from large decreases in populations because of threats such as human disturbance during hibernation, habitat alteration through stream channelization, deforestation for agriculture, surface strip-mining, and urban expansion (Gardner and Gardner, 1992; Murry and Kurta, 2004).

The Indiana bat's range is presumed to be any forested habitat within the entire state, therefore any HUC 10 watersheds which fall within the state boundary would be considered potential habitat.

Northern Long-Eared Bat (*Myotis septentrionalis*)

The northern long-eared bat (Myotis septentrionalis), listed as federally endangered in 2015 (USFWS, 2016), is a medium- sized bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (Wisconsin Department of Natural Resources, 2013). The distribution range of the northern long-eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and the United States from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increase agricultural and household pesticide use, and hibernaculum disturbance (Wisconsin Department of Natural Resources, 2013).

The northern long-eared bat's range is presumed to be any forested habitat within the entire state, therefore any HUC 10 watersheds which fall within the state boundary would be considered potential habitat.

Cheat Mountain Salamander (*Plethodon nettingi*)

The Cheat Mountain salamander was listed as threatened in 1989 because of habitat loss associated with historic and current logging of high-elevation spruce-hardwood forests, road construction, pipeline right-of-ways (ROWs), and other human development within the species' limited range (USFWS, 1989b). This salamander is endemic to West Virginia; it occurs only in the higher elevations in the east-central part of the state (USFWS, 1989b). Historically, the species was probably restricted to the red spruce (*Picea rubens*) forests of West Virginia's higher mountains (Brooks, 1948). Since most of these forests were extensively logged by 1920, several populations today occur in mixed deciduous forests that have replaced red spruce stands - most likely as a result of fire (Clarkson, 1964). These forests include yellow birch (*Betula alleghaniensis),* American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), striped maple (*Acer pensylvanicum*), and eastern hemlock (*Tsuga canadensis*) (Pauley, 1980). Typically, this species is found in cool, moist red spruce forests with a ground cover comprised of a liverwort called Bazzania (*Bazzania sp.)* and an abundance of leaf litter, fallen logs, and sticks (Pauley, 1980).

The main threat to the species is degradation of high-elevation red spruce and spruce/northern hardwood forests. Habitat protection on public lands may not be sufficient to minimize threats to populations from habitat fragmentation. Any disturbance that exposes the forest floor to sunlight, such as tree-clearing, changes the cool, moist conditions on which these animals depend for nest sites as well as food and oxygen procurement (USFWS, 1989b). Alterations as minor as clearing service roads or hiking trails can fragment and isolate populations, as these salamanders do not cross bare surfaces (USFWS, 1989b).

Priority areas for the Cheat Mountain salamander in West Virginia portion of the Chesapeake Bay watershed include Hydrologic Unit Codes (HUC) 0207000101 North Fork South Branch Potomac River.

Virginia Big-Eared Bat (*Corynorhinus townsendii virginianus*)
Listed in 1979 as federally endangered (USFWS, 1979), the Virginia big-eared bat is a medium-sized, brown bat that inhabits caves and mines in both summer and winter seasons. During the winter, they hibernate in clusters, and during the summer months, they use the caves for maternity sites and roosting (USFWS, 2009). Populations of Virginia big-eared bat are located in West Virginia, Virginia, Kentucky, and North Carolina (Patterson et al., 2003). The largest threats to Virginia big-eared bat populations are its limited distribution, small population size, extreme vulnerability to human disturbance, and white-nose syndrome (USFWS, 2009). A substantial portion of the species population winters in a small number of caves in West Virginia.

Priority areas for the Virginia big-eared bat in West Virginia include Hydrologic Unit Codes (HUC): 0207000101 North Fork South Branch Potomac River, 0207000103 Headwaters South Branch Potomac River, 0207000105 South Fork South Branch Potomac River, 0207000102 Lunice Creek, and 0207000104 South Mill Creek-Mill Creek.

Shale Barren Rockcress (*Arabis serotina*)
Shale barren rock cress (*Arabis serotina*), federally listed as endangered in 1989 (USFWS, 1989a), is a biennial herb in the mustard family that is typically found on steep exposed slopes with a south-westerly aspect (Platt, 1951). It is endemic to the community known as Appalachian shale barren and resides within a band occurring from southern Pennsylvania through Maryland into Virginia and West Virginia (USFWS, 2015). Plants typically grow to a height of 30 to 60 cm with compound inflorescence consisting of many whitish flowers, each approximately 2 to 3 mm long (USFWS, 1989a). The largest threats to the shale barren rock cress are nonnative invasive plant species and over browsing by white-tailed deer (*Odocoileus virginianus*). Additional negative impacts on the populations include quarrying for shale as well as road and railroad construction which can disrupt the erosional processes that form the barrens (West Virginia Natural Heritage Program, 2016).

Priority areas for shale barren rockcress in West Virginia include Hydrologic Unit Codes (HUC) 0207000105 South Fork South Branch Potomac River.

Running Buffalo Clover (*Trifolium stoloniferum*)
This species, listed as endangered in 1987, occurs in mesic habitats of partial to filtered sunlight, where there is a prolonged pattern of moderate periodic disturbance, such as mowing, trampling, or grazing (USFWS, 1987). In West Virginia, running buffalo clover seems to prefer old logging roads, off-road vehicle (ORV) trails, hawthorne thickets, grazed woodlands, jeep trails, railroad grades, game trails, and old fields succeeding to mesic woodlands. The larger occurrences exist within a matrix of mesophytic deciduous forest. All populations are associated with light to moderate disturbance such as occasional ORV or foot traffic, stream scour, or grazing. The primary threat to running buffalo clover is habitat alteration including natural forest succession and subsequent canopy closure, competition by invasive plant species, and catastrophic disturbance such as development or road construction. The elimination of bison and other large herbivores from its range also may have contributed to the decline of this species (Campbell et al., 1988). These animals were sources of the periodic habitat disturbances required by the species and also played a role in seed germination and dispersal.

Priority areas for running buffalo clover in West Virginia include Hydrologic Unit Codes (HUC) 0207000101 North Fork South Branch Potomac River.

Aquatic Species
Aquatic threatened and endangered species listed below are species have some or all of their life history tied directly to the aquatic systems.

Madison Cave isopod (*Antrolana lira*)
The western hemisphere is home to 25 species of troglobitic (adapted for inhabiting subterranean habitats) cirolanid isopods, only 3 of which reside in the United States (Carpenter, 1994). The growing awareness of invertebrates dwelling in subterranean habitats has revealed vulnerabilities of such organisms due to their limited geographic range, low reproductive potential, long life span, and small population size (Hutchins et al., 2010). The only member of the *Antrolana* genus, Madison Cave isopod (*Antrolana lira*) is such an organism. Due to these vulnerabilities and threats from anthropogenic disturbance, the isopod was federally listed as threatened in 1982 (USFWS, 1982).

The Madison Cave isopod is a crustacean characterized by a small, dorso-ventrally flattened body with a pair of short first antennae and a pair of long second antennae. Like most troglobitic organisms, the Madison Cave isopod lacks pigment and is eyeless. Males reach a length of approximately 15 mm and width of 5 mm, with females being larger, reaching lengths of about 18 mm and widths of 6 mm (USFWS, 1996). This species is endemic to the phreatic zone (below the water table) of groundwater aquifers underlying the Shenandoah Valley of Virginia and West Virginia and live in caves and wells developed in soluble sedimentary limestone (Hutchins et al., 2010). The Madison Cave isopod can be found in underground lakes or temporary pools in shallow depressions on the floor of low-level caves, passages, or low-gradient streams previously flooded by rising ground water (USFWS, 1996).

Due to its subterranean habitat, potential threats to the Madison Cave isopod are loss and modification of habitat, ground water contamination, and groundwater draw down (Elliot, 2000). The surface environment is particularly important, as it is their primary source of water and nutrients (Hutchins et al., 2010). Expanding urban development has increased the probability of pollutants entering the groundwater, and because of extensive agriculture in the Shenandoah Valley, pollution from agricultural runoff is a major threat to populations (USFWS, 1996).

In West Virginia, this species is currently known to occur within caves and wells in Jefferson County. Priority areas for the Madison Cave isopod in West Virginia include Hydrologic Unit Codes (HUC): 0207000409 Opequon Creek, 0207000703 Bullskin Run-Shenandoah River, and 0207000702 Long Marsh Run-Shenandoah River.

Harperella (*Ptilimnium nodosum*)

Nearly 25 percent of the world's vascular plant species are in danger of becoming extinct within the next 50 years (Raven, 1987), and 22 percent of the vascular plant species in the United States are currently of conservation concern (Falk, 1992). Harperella (*Ptilimnium nodosum*), listed as federally endangered in 1988 (USFWS, 1988b), is one such plant that faces many threats throughout its range.

Harperella is a semi-aquatic annual herb and a small member of the family Apiaceae. *Ptilimnium nodosum* includes two variates known as the pond and riverine forms (previously referred to as: pond, *H. nodosum*; riverine, *P. fluviatile*). These separate forms were not shown to be quantitatively distinct in morphology and phenology, and are thought to be the results of environmental factors – specifically variation due to the extent of flooding in the environment (USFWS, 1990a). Harperella flowers from late July to frost and are known to reproduce both sexually and asexually through seeds or plantlets formed in the nodes typically being transported downstream to form new subpopulations (Wells, 2012).

Harperella generally prefers rocky riverbeds and has very specific water depth tolerances: neither too shallow, dry conditions, nor too deep to impair completion of its life cycle. The riverine ecotype, *P. fluviatile*, grows on rocky and sandy shoals, and rarely, on muddy banks of seasonally flooded and quickly moving streams with the largest subpopulations found in sunny sections of creeks (USFWS, 1990a). These harperella populations can be found in Maryland, West Virginia, Virginia, North Carolina, Alabama, and Arkansas (Frye and Tessel, 2012).

Frequent and minor flood events are typically beneficial to harperella populations, as they scour cobble bars, preventing most competitors from becoming established, and remove algae, which can overgrow and shade out harperella that is still in the water (Wells, 2012). Although, these flood events are beneficial, manipulations of the water flow to increase or decrease flooding are the primary threat to the species. Manipulation of water flow upstream such as dams, reservoirs, or other water impoundments/diversions can destroy suitable habitat and threaten populations. *P. fluviatile* populations are also sensitive to siltation caused by development and agriculture (USFWS, 1990a). The pond ecotype, *H. nodosum*, is generally negatively affected by drainage of coastal ponds for conversion to pine plantation or row crops and dredging to create deep ponds for livestock (Godfrey and Wooten, 1979). Current populations occur in West Virginia in Back Creek, Cacapon River, Potomac River, and Sleepy Creek.

Priority areas for harperella in West Virginia include Hydrologic Unit Codes (HUC): 0207000402 Sleepy Creek, 0207000404 Back Creek, 0207000307 Cacapon River, and 0207000405 Warm Spring Run-Cherry Run-Potomac River.

Northeastern bulrush (*Scirpus ancistrochaetus*)
Freshwater, seasonal ponds are important habitats to many endemic or rare animal and plant species. These vernal ponds tend to be very sensitive to habitat loss and prone to local extinctions because of their small size (Baskin, 1994). The water level can affect the distribution of aquatic plant species, which could be an important factor to conserving these rare species (Lentz and Dunson, 1998). One important plant species that relies on the seasonal or temporary nature of these ponds is northeastern bulrush (*Scirpus ancistrochaetus*) (Lentz and Dunson, 1999), listed as federally endangered in 1991 (USFWS, 1991).

Northeastern bulrush is a perennial emergent sedge found primarily in small vernal ponds (Lentz and Cipollini, 1998). It grows approximately 80-120 cm in height (Lentz and Dunson, 1999), with the lowermost leaves being much longer than they are wide and the uppermost leaves being narrower and somewhat shorter than the lower leaves. The bulrush flowers from mid-June to July and has an umbellate inflorescence that bears clusters of brown spikelets. Its fruit sets between July and September and has yellow-brown achenes that are obovate and thickened above the seed (USFWS, 1993).

Northeastern bulrush is typically found in small, seasonal, palustrine wetlands, which are frequently isolated (Lentz, 1999). The bulrush tends to grow in acidic to circumneutral areas, with sites varying geographically from sinkhole ponds in the southern portion of the range to a various other wetland types in the northern portions (USFWS, 1993). The wetlands inhabited by the northeastern bulrush seem to be fed primarily from surface water, and can vary greatly within a season (Lentz and Dunson, 1998). It is also thought that the distribution pattern is greatly influenced by light availability, and can usually be found in areas associated with percent forest canopy cover levels of less than 60 percent (Lentz and Cipollini, 1998). Populations of northeastern bulrush can be found in West Virginia, Virginia, Maryland, New York, Pennsylvania, Massachusetts, Vermont, and New Hampshire; with the majority of populations found in Pennsylvania (Lentz, 1999).

The most immediate threats to the northeastern bulrush are anthropogenic activities that lead to the destruction or modification of habitat. Wetland filling, draining, and dredging for development, agriculture, and recreation are the primary forms of habitat destruction (USFWS, 1993). Logging, road construction, agricultural activities, and development also threaten population persistence (Lentz and Dunson, 1999). Little is known about life history, which makes conservation and management of this species more challenging.

Priority areas for northeastern bulrush in West Virginia include Hydrologic Unit Codes (HUC) 0207000404 Back Creek and 0207000307 Cacapon River.

James spinymussel (*Pleurobema collina*)
Freshwater mussels are important components of aquatic ecosystems by serving as energy sources for many species as well as being indicators of ecosystem health (Wisniewski et al., 2005). With the increasing number of introduced species and extensive habitat alteration, freshwater mussels are the most imperiled faunal ground in North America with 60 percent of described species considered endangered or threatened and 12 percent presumed extinct (Ricciardi et al., 2002). There are three spined mussel species that occur in the United States; James spinymussel (*Pleurobema collina*), Tar spinymussel (*Elliptio steinstansana*), and Altamaha spinymussel (*E. spinosa*). The James spinymussel was listed in 1988 (USFWS, 1988a).

While the juveniles of the James spinymussel usually bear one to three short but prominent spines on each valve, the adults usually lack spines. The foot and mantle of the adult are orange in color with the mantle being darkly pigmented in a narrow band around the edges of the branchial and anal openings. The shell of juvenile James spinymussels is more rhombus shaped and becoming increasingly more ovate or acute as it grows (USFWS, 1990b).

The James spinymussel is a tachytictic (short-term) brooder; fertilizing eggs in the spring and releasing the glochidia in spring and summer (USFWS, 1990b). Once released, these glochidia parasitize host fish species which include: the common shiner (*Luxilus cornutus*), rosyside dace (*Clinostomus funduloides*), bluehead chub (*Nocomis leptocephalus*), pumpkinseed (*Lepomis gibbosus*), and fantail darters (*Etheostoma flabellare*) (Hove and Neves, 1994). The James spinymussel is endemic to the James River watershed is known to occupy sediments of cobble and sand in reaches with slow to moderate currents, and can be found in 1.5 to 20m wide second and third order streams at water depth of 0.3 to 2m (Hove and Neves, 1994).

There has been a rapid decline of populations that indicates a high vulnerability to extirpation. Much of this decline is due to siltation generated by agricultural and forestry activities. Because mussels are sedentary and unable to move long distances, they have an inability to deal with heavy silt loads that may result from anthropogenic activities (USFWS, 1990b). Impoundments and habitat alteration also play a key role in the decline of mussel populations. Closure of dams changes habitat by increasing depth, decreasing flow, and enabling silt accumulation which can result in the change of fish communities and host availability (USFWS, 1990b). Habitat alteration allows for the increasingly prevalent Asian clam (*Corbicula fluminea*) to expand into the habitat and outcompete other mussel and clam species (Hove and Neves, 1994). Insecticide pollution from inland waters as a result of agricultural practices has been found to significantly affect mussel by reducing siphoning activity (Salanki and Varanka, 1977).

Priority areas for James spinymussel in West Virginia include Hydrologic Unit Codes (HUC) 0208020104 Potts Creek.

CBRA
There are no CBRA resources in West Virginia.

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Eastern Brook Trout Joint Venture

The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and federal agencies, regional and local governments, businesses, conservation organizations, academia, scientific societies, and private citizens (EBTJV, 2017). The EBTJV is dedicated to protecting, restoring, and enhancing aquatic habitat within the eastern Brook Trout's range, and is modeled after the joint ventures created in support of the North American Waterfowl Management Plan. Working at a variety of geographic and jurisdictional scales, the EBTJV works within a non-regulatory framework to both secure adoption of policies that support protection of aquatic habitats, and accomplish measurable conservation gains. The Joint Venture seeks to secure populations of wild Brook Trout, aid in the restoration of watershed integrity, protect water quality, and enhance stewardship and human connections to our natural environment through collaboration among its partners (EBTJV, 2017).

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a 13-state region, from Maine to West Virginia. Work to assess road-stream crossings has been focused on streams and rivers where roads are fragmenting habitat of alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), brook trout (*Salvelinus fontinalis*), and imperiled freshwater mussels including the endangered dwarf wedgemussel (*Alasmidonta heterodon*). Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcontinuity.org (NAACC, 2017). There is also an effort to remove low head dams. HUCS were not assigned to Aquatic Connectivity as this is prioritized throughout entire states.

At-Risk Species

Bald Eagle (*Haliaeetus leucocephalus*)

The bald eagle (*Haliaeetus leucocephalus*), a North American species that historically occurred throughout the contiguous United States and Alaska, was listed in 1967 as endangered south of the 40^{th} parallel. In 1978, it was listed under the ESA as endangered throughout most of the lower 48 states. This segment of the population was down-listed to threatened in 1995, and in 2007 it was deemed recovered and removed from the list of threatened and endangered species. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA) from a variety of human induced conditions and activities.

Bald eagle distribution varies seasonally; eagles that nest in southern latitudes frequently move northward in late spring and early summer, often summering as far north as Canada. Most eagles that breed at northern latitudes migrate southward during winter or to coastal areas where waters remain unfrozen. Migrants frequently concentrate in large numbers at sites where food is abundant and they often roost together communally. In some cases, concentration areas are used in the summer by southern eagles and in the winter by northern eagles.

Bald eagles may occur throughout West Virginia during the winter. Active nest sites, while most numerous in the Eastern Panhandle, have been documented in Grant, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Mineral, Morgan, Pendleton, Pocahontas, Summers, and Taylor Counties. During the breeding season, bald eagles are sensitive to a variety of human activities. However, not all bald eagle pairs react to human activities in the same way. This variability may be related to a number of factors, including visibility, duration, noise levels, extent of the area affected by the activity, prior experiences with humans, and tolerance of the individual nesting pair.

In most of West Virginia, nest building typically occurs between early December and early March, followed by egg laying/incubation between late January and early May, hatching/rearing of young between late February and early July, and fledging of young between late May and late August. These breeding stages may occur up to two weeks earlier in the Eastern Panhandle of West Virginia.

Priority areas for bald eagles in West Virginia include Hydrologic Unit Codes (HUC): 0207000101 North Fork South Branch Potomac River, 0207000103 Headwaters South Branch Potomac River, 0207000105 South Fork South Branch Potomac River, 0207000305 Lost River, 0207000402 Sleepy Creek; 0207000703 Bullskin Run-Shenandoah River, 0207000102 Lunice Creek, 0207000104 South Mill Creek-Mill Creek, 0207000106 Outlet South Branch Potomac River, 0207000306 North River, 0207000307 Cacapon River, 0207000411 Rocky Marsh Run-Potomac River, 0207000202 Stony River-North Branch Potomac River, and 0207000207 Patterson Creek.

Green Floater (*Lasmigona subviridis*)
The green floater mussel is currently under review for listing under the Endangered Species Act. It historically has been found in the headwaters of the Potomac River (Clayton et al., 2001; Taylor, 1985). According to Clarke (1985:56), the green floater mussel is erratically distributed, preferring smaller streams over larger streams, avoiding areas with strong current and is more likely to be found in small pools with gravelly and sandy bottoms.

HUC 10 layers will be provided by the NYFO after the data call and Species Status Assessment for the green floater is complete.

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Chapter 6. Pennsylvania

Over half of Pennsylvania lies within the Chesapeake Bay watershed and two major rivers are part of that watershed: the Susquehanna River, largest tributary of the Chesapeake Bay with 21,000 square miles, and the Potomac River, with 1,600 square miles. Together, they total 40 percent of the entire Chesapeake Bay watershed (NRCS, 2016). The Susquehanna River provides 90 percent of the freshwater flow to the upper Bay and half of the total freshwater flow to the Bay (PADEP, 2016). Forty-one Pennsylvania counties are either completely or partially within the Chesapeake Bay watershed. This area is equivalent to about 14,447,457 acres total.

REFUGES

None of Pennsylvania's refuges (Ohio River Islands National Wildlife Refuge, Erie National Wildlife Refuge, Cherry Valley National Wildlife Refuge, and John Heinz National Wildlife Refuge) are within the Chesapeake Bay watershed.

ENDANGERED SPECIES

There are five threatened and endangered species in the Pennsylvania's portion of the Chesapeake Bay watershed. This section describes the life history and identifies the major stressor(s) that adversely affect these species. The section identifies two categories of threatened and endangered species for Pennsylvania, those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats

Non-Aquatic Threatened and Endangered Species

Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems as forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems, they should be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Indiana Bat (*Myotis sodalis*)

The Indiana bat (*Myotis sodalis*) is an insectivorous species that spends its summer in wooded areas where it roosts in loose tree bark on dead or dying trees. During winter months, the Indiana bat will migrate to caves and mines where it hibernates colonially (USFWS, 2007a). This species forages along rivers or upland lakes, with preferential foraging in woodland areas, where it consumes a variety of flying insects (Sparks et al., 2005).

Current winter distribution includes hibernacula found in 19 states: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. States were maternity colonies have been found, summer habitats, include: Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Missouri, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS, 2007a).

The Indiana bat was declared endangered in 1967. It suffered from large decreases in populations because of threats such as human disturbance during hibernation, habitat alteration through stream channelization, deforestation for agriculture, surface strip-mining, and urban expansion (Garner and Gardner, 1992; Murry and Kurta, 2004).

Priority areas for Indiana bat in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030104 Penns Creek, 0205030203 Lower Frankstown Branch Juniata River, 0205030205 Little Juniata River, 0205030301 Upper Raystown Branch Juniata River, 0205030102 Pine Creek, 0205030406 Honey Creek, 0205030408 Middle Juniata River, 0205010702 Upper Susquehanna River, 0205010703 Middle Susquehanna River, 0205010704 Nescopeck Creek, 0207000902 Marsh Creek, 0205030602 Upper Conewago Creek , and 0205030603 Bermudian Creek.

Northern Long-Eared Bat (*Myotis septentrionalis*)
The northern long-eared bat (*Myotis septentrionalis*), listed as federally endangered in 2015 (USFWS, 2016a), is a medium-size bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (WDNR, 2013). The distribution range of the northern long-eared bat spans throughout much of Canada, including all territories except Nunavut, Canada, and the United States from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014). The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increase agricultural and household pesticide use, and hibernaculum disturbance (WDNR, 2013).

Priority areas for northern long-eared bat in Pennsylvania include Hydrologic Unit Codes (HUC): 205030406 Honey Creek, 0207000205 Wills Creek, 0207000401 Tonoloway Creek, 0205030104 Penns Creek, 0205030105 Mahanoy Creek, 0205030107 Deep Creek, 0205030203 Lower Frankstown Branch Juniata River, 0205030204 Spruce Creek, 0205030205 Little Juniata River, 0205030206 Shaver Creek, 0205030207 Standing Stone Creek, 0205030208 Juniata River, 0205030301 Upper Raystown Branch Juniata River, 0205030303 Dunning Creek, 0205020304 Lower West Branch Susquehanna River, 0205020401 Spring Creek, 0205020403 Fishing Creek, 0205020502 Upper Pine Creek, 0205020605 Lower Loyalsock Creek, 0205030101 Shamokin Creek, 0205030102 Pine Creek, 0205030305 Middle Raystown Branch Juniata River, 0205030306 Yellow Creek, 0205030307 Great Trough Creek, 0205030308 Lower Raystown Branch Juniata River, 0205030402 Sideling Hill Creek; 0205030403 Blacklog Creek, 0205030404 Aughwick Creek, 0205030405 Upper Juniata River, 0205030407 Kishacoquillas Creek, 0205030409 Tuscarora Creek, 0205010701 Lackawanna River, 0205010702 Upper Susquehanna River, 0205010703 Middle Susquehanna River, 0205010704 Nescopeck Creek, 0205010705 Huntington Creek, 0205010708 Catawissa Creek, 0205010710 Lower Susquehanna River, 0205020102 Anderson Creek, 0205020104 Upper West Branch Susquehanna River, 0205020105 Moshannon Creek, 0205020107 Lower West Branch Susquehanna River, 0207000301 Town Creek, 0205020103 Clearfield Creek, 0205010409 Tioga River, 0205030611 Conestoga River, 0205030505 Yellow Breeches Creek, 0205030506 Upper Swatara Creek, 0205030510 Susquehanna River, and 0205030612 Pequea Creek.

Small Whorled Pogonia (*Isotria medeoloides*)
Listed as federally endangered in 1982 (UFWS, 1982) and reclassified as threatened in 1994 (USFWS, 1994), the small whorled pogonia (*Isotria medeoloides*), is one species greatly affected by habitat destruction.

The small whorled pogonia is a perennial member of the Orchidaceae family and has slender, hairy, fibrous roots that radiate from the crown or rootstock (USFWS, 1992). It is characterized by a whorl of five or six leaves at the top of a glabrous, pale-green, hollow stem and a single yellowish-green flower, occasionally two, that may bloom from the center of the leaf whorl (Sperduto and Congalton, 1996). The small whorled pogonia has four different states: vegetative, with an abortive flower bud, flowering, or dormant. Although insect pollination may take place, the species is primarily self-pollinating (USFWS, 1992).

Habitat for the small whorled pogonia is in mixed deciduous or mixed deciduous/coniferous forests with common herbs, ferns, and occasionally other orchids (Sperduto and Congalton, 1996). Preferred habitats are forests in second or third- growth successional stages (USFWS, 1992). Populations are very isolated and typically very small, being made up of less than 20 plants, although some have been found to contain close to 100 plants (Mehrhoff, 1989). The small whorled pogonia can be found in Maine and Ontario in the northern portion of its range, west to Michigan, Illinois, and Missouri, and south along the eastern seaboard to Georgia (Massachusetts Natural Heritage and Endangered Species Program, 2015).

The two main threats for the small whorled pogonia are habitat destruction and collection. This destruction is primarily a result of residential and commercial development. These activities directly destroy habitat and indirectly through the construction of roads, powerlines, and sewer mains forming barriers to seed dispersal (USFWS, 1992). Heavy timbering and clear-cutting also threatens populations (USFWS, 1992). The small whorled pogonia requires very specific habitat to persist, and these anthropogenic activities are significantly reducing the amount of suitable habitat available (Massachusetts Natural Heritage and Endangered Species Program, 2015).

Priority areas for small-whorled pogonia in Pennsylvania include Hydrologic Unit Codes (HUC) 0205020404 Bald Eagle Creek.

Aquatic Threatened and Endangered Species
Aquatic threatened and endangered species listed below are species that have some or all of their life history tied directly to aquatic ecosystems.

Bog Turtle (*Glyptemys muhlenbergii*)
The bog turtle (*Glyptemys muhlenbergii*) was listed as federally threatened in 1997 (USFWS, 1997). The bog turtle is one of North America's smallest turtles with New England specimens

measuring less than 100 mm in carapace length and specimens from more southern populations reaching sizes up to 115 mm in carapace length (USFWS, 2001). The turtles are dark in color and have large yellow to orange markings on both sides of the head. The markings on juveniles and hatchlings are lighter, whereas older adults have more intense color blotches (NRCS, 2006). The carapace is usually black or brown, somewhat domed, and has a slight mid-dorsal keel (Pennsylvania Fish and Boat Commission, 2011). The carapace may be marked with yellowish rays of color, and the plastron is usually black with varying amounts of white or pale yellow patches (NRCS, 2006). Bog turtles in the northern populations typically emerge from hibernation in late March through April and return to hibernacula in October. Breeding occurs from late April to early June and nesting occurs 21 to 31 days after copulation. Hatchlings then emerge from mid-August to September and overwinter at or near the nest site (Pennsylvania Fish and Boat Commission, 2011).

Bog turtles typically inhabit shallow wetland habitats such as sphagnum bogs, marshes, and wet meadows (Chase et al., 1989). These wetland habitats are seepages or spring-fed emergent freshwater wetlands, are associated with streams, and are bordered by wooded areas. The wetlands generally have a variety of microhabitats for the bog turtles to use for foraging, nesting, basking, hibernation, shelter, and other needs (NRCS, 2006). Populations of bog turtles can be found in New York, Massachusetts, Connecticut, New Jersey, Pennsylvania, Delaware, and Maryland with some populations located further to the south in Virginia, North Carolina, South Carolina, Tennessee, and Georgia (USFWS, 2001).

Bog turtles are very sensitive to changes in habitat and have declined greatly due to habitat degradation and loss from activities such as wetland filling, fragmentation, and drainage (NRCS, 2006). The creation of farm ponds, reservoirs, and other impoundments inundate the shallow, open wet meadows and fens required for bog turtles. Because bog turtles are sustained by groundwater regimes, they are particularly sensitive to changes in subsurface water supplies. Construction and development has the ability to alter subsurface flow as well as drilling under wetlands, which can fracture bedrock and significantly impact small wetland systems (USFWS, 2001). HUCs for bog turtle were not included in this report as the information was deemed too sensitive and would risk the species recovery. One of the greatest threats to Bog Turtle recovery is collection of the species (USFWS, 2001). Providing the HUC locations would allow collectors to know where bog turtles are currently located. Bog turtle must be coordinated with the Service on a project specific basis.

Northeastern Bulrush (*Scirpus ancistrochaetus*)
Freshwater, seasonal ponds are important habitats to many endemic or rare animal and plant species. Northeastern bulrush (*Scirpus ancistrochaetus*) is a plant species that relies on the seasonal or temporary nature of these ponds (Lentz and Dunson, 1999) and was listed as federally endangered in 1991 (USFWS, 1991).

Northeastern bulrush, a perennial emergent sedge, is found primarily in small vernal ponds (Lentz and Cipollini, 1998). It grows approximately 80-120 cm in height (Lentz and Dunson, 1999), with the lowermost leaves being much longer than they are wide and the uppermost leaves being narrower and somewhat shorter than the lower leaves. The bulrush flowers from mid-June to July and has an umbellate inflorescence that bears clusters of brown spikelets. Its fruit sets between July and September and has yellow-brown achenes that are obovate and thickened above the seed (USFWS, 1993).

Northeastern bulrush is typically found in small, seasonal, palustrine wetlands which are frequently isolated. The bulrush tends to grow in acidic to circumneutral areas, with sites varying geographically from sinkhole ponds in the southern portion of the range to a various other wetland types in the northern portions (USFWS, 1993). The wetlands inhabited by the northeastern bulrush seem to be fed primarily from surface water, and can vary greatly within a season (Lentz and Dunson, 1999). Distribution is thought to be influenced by light availability. Northeastern bulrush can usually be found in areas with less than 60 percent canopy cover (Lentz and Cipollini, 1998). Populations of northeastern bulrush can be found in West Virginia, Virginia, Maryland, New York, Pennsylvania, Massachusetts, Vermont, and New Hampshire; with the majority of populations found in Pennsylvania (Lentz, 1999).

The most immediate threats to the northeastern bulrush are destruction or modification of habitat (USFWS, 1993). Wetland filling, draining, and dredging for development, agriculture, and recreation are the primary forms of habitat destruction (USFWS, 1993). Logging, road construction, agricultural activities, and development also threaten population persistence (Lentz and Dunson, 1999). Little is known about life history, which makes conservation and management of this species more challenging.

Priority areas for northeastern bulrush in Pennsylvania include Hydrologic Unit Codes (HUC): 207000408 Conococheague Creek, 0207000410 Antietam Creek, 0205030104 Penns Creek, 0205030110 Susquehanna River, 0205030204 Spruce Creek, 0205030205 Little Juniata River, 0205030206 Shaver Creek, 0205030207 Standing Stone Creek, 0205030208 Juniata River, 0205020304 Lower West Branch Susquehanna River, 0205020402 Beech Creek, 0205020403 Fishing Creek, 0205020502 Upper Pine Creek, 0205020503 Marsh Creek, 0205020504 Babb Creek, 0205020506 Lower Pine Creek, 0205020602 Lycoming Creek, 0205020606 West Branch Susquehanna River, 0205020609 White Deer Hole Creek, 0205020610 Buffalo Creek, 0205020612 West Branch Susquehanna River, 0205030102 Pine Creek, 0205030404 Aughwick Creek, 0205030406 Honey Creek, 0205030409 Tuscarora Creek, 0205030412 Lower Juniata River, 0205030501 Sherman Creek, 0205030502 Upper Conodoguinet Creek, 0205030503 Middle Conodoguinet Creek, 0205030505 Yellow Breeches Creek, 0205030510 Susquehanna River, 0205010701 Lackawanna River, 0205010705 Huntington Creek, 0205010707 Fishing Creek; 0205020105 Moshannon Creek, 0205020107 Lower West Branch Susquehanna River, 0205010406 Crooked Creek, 0207000301 Town Creek, and 0205020103 Clearfield Creek.

CBRA

There are no CBRA resources in Pennsylvania.

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - The Young Forest Project

This project is a collaboration between partners to create and renew the young forest habitat that so many kinds of wildlife need (YFP, 2017). Partners pool resources, efficiently use funds, and devise new and innovative approaches to conservation (YFP, 2017). They conduct strong science to constantly improve knowledge of how and when wildlife uses different habitats. Partners include U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Forest Service, U.S. Department of Agriculture, tribal interests, and many non-governmental organizations.

A young forest usually lasts for only 10 to 20 years, after which, it becomes less useful to many species of wildlife. Fortunately, a young forest can be renewed through periodic timber harvesting, mowing with heavy-duty machines, or the controlled use of fire. To benefit a broad range of wildlife, conservationists create a mosaic of different-aged habitats on a given tract of land. The Young Forest Project ensures there is enough of this productive, essential habitat. Wildlife that benefit from young forest management include forest interior birds and songbirds that nest in deep woods, such as hermit thrushes and wood warblers. Wild turkeys nest in young forests, and black bears wade into shrubs and brambles to gorge on berries and build up fat before hibernation (YFP, 2017).

Other wildlife that uses young forests for habitat and foraging needs include: wood turtle (*Glyptemys insculpta*), ruffed grouse (*Bonasa umbellus*), American woodcock (*Scolopax minor*), whip-poor-will (*Caprimulgus vociferous*), brown thrasher (*Toxostoma rufum*), indigo bunting (*Passerina cyanea*), New England cottontail (*Sylvilagus transitionalis*), snowshoe hare (*Lepus americanus*), and bobcat(*Lynx rufus*). More than 60 reptiles, birds, and mammals that require young forest have been designated species of greatest conservation need in the Northcentral and Northeastern United States (YFP, 2017).

Landscape Conservation - Eastern Brook Trout Joint Venture

The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and federal agencies, regional and local governments, businesses, conservation organizations, academia, scientific societies, and private citizens. The EBTJV is dedicated to protecting, restoring, and enhancing aquatic habitat within the Eastern brook trout's range, and is modeled after the joint ventures created in support of the North American Waterfowl Management Plan. Working at a variety of geographic and jurisdictional scales, the EBTJV works within a non-regulatory framework to secure adoption of policies that support protection of aquatic habitats and accomplish measurable conservation gains. The Joint Venture seeks to secure populations of wild brook trout, aid in the restoration of watershed integrity, protect water quality, and enhance human connections to and stewardship of our natural environment through collaboration among its partners (EBTJV, 2017).

Pennsylvania brook trout priority areas were determined with assistance from The Mellon Foundation, The Trust for Public Land (TPL), the National Fish and Wildlife Foundation (NFWF), and the Chesapeake Conservancy (CC). TPL and CC identified areas where there are biologically-and geographically- rich, diverse landscapes with extensive stream and river networks and healthy forests, but human influences or disturbances that threaten the habitat range of aquatic species of interest, specifically brook trout (areas best for restoration, enhancement, and protection).

Priority areas for brook trout in Pennsylvania include Hydrologic Unit Codes (HUC): 0205010112 Middle Susquehanna River, 0205010305 Pipe Creek-Susquehanna River, 0205010306 Cayuta Creek, 0205010505 Middle Chemung River, 0207000205 Wills Creek, 0207000406 West Branch Conococheague Creek, 0207000408 Conococheague Creek, 0207000410 Antietam Creek, 0205010113 Lower Susquehanna River, 0205010307 Wappasening Creek-Susquehanna River, 0205010408 Cowanesque River, and 0205010409 Tioga River.

Landscape Conservation - North American Wetlands Conservation Act (NAWCA)
NAWCA grants increase bird populations and wetland habitat, while supporting local economies and American traditions such as hunting, fishing, birdwatching, family farming, and ranching. Wetlands protected by NAWCA provide valuable benefits such as flood control, reducing coastal erosion, improving water and air quality, and recharging groundwater. In the past two decades, the North American Wetlands Conservation Act has funded 2,644 projects totaling $1.4 billion in grants. More than 5,600 partners have contributed another $3 billion in matching funds to affect 33.4 million acres of habitat. The North American Wetlands Conservation Act was passed, in part, to support activities under the North American Waterfowl Management Plan, an international agreement that provides a strategy for the long-term protection of wetlands and associated uplands habitats needed by waterfowl and other migratory birds in North America. The Service's Partners for Fish and Wildlife Program works in conjunction with NAWCA to provide wetland habitat throughout the State for the benefit of waterfowl, wildlife, and aquatic organisms (NAWCA, 2017).

Landscape Conservation - Partners in Flight
Partners in Flight is a dynamic network of more than 150 partner organizations throughout the Western Hemisphere engaged in landbird conservation through science, research, planning, and policy development to land management, monitoring, education, and outreach (Partners in Flight, 2017). Partners collaborate to protect landbirds through strategic monitoring and assessment tools, and development of priority species lists, conservation plans, maps, and databases that facilitate cross-border cooperation among the United States, Canada, and Mexico. Birds and their habitats face unprecedented threats from climate change, poorly planned urban growth, unsustainable agriculture, and forestry, and a widespread decline in habitat quantity and quality. The spectacle of bird migration is being diminished by direct mortality as every year millions of birds die from anthropogenic sources. Nearly 20 percent of American and Canadian landbird species are on a path towards endangerment and extinction in the absence of conservation action (Partners in Flight, 2017).

Strategic goals include: maintaining healthy bird populations, in natural numbers, in healthy habitats and ecosystems; keeping species from becoming threatened or endangered through proactive measures and science-based planning; promoting full life-cycle conservation of migratory birds throughout the Western Hemisphere; and promoting the value of birds as indicators of environmental health and human quality of life. HUCS were not assigned to Partners in Flight as this is prioritized throughout the entire State (Partners in Flight, 2017).

Landscape Conservation - Pollinator Initiative

Pollinators are a diverse group of animals and insects (including bees, butterflies, birds, and moths) that assist in the reproductive success of nearly 75 percent of the world's crop species and flowering plants. In the United States, native pollinators are vital to food security and are estimated to add a $3 billion per year to the economy in ecological services (Xerces Society, 2015). Wild pollinator populations, though, are in decline worldwide due to stressors like habitat loss, pesticide use, and introduction of disease in response to this decline. A Federal Interagency Task Force was assigned the job of creating a plan to combat population loss and to promote overall pollinator health. The Task Force's plan includes three overarching goals: reduce honey bee (*Apis mellifera*) losses to economically sustainable levels; increase monarch butterfly (*Danaus plexippus*) numbers to protect the annual migration; and restore or enhance millions of acres of land for pollinators through combined public and private action (Holdren, 2015).

Restoring degraded habitat or planting open patches of land with native plants provides habitat and forage for pollinators as well as other native wildlife. Native wildflowers are attractive to pollinators, provide the nectar that pollinators eat, and provide vital relationships with specific pollinators. For example, the monarch butterfly's only apparent larval host plant is milkweed (*Asclepias sp.*). The monarch butterfly's success is contingent on the health and abundance of the native wildflower (Xerces Society, 2015). Native grasses and wildflowers are adapted both to an area's climate conditions and serve the specific needs of wildlife (Holdren, 2015).

In addition to these services, native plants stabilize soil, store carbon, and help to reduce runoff. Because native plants are adapted to local environmental conditions, they require far less water, saving time, money, and perhaps the most valuable natural resource, water. They do not normally require the use of fertilizer and do not need constant maintenance in the form of watering and mowing, proving to be generally low maintenance and less costly in their long term management. Native plants also help clean the air by sequestering airbourne carbon; providing shelter and food for wildlife; supporting pollinators; and promoting diodiversity, which is beneficial to wildlife.

In 2013 the Federal Highway Administration (FHWA) estimated that the State of Pennsylvania had 250,199 miles of road including roadside right-of-ways and other properties associated with major highways. Pennsylvania roadsides can benefit pollinators by providing foraging habitat, places to breed, nest, and overwinter, and may act as corridors, linking patches of fragmented habitat.

The Service together with partners that Pennsylvania Department of Transportation (PennDOT) and FHWA are working together to provide pollinator habitat along the many miles of Pennsylvania's roadsides and on PennDOT sites developed to provide compensatory mitigation and restoration to offset impacts to aquatic resources, including using pollinator-friendly seed mixes, incorporating more flowering plants into planting plans, the use of appropriate herbicides, and adjusting the mowing schedule.

Other areas that the Service has worked toward providing landscape conservation for pollinators include working through the Natural Resource Damage Assessment and Restoration Program (NRDAR). For example, the Service has used NRDAR resources to convert landfill caps to native meadows that are beneficial to both birds and pollinators (East Mount Zion Landfill). HUCS were not assigned to Pollinator Initiative as this is prioritized throughout the entire State.

Aquatic Connectivity

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a network of individuals from universities, conservation organizations, and state and federal natural resource and transportation departments focused on improving aquatic connectivity across a thirteen-state region, from Maine to West Virginia. To date 1,733 road-stream crossings have been completed in Maryland by the Maryland Fish and Wildlife Conservation Office and partners including 40 at the Patuxent Research Refuge. Work to assess road-stream crossings has been focused on streams and rivers where roads are fragmenting habitat for anadromous fish (alewife, blueback herring, and shad), brook trout, and imperiled freshwater mussels including the endangered dwarf wedgemussel. Pictures and data describing assessed culverts and bridges can be found in the on-line database at streamcontinuity.org (NAACC, 2017).

Pennsylvania has partnered with the Mellon Foundation and the Trust for Public Lands (TPL) to craft TPL's Western Pennsylvania Restoration Plan, a comprehensive strategy to guide investment that will improve and protect critical aquatic and forest habitat in Pennsylvania's western counties, including barriers to fish passage. The plan identifies measureable outcomes for species responses to habitat improvement and management in a strategically directed framework. The plan was developed in consultation with key Federal and State agencies and non-governmental organizations committed to the conservation and stewardship of Western Pennsylvania's outstanding habitat, species, and watersheds (TPL, 2016).

Additionally, Pennsylvania has also been working with PennDOT to facilitate aquatic life passage at new culvert and bridge crossings and existing culvert sites to reestablish passage and connectivity for aquatic life in stream corridors. HUCS were not assigned as this is prioritized throughout the entire State.

At-Risk Species

Eastern Hellbender (*Cryptobranchus alleghaniensis alleghaniensis*)

The eastern hellbender (*Cryptobranchus alleghaniensis alleghaniensis*) is a species of very high concern. It is currently undergoing a Species Status Assessment to determine if listing is warranted.

Historically, the eastern hellbender's range extended to 15 states, within 4 large river basins; the Ohio, the Tennessee, the Susquehanna, and the Mississippi. Currently, it can be found in about 420 streams, and 134 HUC 8's. It is typically found in cool to cold moderate (less than 20 square miles) to large perennial streams with abundant rock cover and abundant crayfish/invertebrate populations (PGC and PFBC, 2015). The highest density populations can be found in clear, high gradient streams (Applegate 2017).

Threats to the eastern hellbender include: water quality degradation from increased run-off from residential and commercial development and transportation infrastructure; nutrient loading and sedimentation; pollution from agricultural chemical run-off and transportation infrastructure; water withdrawals from energy production and mining operations; pathogens from water withdrawals; and habitat loss/modification of natural systems due to dams and fragmenting of riverine habitat (Applegate 2017, PGC and PFBC, 2015). Direct threats include accidental angler bycatch and increased flooding, which can wipe out entire colonies. Introduced invasive aquatic species also affect the eastern hellbender through habitat alteration, extirpation, introduction of foreign parasites and pathogens, habitat utilization shifts, competition, and ecological shifts (PGC and PFBC, 2015).

If the eastern hellbender is to survive, it will take a concerted effort and commitment to improve water quality throughout the Chesapeake Bay watershed. Identified research needs include information on the species' life history, genetics, and refining the species range, including occupied-and-declining and unoccupied streams. Conservation goals and actions include: developing an appropriate monitoring protocol to avoid surveyor induced disturbances; protect and conserve extant populations; and protect streams and habitat from agricultural and urban run-off (PGC and PFBC, 2015).

Due to the sensitivity of hellbender and the concern over collectors being able to use the HUC 10 data to find individuals the Service is not providing HUC 10 priority areas for this species. Instead we are providing priority focus area by county. The priority areas include: Bedford, Clearfiled, Clinton, Columbia, Huntingdon, Lycoming, Perry, Wyoming and York Counties.

Chesapeake Logperch (*Percina bimaculata*)

The Chesapeake logperch (*Percina bimaculata*) is listed as threatened in Pennsylvania and threatened in Maryland. There are those who consider this species endangered range-wide. On September 27, 2011 the U.S. Fish and Wildlife Service was petitioned to list 404 different species as threatened or endangered (with or without critical habitat), of which the Chesapeake logperch was one.

Historically, the Chesapeake logperch was found in the Chesapeake Bay watershed in the District of Columbia, Maryland, Pennsylvania, and Virginia. It was limited to the lower sections of the Potomac and Susquehanna Rivers and their tributaries, and a few direct tributaries to the Chesapeake Bay. It formerly occurred in the Susquehanna River, as far upstream as Columbia, in Lancaster County. It has not been reported in the Potomac River drainage since 1938, and is thought to have been extirpated from the Potomac River drainage due to pollution and sedimentation. Further, it has not been found upriver of the Conowingo Pool in the Susquehanna River since it has been described in 1842.

Currently, the Chesapeake logperch occurs in the Piedmont Province of the lower Chesapeake Bay drainage, and is restricted to the Susquehanna River above and below the Conowingo Dam, the lower-most sections of four tributaries to Conowingo Pool (including Fishing Creek, Michael Run, Muddy Creek, and Octoraro Creek (30 combined river miles) in Pennsylvania. In Maryland, the Chesapeake logperch has been collected in Broad, Conowingo, Deer, Northeast, and Octoraro Creeks, and in 2009-2010, it was found for the first time in Swan Creek. The species has also been collected in Winters Run and the Northeast River, which drain directly into the upper Chesapeake Bay in Maryland.

Threats to the Chesapeake logperch include: poor water quality from nutrient loading, sediment loading (USFWS 2016b, PFBC 2015), polychlorinated biphenyls (PCBs) (Bigler et.al. 1992) , and chlordane (PGC/PFBC 2015, Bigler et.al. 1992); pollution from coal, sand, and granite mining operations, chemical releases, erosion, sedimentation, agricultural, municipal sources, on-lot sewage, acid rain, and urban run-off (Risser and Siwiec 1996; PFBC 2015) ; and habitat loss/modification of natural systems due to dams and fragmenting of riverine habitat (PGC/PFBC 2015). Direct threats include impingement (at the intake structures for the Peach Bottom Nuclear Facility, Unit 3) (Criswell and Fischer 2012; RMC 1978) and stranding in shallow pools during mid-summer months (Hern 2011). Introduced aquatic species, such as the banded darter (*Etheostoma zonale*), greensides darter (*Etheostoma blennoides*), and mimic shiner (*Notropis volucellus*) have the potential to affect Chesapeake logperch through hybridization, vegetation removal, extirpation, introduction of foreign parasites and pathogens, habitat utilization shifts, competition, and ecological shifts (Ross 1991, Criswell and Fischer 2012, PFBC 2015).

If the Chesapeake logperch is to survive, it will take a concerted effort and commitment to improve water quality throughout the Chesapeake Bay watershed. Identified research needs include information on the species' life history, genetics, a relocation pilot study and refining the species range in Maryland. Conservation goals and actions include: protecting, conserving, and enhancing extant populations; reintroducing the species to historical range, or augmenting existing populations; monitoring; and protecting streams and habitat from agricultural and urban run-off (Kagel 2017).

Priority areas for Chesapeake logperch in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030613 Muddy Creek, 0205030615 Octoraro Creek, and 0205030617 Susquehanna River.

Monarch Butterfly (*Danaus plexippus*)
The monarch butterfly (*Danaus plexippus*) is one of the most recognizable species in North America. They are found throughout the United States and some populations migrate vast distances across multiple generations each year. Many monarchs fly between the United States, Mexico and Canada – a journey of over 3,000 miles, but this phenomenal journey has become more perilous for many monarchs because of threats along their migratory paths and on their breeding and wintering grounds. Threats include habitat loss and fragmentation – particularly the loss of milkweed, the monarch caterpillar's sole food source, pesticide use - which can

destroy the milkweed monarchs need to survive and indirectly cause monarch mortality, and a changing climate - which has intensified weather events that have an effect on monarch populations (USFWS, 2017a.)

Monarch populations have declined substantially over the last 20 years. So much so, that in 2014, the Service was petitioned to protect the monarch butterfly under the Endangered Species Act. Based on information in the petition, the Service determined that federally protecting the monarch may be warranted. An assessment to determine if the monarch requires Endangered Species Act protection using the Species Status Assessment framework is currently underway (USFWS, 2017a)

In the United States, there is a massive effort to provide habitat for monarch butterflies. There is no one group or agency responsible for providing habitat needed for monarch conservation. However, many organizations, agencies and individuals are working together to improve, restore and create grassland habitats and stands of milkweed to save monarchs (USFWS, 2017b)

Regal Fritillary Butterfly (*Speyeria idalia*)

The regal fritillary (*Speyeria idalia*) is known to occur at the Pennsylvania National Guard's Fort Indiantown Gap in Pennsylvania, and is the only known remaining viable population in the eastern United States. The Service received a petition dated April 19, 2013, from WildEarth Guardians, requesting that the regal fritillary be listed as endangered or threatened under the Endangered Species Act (WildEarth Guardians 2013).

The regal fritillary is found in grasslands in an old field succession stage. The sole larval host plant for regal fritillary is the violent (*Viola spp.*) and adults primarily feed on the nectar of butterfly milkweed (*Asclepias tuberosa*), common milkweed (*Asclepius syriaca*), thistle (*Cirsium spp*.), red clover (*Trifolium pretense*), and mountain mint (*Pycnanthemum spp.*). The regal fritillary's habitat and reproductive characteristics make it particularly vulnerable to extirpation. It lives in remnant prairie habitats, has an extended reproductive diapause (extended period of time between mating and laying eggs), and deposits its eggs throughout its habitat on the ground near host-plants rather than on the host-plants (Hovis 2011, Hovis 2017).

The Service continues to work with the Pennsylvania National Guard with ongoing monitoring and conservation efforts for the regal fritillary butterflies that occur there.

Priority areas for regal fritillary in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030506 Upper Swatara Creek and 0205030509 Lower Swatara Creek.

American shad (and cohorts)

American shad (*Alosa sapidissima*) are an anadromous, pelagic, highly migratory, schooling species (Colette and Klein-MacPhee, 2002). American shad spend most of their lives in marine waters, with adults migrating into coastal rivers and tributaries to spawn (Greene et al., 2009). On average, American shad spend 4 to 5 years at sea, and some individuals from the southernmost range may travel over 20,000 km during this time period (Dadswell et al., 1987). Researchers believe that the historical spawning range of American shad included all accessible rivers and tributaries along the Atlantic Coast (MacKenzie et al., 1985). Over the past 170 years, declines in American shad stocks have been attributed to overfishing, pollution, and habitat loss due to dams, upland development, and other factors. The American shad population drastically declined in 1928 when a large hydroelectric dam was built in the lower Susquehanna River, near the Town of Conowingo, Maryland. Specifically, declines in Susquehanna River shad can be attributed to poor efficiency of fish passage measures and facilities; low hatchery production in recent years; low numbers of spawning fish accessing quality upstream habitat; poor young-of-year recruitment upstream of Conowingo Dam; excessive ocean fishery mortality; and potentially high predation mortality (SRFAFRC, 2010). The shad cohort includes American shad, blueback herring (*Alosa aestivalis*), hickory shad (*Alosa mediocris*), and alewife (*Alosa pseudoharengus*).

The Susquehanna was once the Bay's most important river for spawning shad. The Pennsylvania canal system, built in the 1830s, required feeder dams that restricted migration to the lower 45 miles of the river. Later, four hydroelectric dams eliminated all shad runs in Pennsylvania (USFWS, 2017c). Overfishing, blocked passage to historical spawning grounds, river pollutants, domestic sewage, and inappropriate land use practices further degraded vital shad spawning grounds and hampered passage to these spawning grounds. Shad all but disappeared from the Susquehanna River by the 1930s (USFWS, 2017c). Coastal-wide assessments have indicated that shad stocks are are an all-time low, and do not appear to be recovering. The primary causes for stock declines include overfishing, pollution, and habitat losses due to dam construction (Altlantic States Marine Fisheries Commission 2017a). Shad restoration is currently underway in Pennsylvania. Success depends on improving water quality, preventing overfishing, and reopening spawning grounds, with the goal of self-sustaining runs of shad. Throughout the watershed, various entities have been removing or modifying fish passage barriers to open spawning areas to shad and other migratory fish. Dams still in use may require a fish ladder, a nature-like fishway, rock ramps, or fish lifts. Fishway removal is often paired with shad reintroduction (fertilized eggs, juvenile shad, or adult shad) (USFWS, 2017c).

Passage of migratory fish, especially in relation to shad restoration in the Susquehanna River, is a primary concern for the State of Pennsylvania. Over the past 45 years, state and Federal resource agencies, utilities, and citizen interest groups have committed to rebuilding shad populations in the Susquehanna River and have constructed and improved upstream and downstream fish passage at the four most downstream dams on the Susquehanna River, including the Conowingo Dam, the Holtwood Dam, the Safe Harbor Dam, and the York Haven Dam. Resource agencies have been working together with hydropower companies and others to establish shad passage, shad culture, and shad stocking programs to more effectively manage migratory fish resources in Pennsylvania. The shad restoration program goal is to reestablish an annual spawning population of 2 million shad and 20 million herring by 2025 (USFWS, 2005). According to the Atlantic States Marine Fish Commission, a successful shad restoration program should focus on reducing fishing mortality, enhancing fish passage at dams, mitigating dam-related fish mortality, encouraging stocking, and providing habitat restoration (2017a).

Priority areas for American shad in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030617 Susquehanna River, 0205030510 Susquehanna River, 0205010302 Choconut Creek-Susquehanna River, and 0205010409 Tioga River.

Priority areas for alewife/blueback herring in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030617 Susquehanna River and 0205030510 Susquehanna River.

American eel (*Anguilla rostrata*)
American eels were once abundant in estuaries and freshwater tributaries in much of the eastern U.S. and Canada (Eyler, 2014). American eels spawn in the Sargasso Sea, where newly-hatched larvae (leptocephali) begin their migration to coastal streams where they transform and move upstream, some travelling thousands of kilometers. Because they are migratory, they inhabit multiple habitats at different times during their lives.

The American eel population drastically declined when in 1928, a large hydroelectric dam was built in the lower Susquehanna River, near the Town of Conowingo, Maryland. Once completed, eels were no longer able to migrate upstream (SRAFRC, 2010). The dam was later retrofitted with a fish lift and can pass American shad and other anadromous fish however it is not able to pass migrating eels (SRAFRC, 2010). Currently, the American eel population is depleated in America's waters. Eel populations are at or near historically low levels due to a combination of historical over fishing, habitat loss, food web alterations, predation, turbine mortaility (from hydropower), enbironmental changes, toxins and contaminants, and disease (Altlantic States Marine Fisheries Commission 2017a).

The Service has been stocking eels from 2008 to 2016 in the Susquehanna River and transferring eels over dams in an effort to increase the population of eels in the upper watershed. A third party began managing this effort in 2017, with oversight from the Service (Mangold 2017 personal communication). According to the Atlantic States Marine Fish Commission, a successful eel restoration program should focus on assessing current stocks of eel for management use, and providing more protections for the spawning stock biomass (2017b)

Priority areas for American eel in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030617 Susquehanna River, 0207000411 Rocky Marsh Run-Potomac River, 0205030510 Susquehanna River, 0205010305 Pipe Creek-Susquehanna River, 0205010306 Cayuta Creek, 0205010409 Tioga River, 0205010505 Middle Chemung River, and 0205010506 Lower Chemung River.

Bald Eagle (*Haliaeetus leucocephalus*)
The bald eagle (*Haliaeetus leucocephalus*) is a species found throughout the United States usually occupying habitats close to large water bodies where they primarily forage for fish. Bald

eagles nest in mature trees within a half mile of their foraging areas preferring to nest in the tallest canopy tree or along an open forest edge. Eagle nest sites and communal roost areas require natural protection buffers to avoid being disturbed from commercial and residential development and other associated human activities. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA) from a variety of human induced conditions and activities.

In 2007, the Service removed the species from the list of threatened and endangered species, created National Bald Eagle Management Guidelines, and promulgated new rules under BGEPA (in 2012) to permit incidental take of eagles during activities of otherwise, lawful projects.

The guidelines advise landowners and land managers with measures on how to avoid and minimize disturbance to nesting eagles on private and federal lands. A variety of human actions can potentially interfere with bald eagles, affecting their ability to forage, nest, roost, breed, or successfully raise young. The guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute “disturbance,” which is prohibited by the Eagle Act. All bald eagle nest trees including the 660-foot concentric circular forest buffer surrounding the nest, are federally protected and therefore considered as areas restricted from development unless authorized by issuance of an Eagle Act Permit. Proposed projects in the Chesapeake Bay watershed region must consider the protection standards for bald eagles which includes: time-of-year restriction from activities (December-June); habitat/nest protection buffers (330-foot and 660-foot zones); and Important High Eagle Use Areas (communal roosts/concentration areas).

Priority areas for bald eagle in Pennsylvania include Hydrologic Unit Codes (HUC): 0206000202 Elk River; 0205030617 Susquehanna River; 0206000201 North East River-Upper Chesapeake Bay; and 0207000411 Rocky Marsh Run-Potomac River.

Other Significant Habitat and Priorities

Freshwater mussels

Freshwater mussels (*Unionidae*) are one of the most endangered taxonomic groups in the United States. Approximately 12 species of unionids have been documented as residing in the Susquehanna River (Reese, 2017). Threats to mussels in this watershed include sedimentation, impediments to aquatic organism passage, pollution, and exotic species.

The function and value of freshwater mussels within the aquatic ecosystem are many. In general, freshwater mussels are indicators of aquatic health; they are natural filters and feed on algae and plankton, removing particulate matter from aquatic systems (Vaughn et al., 2008); and they are an important food source for many species of wildlife. Freshwater mussels have a unique life cycle in which their larvae attach to the gills of a fish where they hitch a ride while undergoing metamorphosis to the juvenile life stage. Each mussel species attaches to specific host fish species. Within the Susquehanna River watershed, mussel species of concern to

Pennsylvania include the eastern elliptio (*Elliptio complanata),* brook floater (*Alasmidonta varicosa*), and green floater (*Lasmigona subviridis).*

Eastern elliptio is a common freshwater mussel species in rivers draining to the Atlantic Ocean and is the dominant species of mussel in the Susquehanna drainage. However, eastern elliptio is much less abundant in the Susquehanna River in comparison with the nearby Delaware River. This lower abundance may be due to lack of recruitment (Reese, 2017). The lack of young eastern elliptio may be attributed to the loss of the American eel from the upper Susquehanna River basin due to damming by four large hydroelectric dams on the lower Susquehanna. American eel have been documented as the most successful host fish for eastern elliptio (Lellis et al., 2013) from the Susquehanna River watershed. However, following construction of the dams, Pennsylvania Fish and Boat Commission only stocked eels above the dams from 1936 to 1980 (SRAFRC, 2010). To boost the population of freshwater mussels (*Elliptio complanata*) upstream from hydroelectric dams, over 240,000 juvenile eels, or elvers, were stocked in tributaries of the Susquehanna River (Buffalo Creek in Union County and Pine Creek in Tioga County) between 2010 and 2013 as part of an ongoing effort to reintroduce eels and enhance mussel recruitment (USFWS, 2014). Since 2013, an additional 599,418 eels have been stocked in locations throughout the Susquehanna River watershed (USFWS, 2016). State and federal biologists hope that increasing the eel population will increase the recruitment of juvenile mussels.

On September 27, 2011 the U.S. Fish and Wildlife Service was petitioned to list 404 species as threatened or endangered (with or without critical habitat), two of which were the brook floater and green floater. The Service is currently conducting a Species Status Assessment for these two species to see if they are warranted for listing under the Endangered Species Act, or not. The assessment will be conducted from 2017 to 2018 with a decision in the fall of 2018.

Priority areas for freshwater mussels in Pennsylvania include Hydrologic Unit Codes (HUC): 0205030617 Susquehanna River and 0205030510 Susquehanna River.

Important Bird Areas

Pennsylvania developed the first statewide Important Bird Area (IBA) program in the country in 1996. The Ornithological Technical Committee (a group of scientific advisors) identified over 80 IBA sites encompassing over 2 million acres of Pennsylvania's public and private lands including migratory staging areas, winter roost sites, and prime breeding areas for songbirds, wading birds, and other species.

Penn's Woods are critical to many interior forest birds, providing nesting habitat to 17 percent of the world's scarlet tanagers (*Piranga olivacea*) and 9 percent of the wood thrushes (*Hylocichla mustelina*). The IBA program helps to promote proactive habitat conservation, benefiting birds and biodiversity, and has a primary focus on the most essential and vulnerable habitat areas. Designated IBA sites are the most critical regions in Pennsylvania for conserving bird diversity and abundance (Audubon, 2017).

Forest Habitat Management/Healthy Forest

Young forest management is an initiative to create and renew the young forest habitat in Pennsylvania. The following priority species benefit from managing forest habitat and maintaining a healthy forest/meadow matrix habitat:

American Woodcock (Scolopax minor)

The American woodcock (*Scolopax minor*), also known as timberdoodle, is a migratory shorebird that has adapted to forested habitats. It nests in young forests and old fields with courtship displays and nesting spanning 6 months, beginning in mid-winter in the south and extending into June in the north (Keppie and Whiting, 1994). Across its northern range, woodcock appear to be the earliest migrant species to breed. It is strongly associated with both upland and wetland habitat types. Woodcock are most abundant where available habitats include a mix of fields or openings, forests of different ages, and feeding habitat with moist soils and high shrub cover (Keppie and Whiting, 1994).

Since woodcock surveys began in 1966, it is estimated that woodcock populations have steadily decreased over the last quarter century and at rate of about 1 to 2 percent per year (Wildlife Management Institute, 2008) within their geographic range. Land use changes such as wetland drainage and land conversion from early successional to mature forest are likely causes of population declines (Case and Associates, 2010). As a result, national and international bird conservation organizations consider the American woodcock a species of continental concern, and protecting the woodcock is a high priority in its habitat ranges. There has been a loss of over 829,000 singing male woodcock since the early 1970s (Kelley et al., 2008).

The woodcock's decline is mostly attributed to loss of upland and wetland habitat. In particular, the loss of early successional forest due to forest and farmland maturation and a lack of adequate rotational cutting, especially in riparian areas (critical for breeding and migrating) have been critical. There has been a net loss of 2.3 million acres of early-successional habitats since the 1970s, resulting in declines of American woodcock and other birds that use this habitat (NAS, 2009).

Another threat identified is the decline in food supply (earthworms). It is suggested that changes in soil pH due to acid deposition has resulted in decreasing numbers of earthworms (NAS, 2009).

Climate change effects that modify water levels in rivers, lakes, and wetlands, result in direct habitat alterations. Changes in seasonal climate regimes could shift migration patterns of birds such as woodcock, and result in indirect adverse effects because of changes in food availability and/or reproductive success (Carey, 2009).

Woodcock populations were highest when working farms provided a mosaic of habitats including field edges, stream banks, orchards and fallow fields, pastures, reverting farm fields, and managed wood lots. Working farms and forestlands are still the best way to recreate the habitat mosaics of the past, and woodcock responds favorably to habitat improvements usually within a year of land management treatments (NRCS, 2010).

The Service, together with the Natural Resource Conservation Service (NRCS), works with public and private landowners to create a wide variety of woodcock habitat. The ultimate conservation goal is to halt the decline of woodcock populations and return them to densities which provide adequate opportunity for utilization of the woodcock and increase early successional habitat by 2022 (NRCS 2010).

Priority areas for woodcock are provided by county and include: Potter, Tioga, Lycoming, Clinton, Centre, Blair, Huntingdon, Mifflin, Juniata, Perry, Franklin, Fulton, Bedford, and Schuylkill Counties.

Golden-Winged Warbler (Vermivora chrysoptera)
The golden-winged warbler (*Vermivora chrysoptera*) is a small, neotropical migratory songbird that breeds in the United States in the Northeastern and Great Lakes regions and in the higher elevations in southeastern Canada and the southern Appalachians (Larkin, 2008). Males are slate gray in color with a white chest, black cheek and throat patches, and yellow patches on their crown, forehead, and wings. Females have grey cheek and throat patches and their back is generally olive in color with some yellow markings. Golden-winged warblers nest in uplands, marshes, and bogs, power line right-of-ways, and other areas with sparse tree cover and patches of shrubs. In uplands, they prefer areas in the early stages of succession, similar to the woodcock. These birds nest on the ground in a field or marsh generally at the base of ferns or briars. They are widely distributed throughout Pennsylvania but are rare in the northern tiers and absent in the southeast regions (Confer, 1992).

Pennsylvania has seen a 7.2 percent annual decline of golden-winged warbler populations. Likewise, populations throughout the Northeast show an annual decline of 7.5 percent (Sauer et al., 2007). The primary factors that are driving this trend include loss of breeding and wintering habitat, parasitism by brown-headed cowbirds (*Molothrus ater*) and hybridization with blue-winged warblers (*Vermivora cyanoptera*). There is a high probability that if immediate action is not taken, the golden-winged warbler will require protection under the Endangered Species Act (Larkin, 2008). In Pennsylvania, the golden-winged warbler is a priority species because of the degree of population decline, its priority status among our conservation partners, and the ability to deliver early-successional habitat restoration projects.

In northcentral Pennsylvania, the Partners for Fish and Wildlife Program prioritized two sites for golden-winged warbler habitat restoration. The first site is located at Bald Eagle State Park in northern Centre County and is part of an ongoing, multi-year early-successional habitat restoration project. The second site is located in Sproul State Forest in northern Centre County and western Clinton County and is included in habitat studies undertaken by Indiana University of Pennsylvania (IUP).

Priority areas for golden winged warbler are similar to that of the American woodcock (they prefer early successional habitat like the woodcock), and are provided here by county and include: Potter Tioga, Lycoming, Clinton, Centre, Blair County, Huntingdon, Mifflin, Juniata, Perry, Franklin, Fulton, Bedford, Schuylkill, and Sullivan Counties.

Cerulean Warbler (*Dendroica cerulea*)
The cerulean warbler **(***Dendroica cerulea***)** is a small neotropical migratory songbird that breeds in eastern North America and winters in middle elevations of the Andes Mountains in northern South America. This species has specific habitat preferences on both the breeding and wintering grounds, largely associated with mature forests having structurally diverse canopies with multiple vegetation layers. The species occupies two habitat types: river valleys and ridge slopes. Common tree species in bottomlands are American sycamore (*Platanus occidentalis*), cottonwood (*Populus spp.*), and elm (*Ulmus spp.*), while in uplands they use oaks (*Quercus spp.*), maples (*Acer spp.*), and black locust (*Robinia pseudoacacia*). This species is a canopy insectivore eating primarily caterpillars, beetles, wasps, and bees.

The cerulean warbler was once a common species of eastern North America, particularly in the Mississippi River and Ohio River valleys (Hamel, 2000a; 2000b). Cerulean warbler numbers have declined at the steepest rate of any North American warbler species monitored by the North American Breeding Bird Survey (BBS). It now is common only in the core of the range in the central portions of the Appalachian Mountains, particularly the Ohio Hills and Allegheny Plateau regions. This long-term, steep decline is one of the primary reasons for a high level of concern for this species (with listings as Partners in Flight Priority, species requiring immediate management, a Pennsylvania Watch List species, and a High Level Concern Species). The core breeding habitat of this species coincides with a major natural gas deposit currently being developed. Creation of the extraction infrastructure results in permanent loss of woodlots and fragmentation of forests on ridgetops and riparian corridors (Hamel, 2000a; 2000b).

Other forest species that will benefit from cerulean warbler habitat conservation and enhancement include Kentucky warbler (*Geothlypis formosa*), Canada warbler (*Cardellina canadensis*), yellow-throated warbler (*Setophaga dominica*), worm-eating warbler (*Helmitheros vermivorum*), black-throated blue warbler (*Setophaga caerulescens*), Louisiana waterthrush (*Parkesia motacilla*), yellow-throated vireo (*Vireo flavifrons*), scarlet tanager (*Piranga olivacea*), northern goshawk (*Accipiter gentilis*), red-shouldered hawk (*Buteo lineatus*), broad-winged hawk (*Buteo platypterus*), Indiana bat , northern long-eared bat, and eastern small-footed bat (*Myotis leibii*) (PGC and PFBC, 2015).

Cerulean warblers have specific habitat preferences within mature forests - tall, large diameter trees and a structurally diverse canopy with multiple vegetation layers (Oliarnyk and Robertson 1996; Jones and Robertson, 2001; Nicholson, 2003). Throughout much of their breeding range, they exhibit a preference for nesting within large forest patches (Hamel 2000a; 2000b). Cerulean warblers avoid abrupt edges between forests and large areas of open land. Threats to this species include loss of mature deciduous forest, forest fragmentation, and loss of diverse, multi-layer vegetation within mature deciduous forest (USFWS,2007b).

Other threats include: potential effects from climate change such as shifts in location of suitable forest types and timing of emergence of insects in the spring; risks from collisions with towers including gas drilling rigs, wind farms, communications towers; mercury contamination; and acid deposition. In addition to suppressing the regeneration of acid sensitive plants within forest habitat, acid deposition could be a threat to the cerulean warbler and other priority birds through reductions in available calcium and increases in the availability of toxic metals (PGC and PFBC, 2015). Air emissions, excessive noise, and light pollution from gas compressor stations and drill pads throughout the breeding habitat could affect habitat use and nest abandonment (PGC and PFBC, 2015).

Priority areas for cerulean warbler are similar to the American woodcock and the golden-winged warbler (but they prefer more mature forested areas), and are provided here by county and include: Potter, Tioga, Lycoming, Clinton, Centre, Union, Blair, Huntingdon, Mifflin, Juniata, Perry, Franklin, Fulton, Bedford, Dauphin, Schuylkill, and Snyder Counties.

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Chapter 7. New York
The Upper Susquehanna River watershed in New York is located in the southern tier portion of New York State and includes two major sub-watersheds - the Susquehanna River and Chemung River watersheds. The watershed is almost entirely within the Glaciated Allegheny Plateau. The headwaters of the Upper Susquehanna River begin in Cooperstown, New York, and the river flows approximately 444 miles south to the northern end of the Chesapeake Bay in Maryland. The River flows into Pennsylvania, loops back into New York at Great Bend, Pennsylvania, then flows south again and joins the Chemung River in Sayre, Pennsylvania (SRBC 2017). Major tributaries to the Upper Susquehanna River in New York include Chenango, Tioughnioga, and Unadilla Rivers. Major cities along the route include Binghamton, Johnson City, Endicott, Cortland, and Oneonta.

All of, or portions of, 19 counties are located within the Upper Susquehanna River watershed boundary. These counties are Allegany, Broome, Chemung, Chenango, Cortland, Delaware, Herkimer, Livingston, Madison, Oneida, Onondaga, Ontario, Otsego, Schoharie, Schuyler, Steuben, Tioga, Tompkins, and Yates.

Land use within the watershed has changed over the years since the late 19th century, when greater than 90 percent of the watershed was cleared for agriculture. Today it is 70 percent deciduous, mixed, and evergreen forests and 27 percent agriculture. It contains 20,000 acres of lakes and 11,000 miles of mapped streams. About 640,000 people live in New York's portion of the watershed (NYSDEC 2005).

REFUGES
There are no National Wildlife Refuges in the New York portion of the Upper Susquehanna River.

CBRA
There are no CBRA resources in the New York portion of the Upper Susquehanna River.

THREATENED AND ENDANGERED SPECIES
There are two threatened and endangered species within the Upper Susquehanna watershed boundary in New York. This section describes the life history and identifies the major stressor(s) that adversely affect these species. The section identifies two categories of threatened and endangered species, those that are directly associated with aquatic habitats and those that are not. Those that are not directly associated with aquatic habitats may still have indirect interactions with aquatic habitats, but their life histories are not directly tied to those aquatic habitats

Non-Aquatic Threatened and Endangered Species
Non-aquatic threatened and endangered species are species that are not directly tied to aquatic systems. The species identified below may opportunistically use aquatic systems for forage areas or other life history activities, however, these species are not dependent on aquatic systems. Although these species are not directly related to aquatic systems they need

to be considered during all specific projects that occur as a result of the Chesapeake Comprehensive Plan.

Northern Long-Eared Bat

The northern long-eared bat, federally listed as threatened in 2015 (USFWS, 2016), is a medium-sized bat that uses caves and mines for hibernacula during the winter months and commonly roosts in trees under the bark or close to the tree trunk during the summer (Wisconsin Department of Natural Resources, 2013). Although this species is not directly tied to riverine habitat within the Upper Susquehanna watershed, it may opportunistically use aquatic systems (i.e., for forage areas or other life history activities). The distribution range of the northern long-eared bat spans much of Canada, including all territories except Nunavut, Canada, and the United States from Maine to North Dakota and extending south to Wyoming, Nebraska, Kansas, Oklahoma, Louisiana, and all states further east to the coast (USDA Forest Service, 2014).

The main threats to the northern long-eared bat are white-nose syndrome, habitat degradation caused by increased agricultural and household pesticide use, and hibernaculum disturbance (Wisconsin Department of Natural Resources, 2013).

White-nose syndrome is the primary threat to this species and other cave/mine hibernating bats. The Service continues to work on understanding white-nose syndrome in order to reduce its impact on bat populations. Habitat degradation (tree removal) associated with human activities is also a factor. Suitable habitat for the northern long-eared bat includes forested areas with trees greater than 3 inches in diameter.

The goal of the northern long-eared bat recovery program is to continue researching white-nose syndrome and protect and maintain the remaining populations and habitat so this species can recover to the point of delisting and be removed from Endangered Species Act protection. In addition, we continue to work with conservation partners on habitat preservation, best management practices, and research and conservation projects to protect this species.

To reduce impacts to northern long-eared bats, the Service suggests that any priorities the U.S. Army Corps of Engineers undertakes in northern long-eared bat habitat occur in the fall/winter (between October 1 and March 31) while bats are hibernating, and outside the pup rearing season (during June-July). In addition, suitable roost trees and forest blocks should be preserved on the landscape, if possible, to provide summer habitat.

Priority areas for northern long-eared bats in New York include Hydrologic Unit Codes (HUC): 205010403 Tuscarora Creek, 205010404 Canisteo River, and 205010408 Cowanesque River.

Aquatic Threatened and Endangered Species

Aquatic threatened and endangered species listed below are species have some or all of their life history tied directly to the aquatic systems.

Northeastern Bulrush (*Scirpus ancistrochaetus*)
The northeastern bulrush (*Scirpus ancistrochaetus*) was federally listed as endangered in 1991 (USFWS, 1991). It is a plant species that relies on the seasonally occurring ponds (Lentz and Dunson, 1999). Northeastern bulrush grows approximately 80-120 cm in height (Lentz and Dunson, 1999), with the lowermost leaves being much longer than they are wide and the uppermost leaves being narrower and somewhat shorter than the lower leaves. The bulrush flowers from mid-June to July and has an umbellate inflorescence that bears clusters of brown spikelets. Its fruit sets between July and September and has yellow-brown achenes that are obovate and thickened above the seed (USFWS, 1993).

This species tends to grow in acidic to circumneutral areas, with sites varying geographically from sinkhole ponds in the southern portion of the range to various other wetland types in the northern portions (USFWS, 1993; USFWS, 2017). The wetlands inhabited by the northeastern bulrush seem to be fed primarily from surface water, and can vary greatly within a season (Lentz and Dunson, 1998). Distribution is thought to be influenced by light availability. Northeastern bulrush can usually be found in areas with less than 60 percent canopy cover. Populations of northeastern bulrush can be found in West Virginia, Virginia, Maryland, New York, Pennsylvania, Massachusetts, Vermont, and New Hampshire; with the majority of populations found in Pennsylvania (Lentz, 1999).

The most immediate threat to the northeastern bulrush in New York is destruction or modification of habitat. Wetland filling, draining, and dredging for developmental, agricultural, and recreational purposes are the primary forms of habitat destruction (USFWS, 1993). Logging and road construction may also threaten population persistence (Lentz and Dunson, 1998). Little is known about the life history, which makes conservation and management of this species more challenging.

The goal of the northeastern bulrush recovery program is to protect and maintain the species and its habitat so it can eventually be removed from Endangered Species Act protection. A population was rediscovered in the Upper Susquehanna watershed in New York in 2010. The New York population is located on private land which is currently undeveloped.

Priority areas for northeastern bulrush in New York include Hydrologic Unit Codes (HUC) 205010409 - Tioga River.

NORTHEAST REGION PRIORITIES

Landscape Conservation

Landscape Conservation - Appalachian Landscape Conservation Cooperative

The Upper Susquehanna River watershed lies within the geography of the Appalachian Landscape Conservation Cooperative (LCC). The LCC is a conservation partnership, consisting of federal agencies, states, universities, and private organizations working collaboratively to develop scientific information and tools needed to prioritize and guide conservation actions in the Appalachian Region. The LCC uses applied science and management partnerships and works to protect natural lands, valued resources, and the biological diversity that provides environmental benefits and services to communities across the region.

Landscape Conservation - Landscape Level Initiatives
Landscape conservation initiatives being undertaken by the Service in the watershed include the Service's Pollinator Initiative, the Eastern Brook Trout Joint Venture, the Black Duck Joint Venture, and the Partners in Flight Initiative. The New York Field Office (NYFO) is also working on these initiatives and the following conservation efforts at the local scale.

In 2015, the New York State Department of Environmental Conservation (NYSDEC) completed a draft final State Wildlife Action Plan (SWAP) which includes identified actions for the Susquehanna River. The Service approved the SWAP in April of 2016. Actions proposed include: restoring aquatic habitat connectivity for American eel migration; surveying extant populations and restoring historic habitat of comely shiner; assessing swallowtail shiner population and habitat; continuing eastern hellbender headstarting project; surveying for the presence of green floater mussel; continuing the Eastern Brook Trout Joint Venture; and protecting habitats of freshwater mussel species of greatest conservation need

Landscape Conservation - New York Field Office Strategic Plan
The New York Field Office's Strategic Plan identified this watershed as a Priority Area to protect ecologically sensitive terrestrial and aquatic species, including endangered and threatened plants and animals, and to maintain or restore their habitats. Habitats include wetlands, rivers and streams (and floodplains), early successional upland habitat, and upland and lowland forest blocks (https://www.fws.gov/northeast/nyfo/Full%20report%202014%20Web.pdf).

In order to implement the Strategic Plan, the NYFO identified partners that were willing to work together and actively seek, promote, and protect natural resources in the watershed. This partnership organization is called the Upper Susquehanna Conservation Alliance (USCA).

Landscape Conservation - Upper Susquehanna Conservation Alliance (USCA)
The USCA is an alliance of agencies, organizations, academic institutions, and individuals, who work collaboratively to conduct green infrastructure planning, implement restoration and maintenance of high quality waters and habitats, protect and restore species of greatest conservation need (SGCN), reduce impacts of flooding, and promote sustainable working landscapes for the people of the watershed. The USCA began in 2010 and has been meeting annually or biannually since its inception. Members establish joint priorities, providing funding, in-kind services such as staff time, equipment, or supplies. Additional information on the USCA priorities is described below.

The USCA has seven work groups to address the following issues: landscape conservation planning (GIS), flooding issues, roadside ditch management (water quality and quantity), invasive species, outreach, fields to young forests (early successional habitat), and natural resources such as brook trout (*Salvelinus fontinalis*), eastern hellbender (*Cryptobranchus alleghaniensis alleghaniensis*), pearly mussels (Unionoida). Other priority species include American eel (*Anguilla rostrata*), American shad (*Alosa sapidissima*), American woodcock

(*Scolopax minor*), and northeastern bulrush.

The USCA work groups identify threats and stressors throughout the basin and discuss ways to combat these threats. They develop creative ways to fund projects by pooling resources to implement conservation projects. Potential threats to fish and wildlife resources identified by the USCA include certain practices associated with energy production, agricultural runoff, transportation, flood control structures such as levees and dams, and commercial and residential development. Major contributors that impact water quality are sediment, sewage, manure, and fertilizers.

The USCA works with land trusts like the Otsego Land Trust and Finger Lakes land Trust (FLLT) to identify land conservation priorities and land protection opportunities. The USCA assisted the FLLT in identifying the following conservation priorities: the Upper Cohocton River Wetlands, Mud Creek Watershed, Six Nations Forest Block, Canisteo River Valley, Erwin Forests, Chemung River Valley, Upper Cayuta Watershed, Upper Catatonk Watershed, Owego Creek, Otselic River Watershed, and the East Branch of the Tioughnioga River Watershed. These areas represent the best remaining natural resources in the Upper Susquehanna watershed, supporting resources such as large forest blocks, wetlands, trout streams, rare species, bird concentration areas, unique natural areas, and wildlife corridors (FLLT, 2012).

Flood Resiliency

The Flood Work Group of USCA works to identify priority floodplain areas for protection and find ways to protect key floodplain areas that provide critical services such as flood attenuation and water filtration. This group provides educational support for training, including the Upper Susquehanna Coalition training on Emergency Stream Intervention, promotes flood resilience through outreach, and serves as a forum for exchange of information and ideas.

Flood control dams, flood walls, and levees have been constructed in key cities in the watershed, like Binghamton and Whitney Point. Landowners have channelized and culverted streams, removed riparian vegetation, and tried to stabilize streams through channelization, using rock rip rap, gabion baskets, and concrete walls, all to reduce flooding. Unfortunately these attempts to reduce flooding, in conjunction with more frequent, greater intensity storms, have exacerbated erosion and sedimentation. Efforts are needed to provide flood resiliency and reduce flood damage, by including increasing the size of culverts, restoring the more natural character of streams, reconnecting streams to floodplains, and managing infrastructure in flood-prone areas.

Threats

The Chesapeake Bay Program lists 24 threats for the Chesapeake Bay Watershed, 20 of which relate to the New York portion of the upper headwaters of the Bay. These threats include, but are not limited to, agriculture, climate change, dams, development, invasive species, nutrients, and population growth.

Climate Change

Climate change is a major concern for the Upper Susquehanna watershed as it poses a threat to the watershed, its species, and their habitats. In New York, the annual average temperatures statewide have increased about 2.4 degrees Fahrenheit (F) since 1970, with winter warming exceeding 4.4 degrees F. The overall precipitation has also increased in the winter and decreased in the summer. Between 1958 and 2010, the amount of precipitation falling in heavy events increased more than 70 percent across the northeast United States (NYSDEC, 2017a). Spring begins earlier, winter snow is decreasing, pollinators (bees) arrive about 10 days earlier than they did in the 1880s, and the breeding bird population ranges have shifted northward over the last several decades. In the future, it is anticipated that these trends will continue. Carbon dioxide (and other greenhouse gases) will remain in the atmosphere, even with reduced emissions, temperatures will continue to increase approximately 3 degrees by the 2020s, and 10 degrees by 2080s, and growing seasons are expected to be about a month longer by 2100, with extreme heat waves and milder winters. Predictive models show that New York precipitation will increase 8 percent by 2020s, 15 percent by 2080s (NYSDEC, 2017a).

Invasive Species

Terrestrial and aquatic habitats have become degraded or choked-out when invasive plant species out- compete the natural plant communities. Transportation of seeds, rootstock and non-native plants have greatly impacted the native plant community. Phragmites, (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and Japanese knotweed (*Polygonum cuspidatum*) are highly destructive terrestrial invasive species that are difficult to control. Japanese knotweed spreads rapidly, forming dense thickets that crowd and shade out native vegetation. This reduces species diversity, alters natural ecosystems, and negatively impacts wildlife habitat. The ground under knotweed thickets tends to have very little other growth. This bare soil is very susceptible to erosion, posing a particular threat to riparian areas. Once established, populations of Japanese knotweed are extremely persistent and hard to eradicate (Cornell, 2017). Nutrient loading and development in wetlands also promote invasive plant species like Phragmites sp. and Typha species, both of which have native and exotic species (varieties) present in New York. Emerald ash borer (*Agrilus planipennis*) and gypsy moth (*Lymantria dispar*) are pests recorded in New York that have greatly impacted tree species (such as Fraxinus sp.) and created a large gap in the forest that will eventually be replaced by healthy, opportunistic species.

Aquatic invasive species in the Upper Susquehanna watershed include, but are not limited to, zebra mussels (*Dreissena polymorpha*), quagga mussels (*Dreissena rostriformis bugensis*), rusty crayfish (*Orconectes rusticus*), water chestnut (*Trapa natans* L.), didymo (*Didymosphenia geminata*), and the recently discovered hydrilla (*Hydrilla verticillata*) (Cornell, 2017; Walsh, 2017).

The New York State Partnership for Invasive Species (Finger Lakes PRISM) is working with the USCA to research and treat, if possible, invasive species in the watershed. Currently, the USCA Invasive Species group is focusing on hydrilla as it is found in one location.

Aquatic Connectivity

Aquatic connectivity is an issue of concern in the Upper Susquehanna watershed for species like brook trout, eastern hellbender, American eel, American shad, and freshwater mussels (and their host fish). These species would benefit from Corps restoration activities that restore habitat and aquatic connectivity. The Service is working with the USCA partners like Trout Unlimited, New York State Department of Transportation, NYSDEC, and the Nature Conservancy to identify barriers to fish and other aquatic species, as well as areas where we can implement restoration and habitat improvement projects to support sustainable brook trout populations and provide passage for host fish. The USCA is also evaluating regulatory mechanisms, such as the water classification of streams, to determine whether revised classification may enable us to justify and find financial resources to improve aquatic connectivity.

Aquatic Passage Barriers

In 2008, a report was published by the Service and NYSDEC entitled "A Strategy for Removing or Mitigating Dams in New York State and Lessons Learned in the Upper Susquehanna Watershed" (USFWS, 2008). This report points out that power generation, water supply, recreation, navigation irrigation, and flood control dams impact fish passage. In the Upper Susquehanna watershed, the Service piloted a Site Assessment Tool and evaluated 94 dams in 7 counties. Nine dams were identified in the Upper Susquehanna watershed as the highest priority for removal or modification for fish passage (Table 1).

Table 1: Highest Priority Dams for Fish Passage/Removal in Upper Susquehanna Watershed of New York.

Dam Name	Waterway	Function	Priority-Options	Dam #	Longitude	Latitude
Rock Bottom	Susquehanna R.	Water Supply	H - Fishway	NY01054	-75.90333	42.095
Willow Point	Susquehanna R.	Water Supply	M - Notch	NY11990	-75.9875	42.11278
American Legion	Canasawacta Ck.	Recreation	M - Removal	NY12128	-75.53444	42.53472
Center Village	Susquehanna R.	Non-functional	M - Removal	NY00351	-75.605	42.16833
Chase Hibbard	Chemung R.	Water Supply	H - Fishway & Portage	NY11370	-76.81028	42.08528
Upper Candor	Catatonk Ck.	Unknown	M - Passage	NY00938	-76.34278	42.235
Newton Fish Line	Tioughnioga R.	Unknown	M - Removal	NY11753	-76.1825	42.62583
East River Mill	Tioughnioga R.	Unknown	M - Removal	NY14250	-76.11639	42.65
M Robert Beach	Thomas Ck.	Recreation	M - Passage or Removal	NY11989	-75.87833	42.18333

The Service recommends that the Corps consider this report and its recommendations during project planning. The USCA groups could provide assistance to the Corps when planning structural and non-structural projects in the Upper Susquehanna Basin.

Roadside Ditches

The USCA Roadside Ditch Work Group evaluates roads and roadside ditches that contribute to surface water runoff carrying nutrients and pollutants into the watershed. There are approximately 13,000 miles of roads in the watershed. The Roadside Ditch Work Group is working with partners to identify road networks with ditch systems that contribute much of the nutrients and pollutants into the tributaries and mainstem river. Once the high priority areas are identified and mapped, the group will set up training workshops for local planners and highway departments to educate them on best management practices for ditch maintenance, culvert replacements, bridge replacements, and sediment and erosion controls to reduce negative effects from roads and ditches.

At-Risk Species

Eastern Brook Trout (*Salvelinus fontinalis*)

The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and federal agencies, regional and local governments, businesses, conservation organizations, academia, scientific societies, and private citizens (EBTJV, 2017). The EBTJV is dedicated to protecting, restoring, and enhancing aquatic habitat within the eastern brook trout's range, and is modeled after the joint ventures created in support of the North American Waterfowl Management Plan. Working at a variety of geographic and jurisdictional scales, the EBTJV works within a non-regulatory framework to secure adoption of policies that support protection of aquatic habitats and accomplish measurable conservation gains. The EBTJV seeks to secure populations of wild brook trout, aid in the restoration of watershed integrity, protect water quality, and enhance human connections to and stewardship of our natural environment through collaboration among its partners (EBTJV, 2017). The brook trout is a priority species for the USCA as well.

Priority areas for brook trout in New York include Hydrologic Unit Codes (HUC): 205010112 Middle Susquehanna River, 205010201 East Branch Tioughnioga River, 205010203 Otselic River, 205010204 Tioughnioga River, 205010205 Upper Chenango River, 205010206 Middle Chenango River, 205010207, Genegantslet Creek, 205010208 Lower Chenango River, 205010301 Nanticoke Creek, 205010303, Catatonk Creek, 205010304 Owego Creek, 205010305 Pipe Creek-Susquehanna River, 205010306 Cayuta Creek, 205010401 Canacadea Creek, 205010402 Bennetts Creek, 205010404 Canisteo River, 205010501 Upper Cohocton River, 205010503 Lower Cohocton River, 205010504 Upper Chemung River, 205010505 Middle Chemung River, 205010101 Canadarago Lake, 205010102 Cherry Valley Creek, 205010103 Schenevus Creek, 205010104 Charlotte Creek, 205010105 Otego Creek, 205010106 Headwaters Susquehanna River, 205010107 Wharton Creek, 205010108 Butternut Creek, 205010109 Unadilla River, 205010111 Upper Susquehanna River, 205010113 Lower Susquehanna River, 205010307 Wappasening Creek-Susquehanna River, 205010408 Cowanesque River, and 205010409 Tioga River.

American shad (Alosa *sapidissima*)

American shad are an anadromous, pelagic, highly migratory, schooling species (Colette and Klein-MacPhee, 2002). American shad spend most of their lives in marine waters, with adults migrating into coastal rivers and tributaries to spawn (Greene et al., 2009). On average, American shad spend 4 to 5 years at sea, and some individuals from the southernmost range may travel over 20,000 km during this time period (Dadswell et al., 1987). Researchers believe that the historical spawning range of American shad included all accessible rivers and tributaries along the Atlantic Coast (MacKenzie et al., 1985). According to historical newspaper and anecdotal sources, the Susquehanna River in New York supported spawning runs of American shad and river herring (*Alosa sp.),* with fish migrating as far upstream as Cooperstown, New York. Over the past 170 years, declines in American shad stocks have been attributed to overfishing, pollution, and habitat loss due to dams, upland development, and other factors (Limburg et al., 2003). Specifically, declines in Susquehanna River shad can be attributed to poor efficiency of fish passage measures and facilities; low hatchery production in recent years; low numbers of spawning fish accessing quality upstream habitat; poor young-of-year recruitment upstream of Conowingo Dam; excessive ocean fishery mortality; and potentially high predation mortality.

The Service is working with partners to restore this species to the Upper Susquehanna Basin by addressing threats to this species, particularly structures that pose a barrier to migration (flood control and hydroelectric dams in the lower part of the watershed), and sources that degrade water quality. Limited stocking of American shad has occurred in the Upper Susquehanna watershed.

Priority areas for American shad in New York include Hydrologic Unit Codes (HUC): 205010106 Headwaters Susquehanna River, 205010302 Choconut Creek-Susquehanna River, and 205010409 Tioga River.

American Eel (*Anguilla rostrata*)
American eels are catadromous (spawn in saltwater and spend most of their lives in freshwater) and need river migration corridors in order to carry out their unique life history. Eels spawn in the Sargasso Sea; leptochephali drift northward in the Gulf Stream and then transform into glass eels that migrate up into coastal streams to mature. The American eel populations in the Susquehanna River were abundant in the early 1920's (SRAFRC, 2010). Major stressors that have negatively influenced the population are large hydroelectric and water storage dams. Eel populations drastically declined in 1928 when a large hydroelectric dam, Conowingo Dam, was built near the mouth of the Susquehanna River in Maryland. Once completed, eels were no longer able to migrate upstream and populations in New York drastically declined. The dam was later retrofitted with a fish lift and can pass American shad and other anadromous fish; however, it is not able to pass migrating eels (Minkkinen et al., 2010).

Prior to dam construction, the annual harvest of silver eels (young eels) in the Susquehanna River was nearly one million pounds (Minkkinen et al., 2010). Barriers to migration limit eels to available habitat and they are observed at the bottom of dams, unable to migrate upstream. Removing barriers not in use or transporting eels around the dams are conservation actions that may help restore miles of upstream riverine habitat and restore eel populations in the Upper Susquehanna River.

The Service has been stocking American eels in the Susquehanna River in upstream tributaries and transferring eels over dams in an effort to increase the population of eels in the upper watershed. In addition, the Service is requiring fish passage during federal relicensing through Section 18 of the Federal Power Act.

The American eel is a host fish for the glochidia (larval stage) of the mussel (*Elliptio complanata*) a species demonstrating extremely low recruitment (Lellis et al, 2013). Restoration of American eel populations would also benefit this mussel species.

The Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC) reports current regulations in New York allow for year-round harvest of eels, both commercial and recreational harvest. There are management plans for American eel, similar to American shad; however, population goals have yet to be determined for eel (SRAFRC, 2010).

Priority areas for American eel in New York include Hydrologic Unit Codes (HUC): 205010201

East Branch Tioughnioga River, 205010202 West Branch Tioughnioga River, 205010203 Otselic River, 205010205 Upper Chenango River, 205010206, Middle Chenango River, 205010208, Lower Chenango River, 205010303 Catatonk Creek, 205010304 Owego Creek, 205010305 Pipe Creek-Susquehanna River, 205010306 Cayuta Creek,205010404 Canisteo River, 205010501, Upper Cohocton River, 205010503 Lower Cohocton River, 205010504 Upper Chemung River, 205010505 Middle Chemung River, 205010101 Canadarago Lake, 205010102 Cherry Valley Creek, 205010105 Otego Creek, 205010106 Headwaters Susquehanna River, 205010109 Unadilla River, 205010111 Upper Susquehanna River, 205010409 Tioga River, 205010506, and Lower Chemung River.

Freshwater Mussels

Freshwater mussels (*Unionidae*) are one of the most endangered taxonomic groups in the United States due to loss of habitat and degraded water quality. Dams, sedimentation, collection are the main causes of their decline. Approximately 12 species of unionids have been documented in the Upper Susquehanna River watershed (Strayer, 1999), including rare species, such as the brook floater (*Alasmidonta varicosa*), the wavy-rayed lampmussel (*Lampsilis fasciola*), and the green floater (*Lasmigona subviridis*), all are New York listed Species of Special Concern.

It has been hypothesized that the documented decline in the freshwater mussel *Elliptio complanata* may be due to the lack of eels serving as hosts for glochidia (Harman and Lord, 2010). In addition to barriers to migration, which limit the number of American eel in the upper watershed, current regulations in the New York portion of the Susquehanna River drainage allow for both commercial and recreational harvest of American eels. Year-round eel harvest by recreational anglers is currently allowed subject to a 6-inch minimum size limit and a daily limit of 50. Commercial harvest is also permitted through special licenses issued at the discretion of the NYSDEC. These licenses provide for the use of both eel pots and eel weirs.

The USCA Mussel Work Group is working to conduct presence/absence surveys of mussel species of greatest conservation need, close data gaps, evaluate species diversity and richness, identify fish hosts for glochidia for each mussel species, identify mussel beds, water quality issues, and determine potential restoration and preservation opportunities in the basin. The group identified the brook floater and green floater mussels as priority species in the Upper Susquehanna Basin. The mussel work group received funding from the Service in 2015 for eel/mussel research and again in 2016 to study *Elliptio complanata* life history characteristics. The group plans to continue to work with USCA partners, the regional brook floater and green floater working group, and other researchers to identify effective conservation actions that will protect freshwater mussels in the Upper Susquehanna watershed.

The Service is currently conducting a Species Status Assessment for the brook floater and green floater to determine if they are warranted for listing under the Endangered Species Act. The assessment will be conducted from 2017 to 2018 with a decision in the fall of 2018. There are no HUC codes provided for these species in the New York Section of this report, as they occur throughout the Upper Susquehanna watershed in New York. The Service recommends that the

Corps consider freshwater mussels during project planning.

Eastern Hellbender (*Cryptobranchus alleghaniensis alleghaniensis*)
The eastern hellbender is the largest, fully aquatic salamander in the United States. This species can be found inhabiting cool to warm water streams and rivers, and uses a variety of microhabitats including large cover rocks, sunken logs, undercut banks, and underwater talus piles for shelter. They typically feed on crayfish, fish, frogs, and invertebrates (NYSDEC 2017b). Historically, the eastern hellbender's range extended to 15 states, within 4 large river basins; the Ohio, the Tennessee, the Susquehanna, and the Mississippi. Currently, it can be found in about 420 streams from southwestern and south central New York, west to Missouri, and south to extreme northeastern Mississippi and the northern parts of Alabama and Georgia. Hellbenders are known to occur in the counties of Allegany, Broome, Cattaraugus, Chenango, Otsego, and possibly Tioga and Delaware.

The USCA Hellbender Work Group is working to further conduct presence/absence surveys, identify suitable habitat for hellbenders and areas for habitat restoration, develop primers for environmental DNA (eDNA) and other detection methods to conduct presence/absence surveys, identify areas for habitat restoration, and develop a management plan including husbandry and captive rearing techniques.

Although hellbenders are not currently listed as threatened or endangered under the Endangered Species Act, or by the state of New York, the state did designate the hellbender as a special concern species in 1983 (NYSDEC, 2017b). The hellbender is listed as endangered in the states of Maryland, Ohio, Illinois, and Indiana and is listed as threatened in Alabama. The Service considers it a priority species for conservation efforts. It is currently undergoing a Species Status Assessment by the Service to determine if federal listing is warranted.

Threats to the eastern hellbender include water quality degradation (sedimentation, nutrients, pollution), water availability (potentially affected by water withdrawals for energy production, mining operations, and other human uses), pathogens, severe drought, and habitat loss/modification of natural systems (dams fragmenting riverine habitat). Direct threats include mortality from accidental angler bycatch and increased flooding which can eliminate entire colonies. Introduced invasive aquatic species also have the potential to affect the eastern hellbender by habitat alteration, extirpation, introduction of foreign parasites and pathogens, habitat utilization shifts, competition, and ecological shifts (PGC and PFBC, 2015).

If the eastern hellbender is to survive in the Upper Susquehanna watershed, it will take a concerted effort and commitment to work toward improved water quality, which is the primary threat for this species. In New York, continued surveys and long-term monitoring of populations within the Allegheny and Susquehanna River drainages are essential for developing a recovery plan for this species. Of particular importance is an investigation of larval and juvenile habits, survivorship, and habitat use to provide insight into the hellbender's life cycle. Anglers fishing in hellbender habitat should be educated to understand that these salamanders are not dangerous, nor do they deplete game fish populations. Captive breeding programs coupled with habitat cleanup and reestablishment of riffle areas, and adequate stream flow may improve survivorship for this species, especially juveniles. Better understanding of how pathogens and invasive species impact hellbender populations is also a priority for conservation planning efforts, in particular as it relates to success of captive breeding programs.

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Appendix A. Table summary of Service resources by state and HUC

STATES	HUC10 NUMBER	HUC10 NAME	SPECIES NAME	SPECIES COMMON NAME	T&E STATUS	MAP LABEL
DC,MD	0207001002	Anacostia River	Myotis septentrionalis	Northern Long-eared bat	LT	DC2
DC,MD	0207001002	Anacostia River	Stygobromus kenki	Kenk's amphipod		DC2
DC,MD,VA	0207000810	Difficult Run-Potomac River	Myotis septentrionalis	Northern Long-eared bat	LT	MD6
DC,MD,VA	0207001001	Rock Creek-Potomac River	Stygobromous hayi	Hay's Spring amphipod	LE	DC1
DC,MD,VA	0207001001	Rock Creek-Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	DC1
DC,MD,VA	0207001001	Rock Creek-Potomac River	Stygobromus kenki	Kenk's amphipod		DC1
DE,MD	0206000203	Sassafras River	Acipenser brevirostrum	Shortnose sturgeon	LE	DE3
DE,MD	0206000203	Sassafras River	Cicindela puritana	Puritan tiger beetle	LT	DE3
DE,MD	0206000203	Sassafras River	Anas rubripes	American black duck		DE3

DE,MD	0206000203	Sassafras River	Haliaeetus leucocephalus	Bald eagle		DE3
DE,MD	0206000204	Chester River	Alasmidonta heterodon	Dwarf wedgemussel	LE	DE9
DE,MD	0206000204	Chester River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	DE9
DE,MD	0206000204	Chester River	Oxypolis canbyi	Canby's dropwort	LE	DE9
DE,MD	0206000204	Chester River	Isotria medeoloides	Small whorled pogonia	LT	DE9
DE,MD	0206000204	Chester River	Anas rubripes	American black duck		DE9
DE,MD	0206000204	Chester River	Merginae sp.	Seaducks		DE9
DE,MD	0206000502	Upper Choptank River	Alasmidonta heterodon	Dwarf wedgemussel	LE	DE10
DE,MD	0208010904	Upper Nanticoke River	Anas rubripes	American black duck		DE1
DE,MD	0208010905	Lower Nanticoke River	Acipenser brevirostrum	Shortnose sturgeon	LE	DE5
DE,MD	0208010905	Lower Nanticoke River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	DE5
DE,MD	0208010905	Lower Nanticoke River	Ammodramus caudacutus	Saltmarsh sparrow		DE5
DE,MD	0208010905	Lower Nanticoke River	Ammodramus maritimus	Seaside sparrow		DE5
DE,MD	0208010905	Lower Nanticoke River	Anas rubripes	American black duck		DE5
DE,MD	0208010905	Lower Nanticoke River	Haliaeetus leucocephalus	Bald eagle		DE5
DE,MD	0208010905	Lower Nanticoke River	Himantopus mexicanus	Black-necked stilt		DE5
DE,MD	0208010905	Lower Nanticoke River	Merginae sp.	Seaducks		DE5
DE,MD	0208010905	Lower Nanticoke River	Tringa semipalmata	Willet		DE5
DE,MD	0208011003	Wicomico River	Ammodramus maritimus	Seaside sparrow		DE6
DE,MD	0208011003	Wicomico River	Anas rubripes	American black duck		DE6
DE,MD	0208011003	Wicomico River	Tringa semipalmata	Willet		DE6
DE,MD,PA	0206000202	Elk River	Acipenser brevirostrum	Shortnose sturgeon	LE	DE2
DE,MD,PA	0206000202	Elk River	Cicindela puritana	Puritan tiger beetle	LT	DE2
DE,MD,PA	0206000202	Elk River	Haliaeetus leucocephalus	Bald eagle		DE2
MD	0206000100	Upper Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD16
MD	0206000100	Upper Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD16

MD	0206000100	Upper Chesapeake Bay	Merginae sp.	Seaducks		MD16
MD	0206000205	Upper Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD18
MD	0206000205	Upper Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD18
MD	0206000205	Upper Chesapeake Bay	Cicindela puritana	Puritan tiger beetle	LT	MD18
MD	0206000205	Upper Chesapeake Bay	Anas rubripes	American black duck		MD18
MD	0206000205	Upper Chesapeake Bay	Merginae sp.	Seaducks		MD18
MD	0206000206	Eastern Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD19
MD	0206000206	Eastern Bay	Merginae sp.	Seaducks		MD19
MD	0206000301	Winters Run-Bush River	Haliaeetus leucocephalus	Bald eagle		MD20
MD	0206000302	Romney Creek-Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD21
MD	0206000302	Romney Creek-Chesapeake Bay	Haliaeetus leucocephalus	Bald eagle		MD21
MD	0206000306	Gunpowder River-Chesapeake Bay	Haliaeetus leucocephalus	Bald eagle		MD24
MD	0206000307	Back River-Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD25
MD	0206000307	Back River-Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD25
MD	0206000307	Back River-Chesapeake Bay	Himantopus mexicanus	Black-necked stilt		MD25
MD	0206000308	North Branch Patapsco River	Agalinis acuta	Sandplain gerardia	LE	MD26
MD	0206000309	Gwynns Falls	Agalinis acuta	Sandplain gerardia	LE	MD27
MD	0206000311	Patapsco River	Helonias bulata	Swamp pink	LT	MD38
MD	0206000312	Patapsco River-Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD39
MD	0206000312	Patapsco River-Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD39
MD	0206000312	Patapsco River-Chesapeake Bay	Helonias bulata	Swamp pink	LT	MD39
MD	0206000312	Patapsco River-Chesapeake Bay	Sternidae sp.	Terns		MD39

MD	0206000401	Magothy River-Chesapeake Bay	Helonias bulata	Swamp pink	LT	MD40
MD	0206000401	Magothy River-Chesapeake Bay	Merginae sp.	Seaducks		MD40
MD	0206000402	Severn River-Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD41
MD	0206000402	Severn River-Chesapeake Bay	Cicindela puritana	Puritan tiger beetle	LT	MD41
MD	0206000403	South River-Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD42
MD	0206000404	Herring Bay-Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD43
MD	0206000404	Herring Bay-Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	LT	MD43
MD	0206000404	Herring Bay-Chesapeake Bay	Cicindela puritana	Puritan tiger beetle	LT	MD43
MD	0206000404	Herring Bay-Chesapeake Bay	Merginae sp.	Seaducks		MD43
MD	0206000501	Tuckahoe Creek	Alasmidonta heterodon	Dwarf wedgemussel	LE	MD44
MD	0206000501	Tuckahoe Creek	Merginae sp.	Seaducks		MD44
MD	0206000504	Little Choptank River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD46
MD	0206000504	Little Choptank River	Merginae sp.	Seaducks		MD46
MD	0206000504	Little Choptank River	Tringa semipalmata	Willet		MD46
MD	0206000505	Lower Choptank River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD47
MD	0206000505	Lower Choptank River	Helonias bulata	Swamp pink	LT	MD47
MD	0206000505	Lower Choptank River	Ardeidae sp	Herons and egrets		MD47
MD	0206000505	Lower Choptank River	Haematopus palliatus	American oystercatcher		MD47
MD	0206000505	Lower Choptank River	Himantopus mexicanus	Black-necked stilt		MD47
MD	0206000505	Lower Choptank River	Merginae sp.	Seaducks		MD47
MD	0206000505	Lower Choptank River	Sternidae sp.	Terns		MD47
MD	0206000505	Lower Choptank River	Tringa semipalmata	Willet		MD47
MD	0206000506	Honga River-Chesapeake Bay	Atlantic sturgeon	Acipenser	LE	MD48

				oxyrhynchus		
MD	0206000506	Honga River-Chesapeake Bay	Ammodramus caudacutus	Saltmarsh sparrow		MD48
MD	0206000506	Honga River-Chesapeake Bay	Ammodramus maritimus	Seaside sparrow		MD48
MD	0206000506	Honga River-Chesapeake Bay	Anas rubripes	American black duck		MD48
MD	0206000506	Honga River-Chesapeake Bay	Ardeidae sp	Herons and egrets		MD48
MD	0206000506	Honga River-Chesapeake Bay	Rynchops niger	Black skimmer		MD48
MD	0206000506	Honga River-Chesapeake Bay	Sternidae sp.	Terns		MD48
MD	0206000506	Honga River-Chesapeake Bay	Tringa semipalmata	Willet		MD48
MD	0206000605	Middle Patuxent River	Aeschynomene virginica	Sensitive joint-vetch	LT	MD53
MD	0206000605	Middle Patuxent River	Anas rubripes	American black duck		MD53
MD	0206000605	Middle Patuxent River	Merginae sp.	Seaducks		MD53
MD	0206000606	Lower Patuxent River	Anas rubripes	American black duck		MD54
MD	0206000606	Lower Patuxent River	Merginae sp.	Seaducks		MD54
MD	0207000201	Savage River	Myotis sodalis	Indiana bat	LE	MD55
MD	0207000201	Savage River	Myotis septentrionalis	Northern long-eared bat	LT	MD55
MD	0207000904	Double Pipe Creek	Myotis sodalis	Indiana bat	LE	MD61
MD	0207000907	Lower Monocacy River	Myotis septentrionalis	Northern long-eared bat	LT	MD64
MD	0207001105	Wicomico River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD67
MD	0207001105	Wicomico River	Merginae sp.	Seaducks		MD67
MD	0207001107	Saint Clements Bay-Potomac River	Alasmidonta heterodon	Dwarf wedgemussel	LE	MD68
MD	0207001107	Saint Clements Bay-Potomac River	Merginae sp.	Seaducks		MD68
MD	0207001109	Saint Marys River	Merginae sp.	Seaducks		MD69
MD	0208011001	Transquaking River	Ammodramus caudacutus	Saltmarsh sparrow		MD70

MD	0208011001	Transquaking River	Ammodramus maritimus	Seaside sparrow		MD70
MD	0208011001	Transquaking River	Anas rubripes	American black duck		MD70
MD	0208011002	Blackwater River	Acipenser brevirostrum	Shortnose sturgeon	LE	MD71
MD	0208011002	Blackwater River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD71
MD	0208011002	Blackwater River	Ammodramus caudacutus	Saltmarsh sparrow		MD71
MD	0208011002	Blackwater River	Ammodramus maritimus	Seaside sparrow		MD71
MD	0208011002	Blackwater River	Anas rubripes	American black duck		MD71
MD	0208011002	Blackwater River	Himantopus mexicanus	Black-necked stilt		MD71
MD	0208011002	Blackwater River	Tringa semipalmata	Willet		MD71
MD	0208011004	Manokin River	Aeschynomene virginica	Sensitive joint-vetch	LT	MD72
MD	0208011004	Manokin River	Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	LT	MD72
MD	0208011004	Manokin River	Ammodramus maritimus	Seaside sparrow		MD72
MD	0208011004	Manokin River	Anas rubripes	American black duck		MD72
MD	0208011004	Manokin River	Haematopus palliatus	American oystercatcher		MD72
MD	0208011004	Manokin River	Merginae sp.	Seaducks		MD72
MD	0208011004	Manokin River	Sternidae sp.	Terns		MD72
MD	0208011004	Manokin River	Tringa semipalmata	Willet		MD72
MD	0208011005	Upper Tangier Sound	Acipenser brevirostrum	Shortnose sturgeon	LE	MD73
MD	0208011005	Upper Tangier Sound	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD73
MD	0208011005	Upper Tangier Sound	Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	LT	MD73
MD	0208011005	Upper Tangier Sound	Ammodramus caudacutus	Saltmarsh sparrow		MD73
MD	0208011005	Upper Tangier Sound	Ammodramus maritimus	Seaside sparrow		MD73
MD	0208011005	Upper Tangier Sound	Anas rubripes	American black duck		MD73

MD	0208011005	Upper Tangier Sound	Ardeidae sp	Herons and egrets		MD73
MD	0208011005	Upper Tangier Sound	Haematopus palliatus	American oystercatcher		MD73
MD	0208011005	Upper Tangier Sound	Himantopus mexicanus	Black-necked stilt		MD73
MD	0208011005	Upper Tangier Sound	Pelecanus occidentalis	Brown pelican		MD73
MD	0208011005	Upper Tangier Sound	Rynchops niger	Black skimmer		MD73
MD	0208011005	Upper Tangier Sound	Sternidae sp.	Terns		MD73
MD	0208011005	Upper Tangier Sound	Tringa semipalmata	Willet		MD73
MD,PA	0205030601	South Branch Conewago Creek	Myotis sodalis	Indiana bat	LE	MD29
MD,PA	0205030607	Codorus Creek	Myotis sodalis	Indiana bat	LE	MD85
MD,PA	0205030613	Muddy Creek	Percina bimaculata	Chesapeake logperch		MD30
MD,PA	0205030615	Octoraro Creek	Percina bimaculata	Chesapeake logperch		MD86
MD,PA	0205030616	Deer Creek	Etheostoma sellare	Maryland darter	LE	MD15
MD,PA	0205030617	Susquehanna River	Acipenser brevirostrum	Shortnose sturgeon	LE	MD87
MD,PA	0205030617	Susquehanna River	Alosa sapidissima	American shad		MD87
MD,PA	0205030617	Susquehanna River	Alosa sp.	Alewife/Blueback herring		MD87
MD,PA	0205030617	Susquehanna River	Anguilla rostrata	American eel		MD87
MD,PA	0205030617	Susquehanna River	Haliaeetus leucocephalus	Bald eagle		MD87
MD,PA	0205030617	Susquehanna River	Percina bimaculata	Chesapeake logperch		MD87
MD,PA	0205030617	Susquehanna River	Unionoida sp.	Freshwater mussel sp.		MD87
MD,PA	0206000201	North East River-Upper Chesapeake Bay	Acipenser brevirostrum	Shortnose sturgeon	LE	MD17
MD,PA	0206000201	North East River-Upper Chesapeake Bay	Helonias bulata	Swamp pink	LT	MD17
MD,PA	0206000201	North East River-Upper Chesapeake Bay	Haliaeetus leucocephalus	Bald eagle		MD17
MD,PA	0206000303	Upper Gunpowder Falls	Myotis sodalis	Indiana bat	LE	MD22
MD,PA	0207000205	Wills Creek	Myotis sodalis	Indiana bat	LE	MD31
MD,PA	0207000205	Wills Creek	Myotis septentrionalis	Northern long-eared	LT	MD31

				bat		
MD,PA	0207000205	Wills Creek	Salvelinus fontinalis	Brook trout		MD31
MD,PA	0207000206	Evitts Creek	Myotis sodalis	Indiana bat	LE	MD32
MD,PA	0207000206	Evitts Creek	Myotis septentrionalis	Northern long-eared bat	LT	MD32
MD,PA	0207000301	Town Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	MD79
MD,PA	0207000301	Town Creek	Myotis septentrionalis	Northern Long-eared bat	LT	MD79
MD,PA	0207000303	Fifteenmile Creek	Ptilimnium nodosum	Harperella	LE	MD89
MD,PA	0207000304	Sideling Hill Creek	Ptilimnium nodosum	Harperella	LE	PA102
MD,PA	0207000401	Tonoloway Creek	Myotis septentrionalis	Northern Long-eared bat	LT	MD33
MD,PA	0207000403	Licking Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	MD34
MD,PA	0207000406	West Branch Conococheague Creek	Salvelinus fontinalis	Brook trout		MD88
MD,PA	0207000408	Conococheague Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	MD35
MD,PA	0207000408	Conococheague Creek	Salvelinus fontinalis	Brook trout		MD35
MD,PA	0207000410	Antietam Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	MD36
MD,PA	0207000410	Antietam Creek	Myotis septentrionalis	Northern long-eared bat	LT	MD36
MD,PA	0207000410	Antietam Creek	Salvelinus fontinalis	Brook trout		MD36
MD,PA	0207000902	Marsh Creek	Myotis sodalis	Indiana bat	LE	MD37
MD,PA	0207000905	Upper Monocacy River	Myotis septentrionalis	Northern long-eared bat	LT	MD62
MD,PA,WV	0207000405	Little Tonoloway Creek-Potomac River	Myotis sodalis	Indiana bat	LE	MD80
MD,PA,WV	0207000405	Little Tonoloway Creek-Potomac River	Ptilimnium nodosum	Harperella	LE	MD80
MD,PA,WV	0207000405	Little Tonoloway Creek-Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	MD80

MD,PA,WV	0207000411	Rocky Marsh Run-Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	MD4
MD,PA,WV	0207000411	Rocky Marsh Run-Potomac River	Anguilla rostrata	American eel		MD4
MD,PA,WV	0207000411	Rocky Marsh Run-Potomac River	Haliaeetus leucocephalus	Bald eagle		MD4
MD,VA	0207000804	Tuscarora Creek-Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	MD59
MD,VA	0207000809	Broad Run-Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	MD5
MD,VA	0207001008	Occoquan River-Potomac River	Acipenser brevirostrum	Shortnose sturgeon	LE	MD81
MD,VA	0207001008	Occoquan River-Potomac River	Isotria medeoloides	Small Whorled Pogonia	LT	MD81
MD,VA	0207001008	Occoquan River-Potomac River	Anas rubripes	American black duck		MD81
MD,VA	0207001008	Occoquan River-Potomac River	Haliaeetus leucocephalus	Bald eagle		MD81
MD,VA	0207001101	Quantico Creek-Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD7
MD,VA	0207001101	Quantico Creek-Potomac River	Aeschynomene virginica	Sensitive Joint-vetch	LT	MD7
MD,VA	0207001101	Quantico Creek-Potomac River	Isotria medeoloides	Small Whorled Pogonia	LT	MD7
MD,VA	0207001101	Quantico Creek-Potomac River	Anas rubripes	American black duck		MD7
MD,VA	0207001101	Quantico Creek-Potomac River	Haliaeetus leucocephalus	Bald eagle		MD7
MD,VA	0207001102	Potomac Creek-Potomac River	Acipenser brevirostrum	Shortnose sturgeon	LE	MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Harperella nodosa	Harperella	LE	MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Aeschynomene virginica	Sensitive Joint-vetch	LT	MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Isotria medeoloides	Small Whorled Pogonia	LT	MD82

MD,VA	0207001102	Potomac Creek-Potomac River	Anas rubripes	American black duck		MD82
MD,VA	0207001102	Potomac Creek-Potomac River	Haliaeetus leucocephalus	Bald eagle		MD82
MD,VA	0207001103	Nanjemoy Creek-Potomac River	Alasmidonta heterodon	Dwarf wedgemussel	LE	MD65
MD,VA	0207001103	Nanjemoy Creek-Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD65
MD,VA	0207001103	Nanjemoy Creek-Potomac River	Anas rubripes	American black duck		MD65
MD,VA	0207001103	Nanjemoy Creek-Potomac River	Haliaeetus leucocephalus	Bald eagle		MD65
MD,VA	0207001106	Machodoc Creek-Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD83
MD,VA	0207001108	Nomini Creek-Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD8
MD,VA	0207001108	Nomini Creek-Potomac River	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	MD8
MD,VA	0207001110	Potomac River	Acipenser brevirostrum	Shortnose sturgeon	LE	MD84
MD,VA	0207001110	Potomac River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD84
MD,VA	0208010100	Lower Chesapeake Bay	Acipenser oxyrinchus	Atlantic Sturgeon	LE	MD9
MD,VA	0208010100	Lower Chesapeake Bay	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD9
MD,VA	0208010100	Lower Chesapeake Bay	Merginae sp.	Seaducks		MD9
MD,VA	0208010201	Great Wicomico River-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA35
MD,VA	0208010201	Great Wicomico River-Lower Chesapeake Bay	Merginae sp.	Seaducks		VA35
MD,VA	0208011006	Lower Tangier Sound	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD10
MD,VA	0208011006	Lower Tangier Sound	Cicindela dorsalis dorsalis	Northeastern Beach tiger beetle	LT	MD10

MD,VA	0208011006	Lower Tangier Sound	Ammodramus maritimus	Seaside sparrow		MD10
MD,VA	0208011006	Lower Tangier Sound	Anas rubripes	American black duck		MD10
MD,VA	0208011006	Lower Tangier Sound	Ardeidae sp	Herons and egrets		MD10
MD,VA	0208011006	Lower Tangier Sound	Haematopus palliatus	American oystercatcher		MD10
MD,VA	0208011006	Lower Tangier Sound	Pelecanus occidentalis	Brown pelican		MD10
MD,VA	0208011006	Lower Tangier Sound	Sternidae sp.	Terns		MD10
MD,VA	0208011006	Lower Tangier Sound	Tringa semipalmata	Willet		MD10
MD,VA	0208011103	Dividing Creek-Pocomoke River	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD75
MD,VA	0208011103	Dividing Creek-Pocomoke River	Haliaeetus leucocephalus	Bald eagle		MD75
MD,VA	0208011104	Pitts Creek-Pocomoke River	Anas rubripes	American black duck		MD11
MD,VA	0208011104	Pitts Creek-Pocomoke River	Haliaeetus leucocephalus	Bald eagle		MD11
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Acipenser brevirostrum	Shortnose sturgeon	LE	MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Ammodramus caudacutus	Saltmarsh sparrow		MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Ammodramus maritimus	Seaside sparrow		MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Anas rubripes	American black duck		MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Haematopus palliatus	American oystercatcher		MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Haliaeetus leucocephalus	Bald eagle		MD12
MD,VA	0208011105	Marumsco Creek-Pocomoke Sound	Tringa semipalmata	Willet		MD12

MD,VA	0208011107	Deep Creek-Pocomoke Sound	Atlantic sturgeon	Acipenser oxyrhynchus	LE	MD13
MD,VA	0208011107	Deep Creek-Pocomoke Sound	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	MD13
MD,VA	0208011107	Deep Creek-Pocomoke Sound	Anas rubripes	American black duck		MD13
MD,VA	0208011107	Deep Creek-Pocomoke Sound	Haematopus palliatus	American oystercatcher		MD13
MD,VA	0208011107	Deep Creek-Pocomoke Sound	Tringa semipalmata	Willet		MD13
MD,VA,WV	0207000703	Bullskin Run-Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA138
MD,VA,WV	0207000703	Bullskin Run-Shenandoah River	Myotis septentrionalis	Northern long-eared bat	LT	VA138
MD,VA,WV	0207000703	Bullskin Run-Shenandoah River	Haliaeetus leucocephalus	Bald eagle		VA138
MD,WV	0207000106	Lower South Branch Potomac River	Haliaeetus leucocephalus	Bald eagle		WV3
MD,WV	0207000106	Lower South Branch Potomac River	Salvelinus fontinalis	Brook trout		WV3
MD,WV	0207000202	Stony River-North Branch Potomac River	Myotis sodalis	Indiana bat	LE	MD14
MD,WV	0207000202	Stony River-North Branch Potomac River	Haliaeetus leucocephalus	Bald eagle		MD14
MD,WV	0207000202	Stony River-North Branch Potomac River	Salvelinus fontinalis	Brook trout		MD14
MD,WV	0207000204	New Creek-North Branch Potomac River	Salvelinus fontinalis	Brook trout		MD1
MD,WV	0207000208	Trading Run-North Branch Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	MD76
MD,WV	0207000308	Long Hollow Run-Potomac River	Myotis sodalis	Indiana bat	LE	MD77
MD,WV	0207000308	Long Hollow Run-Potomac	Myotis septentrionalis	Northern long-eared	LT	MD77

		River		bat		
NY	0205010101	Canadarago Lake	Anguilla rostrata	American eel		NY1
NY	0205010101	Canadarago Lake	Salvelinus fontinalis	Brook trout		NY1
NY	0205010102	Cherry Valley Creek	Alasmidonta varicosa	Brook floater		NY2
NY	0205010102	Cherry Valley Creek	Anguilla rostrata	American eel		NY2
NY	0205010102	Cherry Valley Creek	Salvelinus fontinalis	Brook trout		NY2
NY	0205010103	Schenevus Creek	Salvelinus fontinalis	Brook trout		NY3
NY	0205010104	Charlotte Creek	Salvelinus fontinalis	Brook trout		NY4
NY	0205010105	Otego Creek	Alasmidonta varicosa	Brook floater		NY5
NY	0205010105	Otego Creek	Anguilla rostrata	American eel		NY5
NY	0205010105	Otego Creek	Salvelinus fontinalis	Brook trout		NY5
NY	0205010106	Headwaters Susquehanna River	Alasmidonta varicosa	Brook floater		NY6
NY	0205010106	Headwaters Susquehanna River	Alosa sapidiisima	American shad		NY6
NY	0205010106	Headwaters Susquehanna River	Anguilla rostrata	American eel		NY6
NY	0205010106	Headwaters Susquehanna River	Salvelinus fontinalis	Brook trout		NY6
NY	0205010107	Wharton Creek	Salvelinus fontinalis	Brook trout		NY7
NY	0205010108	Butternut Creek	Alasmidonta varicosa	Brook floater		NY8
NY	0205010108	Butternut Creek	Salvelinus fontinalis	Brook trout		NY8
NY	0205010109	Unadilla River	Alasmidonta varicosa	Brook floater		NY9
NY	0205010109	Unadilla River	Anguilla rostrata	American eel		NY9
NY	0205010109	Unadilla River	Salvelinus fontinalis	Brook trout		NY9
NY	0205010111	Upper Susquehanna River	Anguilla rostrata	American eel		NY11
NY	0205010111	Upper Susquehanna River	Salvelinus fontinalis	Brook trout		NY11
NY	0205010201	East Branch Tioughnioga River	Anguilla rostrata	American eel		NY13
NY	0205010201	East Branch Tioughnioga River	Salvelinus fontinalis	Brook trout		NY13
NY	0205010202	West Branch Tioughnioga River	Alasmidonta varicosa	Brook floater		NY14

NY	0205010202	West Branch Tioughnioga River	Anguilla rostrata	American eel		NY14
NY	0205010203	Otselic River	Anguilla rostrata	American eel		NY15
NY	0205010203	Otselic River	Salvelinus fontinalis	Brook trout		NY15
NY	0205010204	Tioughnioga River	Alasmidonta varicosa	Brook floater		NY16
NY	0205010204	Tioughnioga River	Salvelinus fontinalis	Brook trout		NY16
NY	0205010205	Upper Chenango River	Alasmidonta varicosa	Brook floater		NY17
NY	0205010205	Upper Chenango River	Anguilla rostrata	American eel		NY17
NY	0205010205	Upper Chenango River	Salvelinus fontinalis	Brook trout		NY17
NY	0205010206	Middle Chenango River	Alasmidonta varicosa	Brook floater		NY18
NY	0205010206	Middle Chenango River	Anguilla rostrata	American eel		NY18
NY	0205010206	Middle Chenango River	Salvelinus fontinalis	Brook trout		NY18
NY	0205010207	Genegantslet Creek	Salvelinus fontinalis	Brook trout		NY19
NY	0205010208	Lower Chenango River	Alasmidonta varicosa	Brook floater		NY20
NY	0205010208	Lower Chenango River	Anguilla rostrata	American eel		NY20
NY	0205010208	Lower Chenango River	Salvelinus fontinalis	Brook trout		NY20
NY	0205010301	Nanticoke Creek	Salvelinus fontinalis	Brook trout		NY21
NY	0205010303	Catatonk Creek	Alasmidonta varicosa	Brook floater		NY22
NY	0205010303	Catatonk Creek	Anguilla rostrata	American eel		NY22
NY	0205010303	Catatonk Creek	Salvelinus fontinalis	Brook trout		NY22
NY	0205010304	Owego Creek	Anguilla rostrata	American eel		NY23
NY	0205010304	Owego Creek	Salvelinus fontinalis	Brook trout		NY23
NY	0205010401	Canacadea Creek	Salvelinus fontinalis	Brook trout		NY26
NY	0205010402	Bennetts Creek	Salvelinus fontinalis	Brook trout		NY27
NY	0205010403	Tuscarora Creek	Myotis septentrionalis	Northern Long-eared Bat	LT	NY28
NY	0205010404	Canisteo River	Myotis septentrionalis	Northern Long-eared Bat	LT	NY29
NY	0205010404	Canisteo River	Anguilla rostrata	American eel		NY29
NY	0205010404	Canisteo River	Salvelinus fontinalis	Brook trout		NY29
NY	0205010501	Upper Cohocton River	Anguilla rostrata	American eel		NY30

NY	0205010501	Upper Cohocton River	Salvelinus fontinalis	Brook trout		NY30
NY	0205010503	Lower Cohocton River	Anguilla rostrata	American eel		NY32
NY	0205010503	Lower Cohocton River	Salvelinus fontinalis	Brook trout		NY32
NY	0205010504	Upper Chemung River	Anguilla rostrata	American eel		NY33
NY	0205010504	Upper Chemung River	Salvelinus fontinalis	Brook trout		NY33
NY,PA	0205010112	Middle Susquehanna River	Salvelinus fontinalis	Brook trout		NY12
NY,PA	0205010113	Lower Susquehanna River	Alasmidonta varicosa	Brook floater		NY36
NY,PA	0205010113	Lower Susquehanna River	Salvelinus fontinalis	Brook trout		NY36
NY,PA	0205010302	Choconut Creek-Susquehanna River	Alasmidonta varicosa	Brook floater		NY37
NY,PA	0205010302	Choconut Creek-Susquehanna River	Alosa sapidiisima	American shad		NY37
NY,PA	0205010302	Choconut Creek-Susquehanna River	Alosa sapidissima	American shad		NY37
NY,PA	0205010302	Choconut Creek-Susquehanna River	Lampsilis cariosa	Yellow lampmussel		NY37
NY,PA	0205010305	Pipe Creek-Susquehanna River	Alasmidonta varicosa	Brook floater		NY24
NY,PA	0205010305	Pipe Creek-Susquehanna River	Anguilla rostrata	American eel		NY24
NY,PA	0205010305	Pipe Creek-Susquehanna River	Salvelinus fontinalis	Brook trout		NY24
NY,PA	0205010306	Cayuta Creek	Anguilla rostrata	American eel		NY25
NY,PA	0205010306	Cayuta Creek	Salvelinus fontinalis	Brook trout		NY25
NY,PA	0205010307	Wappasening Creek-Susquehanna River	Alasmidonta varicosa	Brook floater		NY38
NY,PA	0205010307	Wappasening Creek-Susquehanna River	Salvelinus fontinalis	Brook trout		NY38
NY,PA	0205010408	Cowanesque River	Myotis septentrionalis	Northern Long-eared Bat	LT	NY39
NY,PA	0205010408	Cowanesque River	Salvelinus fontinalis	Brook trout		NY39
NY,PA	0205010409	Tioga River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	NY40
NY,PA	0205010409	Tioga River	Myotis septentrionalis	Northern Long-eared	LT	NY40

				Bat		
NY,PA	0205010409	Tioga River	Alosa sapidiisima	American shad		NY40
NY,PA	0205010409	Tioga River	Anguilla rostrata	American eel		NY40
NY,PA	0205010409	Tioga River	Salvelinus fontinalis	Brook trout		NY40
NY,PA	0205010505	Middle Chemung River	Alasmidonta varicosa	Brook floater		NY34
NY,PA	0205010505	Middle Chemung River	Anguilla rostrata	American eel		NY34
NY,PA	0205010505	Middle Chemung River	Salvelinus fontinalis	Brook trout		NY34
NY,PA	0205010506	Lower Chemung River	Anguilla rostrata	American eel		NY41
PA	0205010406	Crooked Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA1
PA	0205010701	Lackawanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA17
PA	0205010701	Lackawanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA17
PA	0205010702	Upper Susquehanna River	Myotis sodalis	Indiana bat	LE	PA18
PA	0205010702	Upper Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA18
PA	0205010703	Middle Susquehanna River	Myotis sodalis	Indiana bat	LE	PA19
PA	0205010703	Middle Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA19
PA	0205010704	Nescopeck Creek	Myotis sodalis	Indiana bat	LE	PA20
PA	0205010704	Nescopeck Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA20
PA	0205010705	Huntington Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA21
PA	0205010705	Huntington Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA21
PA	0205010707	Fishing Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA23
PA	0205010708	Catawissa Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA24
PA	0205010710	Lower Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA26
PA	0205020102	Anderson Creek	Myotis septentrionalis	Northern Long-eared	LT	PA28

				bat		
PA	0205020103	Clearfield Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA99
PA	0205020103	Clearfield Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA99
PA	0205020104	Upper West Branch Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA29
PA	0205020105	Moshannon Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA30
PA	0205020105	Moshannon Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA30
PA	0205020107	Lower West Branch Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA32
PA	0205020107	Lower West Branch Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA32
PA	0205020304	Lower West Branch Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA32
PA	0205020304	Lower West Branch Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA32
PA	0205020401	Spring Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA103
PA	0205020402	Beech Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA42
PA	0205020403	Fishing Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA104
PA	0205020403	Fishing Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA104
PA	0205020404	Bald Eagle Creek	Isotria medeoloides	Small-whorled pogonia	LT	PA43
PA	0205020502	Upper Pine Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA45
PA	0205020502	Upper Pine Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA45
PA	0205020503	Marsh Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA46
PA	0205020504	Babb Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA47
PA	0205020506	Lower Pine Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA49

PA	0205020602	Lycoming Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA51
PA	0205020605	Lower Loyalsock Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA54
PA	0205020606	West Branch Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA55
PA	0205020609	White Deer Hole Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA58
PA	0205020610	Buffalo Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA59
PA	0205020612	West Branch Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA61
PA	0205030101	Shamokin Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA62
PA	0205030102	Pine Creek	Myotis sodalis	Indiana bat	LE	PA88
PA	0205030102	Pine Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA88
PA	0205030102	Pine Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA88
PA	0205030104	Penns Creek	Myotis sodalis	Indiana bat	LE	PA105
PA	0205030104	Penns Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA105
PA	0205030104	Penns Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA105
PA	0205030105	Mahanoy Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA90
PA	0205030107	Deep Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA91
PA	0205030110	Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA94
PA	0205030203	Lower Frankstown Branch Juniata River	Myotis sodalis	Indiana bat	LE	PA97
PA	0205030203	Lower Frankstown Branch Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA97
PA	0205030204	Spruce Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA98
PA	0205030204	Spruce Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA98

PA	0205030205	Little Juniata River	Myotis sodalis	Indiana bat	LE	PA101
PA	0205030205	Little Juniata River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA101
PA	0205030205	Little Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA101
PA	0205030206	Shaver Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA106
PA	0205030206	Shaver Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA106
PA	0205030207	Standing Stone Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA107
PA	0205030207	Standing Stone Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA107
PA	0205030208	Juniata River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA63
PA	0205030208	Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA63
PA	0205030301	Upper Raystown Branch Juniata River	Myotis sodalis	Indiana bat	LE	PA124
PA	0205030301	Upper Raystown Branch Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA124
PA	0205030303	Dunning Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA125
PA	0205030305	Middle Raystown Branch Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA66
PA	0205030306	Yellow Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA67
PA	0205030307	Great Trough Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA68
PA	0205030308	Lower Raystown Branch Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA69
PA	0205030402	Sideling Hill Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA71
PA	0205030403	Blacklog Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA72

PA	0205030404	Aughwick Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA73
PA	0205030404	Aughwick Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA73
PA	0205030405	Upper Juniata River	Myotis septentrionalis	Northern Long-eared bat	LT	PA74
PA	0205030406	Honey Creek	Myotis sodalis	Indiana bat	LE	PA108
PA	0205030406	Honey Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA108
PA	0205030406	Honey Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA108
PA	0205030407	Kishacoquillas Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA75
PA	0205030408	Middle Juniata River	Myotis sodalis	Indiana bat	LE	PA76
PA	0205030409	Tuscarora Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA77
PA	0205030409	Tuscarora Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA77
PA	0205030412	Lower Juniata River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA110
PA	0205030501	Sherman Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA111
PA	0205030502	Upper Conodoguinet Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA112
PA	0205030503	Middle Conodoguinet Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA113
PA	0205030505	Yellow Breeches Creek	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA115
PA	0205030505	Yellow Breeches Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA115
PA	0205030506	Upper Swatara Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA79
PA	0205030506	Upper Swatara Creek	Speyeria idalia	Regal fritillary		PA79
PA	0205030509	Lower Swatara Creek	Speyeria idalia	Regal fritillary		PA116
PA	0205030510	Susquehanna River	Scirpus ancistrochaetus	Northeastern bulrush	LE	PA117
PA	0205030510	Susquehanna River	Myotis septentrionalis	Northern Long-eared bat	LT	PA117
PA	0205030510	Susquehanna River	Alosa sapidissima	American shad		PA117

PA	0205030510	Susquehanna River	Alosa sp.	Alewife/Blueback herring		PA117
PA	0205030510	Susquehanna River	Anguilla rostrata	American eel		PA117
PA	0205030510	Susquehanna River	Unionoida sp.	Freshwater mussel sp.		PA117
PA	0205030602	Upper Conewago Creek	Myotis sodalis	Indiana bat	LE	PA82
PA	0205030603	Bermudian Creek	Myotis sodalis	Indiana bat	LE	PA83
PA	0205030611	Conestoga River	Myotis septentrionalis	Northern Long-eared bat	LT	PA122
PA	0205030612	Pequea Creek	Myotis septentrionalis	Northern Long-eared bat	LT	PA123
VA	0207000501	Upper Middle River	Myotis septentrionalis	Northern Long-eared bat	LT	VA19
VA	0207000502	Christians Creek	Antrolana lira	Madison Cave Isopod	LT	VA20
VA	0207000507	South River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA25
VA	0207000507	South River	Antrolana lira	Madison Cave Isopod	LT	VA25
VA	0207000507	South River	Helenium virginicum	Virginia Sneezeweed	LT	VA25
VA	0207000507	South River	Helonias bullata	Swamp-pink	LT	VA25
VA	0207000507	South River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA25
VA	0207000507	South River	Platanthera leucophaea	Prairie fringed orchid	LT	VA25
VA	0207000508	Naked Creek-South Fork Shenandoah River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA140
VA	0207000508	Naked Creek-South Fork Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA140
VA	0207000508	Naked Creek-South Fork Shenandoah River	Helenium virginicum	Virginia Sneezeweed	LT	VA140
VA	0207000508	Naked Creek-South Fork Shenandoah River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA140
VA	0207000509	Hawksbill Creek-South Fork Shenandoah River	Boechera serotina	Shale barren rock cress	LE	VA141

VA	0207000509	Hawksbill Creek-South Fork Shenandoah River	Plethodon shenandoah	Shenandoah Salamander	LE	VA141
VA	0207000509	Hawksbill Creek-South Fork Shenandoah River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA141
VA	0207000510	Gooney Run-South Fork Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA120
VA	0207000510	Gooney Run-South Fork Shenandoah River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA120
VA	0207000603	Linville Creek-North Fork Shenandoah River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA26
VA	0207000603	Linville Creek-North Fork Shenandoah River	Myotis sodalis	Indiana Bat	LE	VA26
VA	0207000603	Linville Creek-North Fork Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA26
VA	0207000701	Crooked Run-Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA123
VA	0207001004	Pohick Creek	Isotria medeoloides	Small Whorled Pogonia	LT	VA139
VA	0207001004	Pohick Creek	Haliaeetus leucocephalus	Bald eagle		VA139
VA	0207001006	Cedar Run	Isotria medeoloides	Small Whorled Pogonia	LT	VA33
VA	0208010203	Piankatank River-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA37
VA	0208010204	Mobjack Bay-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA38
VA	0208010204	Mobjack Bay-Lower Chesapeake Bay	Isotria medeoloides	Small Whorled Pogonia	LT	VA38
VA	0208010304	Hazel River	Plethodon shenandoah	Shenandoah Salamander	LE	VA128
VA	0208010305	Mountain Run	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA39
VA	0208010306	Marsh Run-Rappahannock	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA40

		River				
VA	0208010307	Conway River-Rapidan River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA129
VA	0208010308	Blue Run-Rapidan River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA41
VA	0208010309	Robinson River	Plethodon shenandoah	Shenandoah Salamander	LE	VA130
VA	0208010309	Robinson River	Isotria medeoloides	Small Whorled Pogonia	LT	VA130
VA	0208010401	Massaponax Creek-Rappahannock River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA132
VA	0208010401	Massaponax Creek-Rappahannock River	Isotria medeoloides	Small Whorled Pogonia	LT	VA132
VA	0208010401	Massaponax Creek-Rappahannock River	Anas rubripes	American black duck		VA132
VA	0208010402	Mill Creek-Rappahannock River	Myotis sodalis	Indiana Bat	LE	VA133
VA	0208010402	Mill Creek-Rappahannock River	Helonias bullata	Swamp-pink	LT	VA133
VA	0208010402	Mill Creek-Rappahannock River	Isotria medeoloides	Small Whorled Pogonia	LT	VA133
VA	0208010402	Mill Creek-Rappahannock River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA133
VA	0208010402	Mill Creek-Rappahannock River	Anas rubripes	American black duck		VA133
VA	0208010402	Mill Creek-Rappahannock River	Haliaeetus leucocephalus	Bald eagle		VA133
VA	0208010402	Mill Creek-Rappahannock River	Stygobromus kenki	Kenk's amphipod		VA133
VA	0208010403	Occupacia Creek-Rappahannock River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA43
VA	0208010403	Occupacia Creek-Rappahannock River	Helonias bullata	Swamp-pink	LT	VA43
VA	0208010403	Occupacia Creek-Rappahannock River	Isotria medeoloides	Small Whorled Pogonia	LT	VA43
VA	0208010403	Occupacia Creek-Rappahannock River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA43

VA	0208010403	Occupacia Creek-Rappahannock River	Anas rubripes	American black duck		VA43
VA	0208010403	Occupacia Creek-Rappahannock River	Haliaeetus leucocephalus	Bald eagle		VA43
VA	0208010403	Occupacia Creek-Rappahannock River	Stygobromus kenki	Kenk's amphipod		VA43
VA	0208010404	Cat Point Creek-Rappahannock River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA44
VA	0208010404	Cat Point Creek-Rappahannock River	Anas rubripes	American black duck		VA44
VA	0208010404	Cat Point Creek-Rappahannock River	Haliaeetus leucocephalus	Bald eagle		VA44
VA	0208010406	Lancaster Creek-Rappahannock River	Merginae sp.	Seaducks		VA46
VA	0208010407	Corrotoman River-Rappahannock River	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA63
VA	0208010407	Corrotoman River-Rappahannock River	Isotria medeoloides	Small Whorled Pogonia	LT	VA63
VA	0208010407	Corrotoman River-Rappahannock River	Merginae sp.	Seaducks		VA63
VA	0208010501	Poni River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA134
VA	0208010501	Poni River	Helonias bullata	Swamp-pink	LT	VA134
VA	0208010501	Poni River	Isotria medeoloides	Small Whorled Pogonia	LT	VA134
VA	0208010501	Poni River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA134
VA	0208010502	Matta River-Mattaponi River	Helonias bullata	Swamp-pink	LT	VA135
VA	0208010502	Matta River-Mattaponi River	Isotria medeoloides	Small Whorled Pogonia	LT	VA135
VA	0208010503	Polecat Creek-Mattaponi River	Helonias bullata	Swamp-pink	LT	VA64
VA	0208010504	Maracossic Creek	Helonias bullata	Swamp-pink	LT	VA65

VA	0208010504	Maracossic Creek	Isotria medeoloides	Small Whorled Pogonia	LT	VA65
VA	0208010505	Chapel Creek-Mattaponi River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA66
VA	0208010506	Garnetts Creek-Mattaponi River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA67
VA	0208010506	Garnetts Creek-Mattaponi River	Anas rubripes	American black duck		VA67
VA	0208010601	Upper South Anna River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA68
VA	0208010602	Middle South Anna River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA69
VA	0208010603	Lower South Anna River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA7
VA	0208010609	Upper Pamunkey River	Anas rubripes	American black duck		VA13
VA	0208010610	Middle Pamunkey River	Isotria medeoloides	Small Whorled Pogonia	LT	VA14
VA	0208010610	Middle Pamunkey River	Anas rubripes	American black duck		VA14
VA	0208010611	Lower Pamunkey River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA15
VA	0208010611	Lower Pamunkey River	Isotria medeoloides	Small Whorled Pogonia	LT	VA15
VA	0208010611	Lower Pamunkey River	Anas rubripes	American black duck		VA15
VA	0208010701	Upper York River	Isotria medeoloides	Small Whorled Pogonia	LT	VA16
VA	0208010701	Upper York River	Anas rubripes	American black duck		VA16
VA	0208010702	Lower York River	Isotria medeoloides	Small Whorled Pogonia	LT	VA17
VA	0208010801	Back River-Lower Chesapeake Bay	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA18
VA	0208010801	Back River-Lower Chesapeake Bay	Charadrius melodus	Piping Plover	LT	VA18
VA	0208010801	Back River-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA18
VA	0208011106	Messongo Creek-Pocomoke	Cicindela dorsalis	Northeastern Beach	LT	VA96

		Sound	dorsalis	Tiger Beetle		
VA	0208011106	Messongo Creek-Pocomoke Sound	Anas rubripes	American black duck		VA96
VA,MD	0208011107	Deep Creek-Pocomoke Sound	Ammodramus caudacutus	Saltmarsh sparrow		MD13
VA	0208011108	Pungoteague Creek-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA97
VA	0208011108	Pungoteague Creek-Lower Chesapeake Bay	Anas rubripes	American black duck		VA97
VA	0208011109	Cherrystone Inlet-Lower Chesapeake Bay	Calidris canutus	Rufa red knot	LT	VA98
VA	0208011109	Cherrystone Inlet-Lower Chesapeake Bay	Charadrius melodus	Piping Plover	LT	VA98
VA	0208011109	Cherrystone Inlet-Lower Chesapeake Bay	Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	LT	VA98
VA	0208011109	Cherrystone Inlet-Lower Chesapeake Bay	Anas rubripes	American black duck		VA98
VA	0208011109	Cherrystone Inlet-Lower Chesapeake Bay	Haematopus palliatus	American oystercatcher		VA98
VA	0208020101	Upper Jackson River	Boechera serotina	Shale barren rock cress	LE	VA99
VA	0208020101	Upper Jackson River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA99
VA	0208020101	Upper Jackson River	Myotis sodalis	Indiana Bat	LE	VA99
VA	0208020101	Upper Jackson River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA99
VA	0208020105	Lower Jackson River	Boechera serotina	Shale barren rock cress	LE	VA101
VA	0208020105	Lower Jackson River	Echinacea laevigata	Smooth Coneflower	LE	VA101
VA	0208020107	Middle Cowpasture River	Boechera serotina	Shale barren rock cress	LE	VA102

VA	0208020107	Middle Cowpasture River	Myotis sodalis	Indiana Bat	LE	VA102
VA	0208020107	Middle Cowpasture River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA102
VA	0208020108	Lower Cowpasture River	Boechera serotina	Shale barren rock cress	LE	VA103
VA	0208020110	Upper Craig Creek	Myotis sodalis	Indiana Bat	LE	VA105
VA	0208020110	Upper Craig Creek	Pleurobema collina	James Spinymussel	LE	VA105
VA	0208020112	Lower Craig Creek	Pleurobema collina	James Spinymussel	LE	VA106
VA	0208020113	Catawba Creek	Echinacea laevigata	Smooth Coneflower	LE	VA107
VA	0208020113	Catawba Creek	Pleurobema collina	James Spinymussel	LE	VA107
VA	0208020114	Looney Creek-James River	Pleurobema collina	James Spinymussel	LE	VA47
VA	0208020115	Cedar Creek-James River	Pleurobema collina	James Spinymussel	LE	VA48
VA	0208020201	Calfpasture River	Boechera serotina	Shale barren rock cress	LE	VA49
VA	0208020201	Calfpasture River	Pleurobema collina	James Spinymussel	LE	VA49
VA	0208020201	Calfpasture River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA49
VA	0208020202	Little Calfpasture River-Upper Maury River	Pleurobema collina	James Spinymussel	LE	VA50
VA	0208020203	Middle Maury River	Alasmidonta heterodon	Dwarf Wedgemussel	LE	VA51
VA	0208020203	Middle Maury River	Pleurobema collina	James Spinymussel	LE	VA51
VA	0208020203	Middle Maury River	Antrolana lira	Madison Cave Isopod	LT	VA51
VA	0208020204	South River	Helenium virginicum	Virginia Sneezeweed	LT	VA52
VA	0208020204	South River	Helonias bullata	Swamp-pink	LT	VA52
VA	0208020205	Lower Maury River	Helenium virginicum	Virginia Sneezeweed	LT	VA53
VA	0208020302	Pedlar River	Pleurobema collina	James Spinymussel	LE	VA55
VA	0208020302	Pedlar River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA55
VA	0208020303	Harris Creek-James River	Echinacea laevigata	Smooth Coneflower	LE	VA56
VA	0208020304	Wreck Island Creek-James	Isotria medeoloides	Small Whorled	LT	VA57

		River		Pogonia		
VA	0208020305	Upper Tye River	Pleurobema collina	James Spinymussel	LE	VA58
VA	0208020305	Upper Tye River	Helonias bullata	Swamp-pink	LT	VA58
VA	0208020306	Buffalo River	Echinacea laevigata	Smooth Coneflower	LE	VA59
VA	0208020308	David Creek-James River	Isotria medeoloides	Small Whorled Pogonia	LT	VA78
VA	0208020311	Ballinger Creek-James River	Pleurobema collina	James Spinymussel	LE	VA81
VA	0208020312	Hardware River	Pleurobema collina	James Spinymussel	LE	VA82
VA	0208020313	Upper Slate River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA83
VA	0208020314	Lower Slate River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA84
VA	0208020401	Moormans River-Mechums River	Pleurobema collina	James Spinymussel	LE	VA86
VA	0208020402	South Fork Rivanna River	Pleurobema collina	James Spinymussel	LE	VA87
VA	0208020403	North Fork Rivanna River	Pleurobema collina	James Spinymussel	LE	VA136
VA	0208020403	North Fork Rivanna River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA136
VA	0208020404	Mechunk Creek-Rivanna River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA88
VA	0208020405	Cunningham Creek-Rivanna River	Pleurobema collina	James Spinymussel	LE	VA89
VA	0208020505	Lickinghole Creek-James River	Pleurobema collina	James Spinymussel	LE	VA94
VA	0208020601	Falling Creek-James River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA108
VA	0208020601	Falling Creek-James River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA108
VA	0208020601	Falling Creek-James River	Helonias bullata	Swamp-pink	LT	VA108
VA	0208020601	Falling Creek-James River	Haliaeetus leucocephalus	Bald eagle		VA108
VA	0208020602	Herring Creek-James River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA109
VA	0208020602	Herring Creek-James River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA109
VA	0208020602	Herring Creek-James River	Haliaeetus leucocephalus	Bald eagle		VA109

VA	0208020603	Upper Chippokes Creek-James River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA145
VA	0208020603	Upper Chippokes Creek-James River	Haliaeetus leucocephalus	Bald eagle		VA145
VA	0208020605	Middle Chickahominy River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA111
VA	0208020605	Middle Chickahominy River	Helonias bullata	Swamp-pink	LT	VA111
VA	0208020606	Lower Chickahominy River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA112
VA	0208020606	Lower Chickahominy River	Isotria medeoloides	Small Whorled Pogonia	LT	VA112
VA	0208020606	Lower Chickahominy River	Haliaeetus leucocephalus	Bald eagle		VA112
VA	0208020607	Powhatan Creek-James River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA146
VA	0208020607	Powhatan Creek-James River	Aeschynomene virginica	Sensitive Joint-vetch	LT	VA146
VA	0208020607	Powhatan Creek-James River	Isotria medeoloides	Small Whorled Pogonia	LT	VA146
VA	0208020607	Powhatan Creek-James River	Haliaeetus leucocephalus	Bald eagle		VA146
VA	0208020608	Lawnes Creek-James River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA113
VA	0208020608	Lawnes Creek-James River	Isotria medeoloides	Small Whorled Pogonia	LT	VA113
VA	0208020608	Lawnes Creek-James River	Haliaeetus leucocephalus	Bald eagle		VA113
VA	0208020608	Lawnes Creek-James River	Merginae sp.	Seaducks		VA113
VA	0208020609	Pagan River-James River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA114
VA	0208020702	Vaughans Creek-Appomattox River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA74
VA	0208020707	Deep Creek	Echinacea laevigata	Smooth Coneflower	LE	VA70
VA	0208020709	Swift Creek	Myotis septentrionalis	Northern Long-eared Bat	LT	VA72
VA	0208020710	Ashton Creek-Appomattox River	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA73
VA	0208020710	Ashton Creek-Appomattox River	Isotria medeoloides	Small Whorled Pogonia	LT	VA73

VA	0208020710	Ashton Creek-Appomattox River	Haliaeetus leucocephalus	Bald eagle		VA73
VA	0208020801	Nansemond River	Picoides borealis	Red-cockaded Woodpecker	LE	VA147
VA	0208020803	Hampton Roads	Acipenser oxyrinchus	Atlantic Sturgeon	LE	VA76
VA	0208020803	Hampton Roads	Charadrius melodus	Piping Plover	LT	VA76
VA	0208020803	Hampton Roads	Haematopus palliatus	American oystercatcher		VA76
VA	0208020803	Hampton Roads	Himantopus mexicanus	Black-necked stilt		VA76
VA,WV	0207000101	North Fork South Branch Potomac River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Glaucomys sabrinus fuscus	Virginia Northern Flying Squirrel	LE	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Myotis sodalis	Indiana Bat	LE	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Trifolium stoloniferum	Running Buffalo Clover	LE	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Plethodon nettingi	Cheat Mountain Salamander	LT	VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Haliaeetus leucocephalus	Bald eagle		VA143
VA,WV	0207000101	North Fork South Branch Potomac River	Salvelinus fontinalis	Brook trout		VA143
VA,WV	0207000103	Upper South Branch Potomac River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA1
VA,WV	0207000103	Upper South Branch Potomac River	Myotis sodalis	Indiana Bat	LE	VA1
VA,WV	0207000103	Upper South Branch Potomac River	Myotis septentrionalis	Northern long-eared bat	LT	VA1

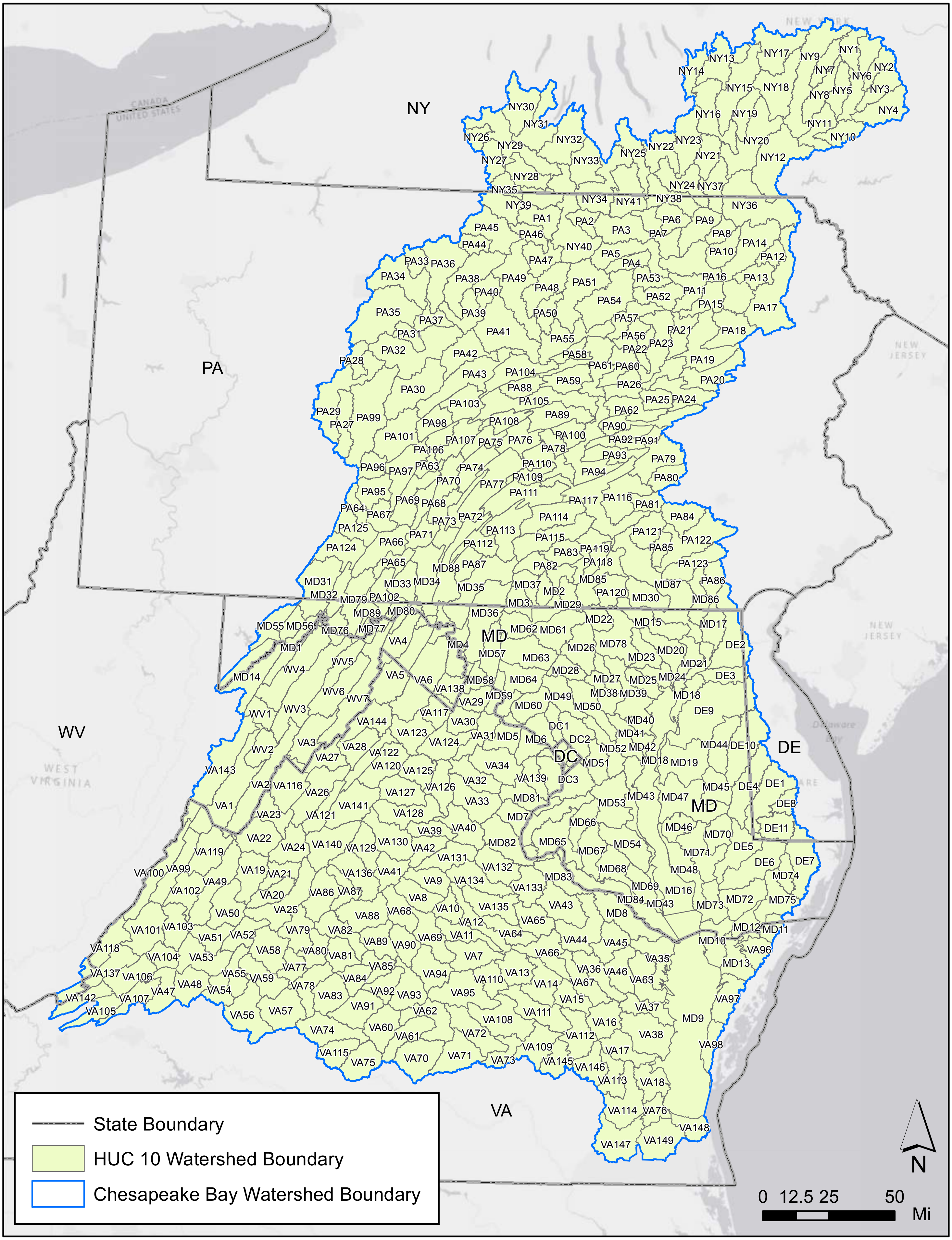
VA,WV	0207000103	Upper South Branch Potomac River	Haliaeetus leucocephalus	Bald eagle		VA1
VA,WV	0207000103	Upper South Branch Potomac River	Salvelinus fontinalis	Brook trout		VA1
VA,WV	0207000105	South Fork South Branch Potomac River	Arabis serotina	Shale Barren Rockcress	LE	VA2
VA,WV	0207000105	South Fork South Branch Potomac River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA2
VA,WV	0207000105	South Fork South Branch Potomac River	Myotis sodalis	Indiana Bat	LE	VA2
VA,WV	0207000105	South Fork South Branch Potomac River	Haliaeetus leucocephalus	Bald eagle		VA2
VA,WV	0207000105	South Fork South Branch Potomac River	Salvelinus fontinalis	Brook trout		VA2
VA,WV	0207000305	Lost River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA3
VA,WV	0207000305	Lost River	Myotis sodalis	Indiana Bat	LE	VA3
VA,WV	0207000305	Lost River	Myotis septentrionalis	Northern long-eared bat	LT	VA3
VA,WV	0207000305	Lost River	Haliaeetus leucocephalus	Bald eagle		VA3
VA,WV	0207000305	Lost River	Salvelinus fontinalis	Brook trout		VA3
VA,WV	0207000307	Cacapon River	Ptilimnium nodosum	Harperella	LE	WV7
VA,WV	0207000307	Cacapon River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	WV7
VA,WV	0207000307	Cacapon River	Haliaeetus leucocephalus	Bald eagle		WV7
VA,WV	0207000307	Cacapon River	Salvelinus fontinalis	Brook trout		WV7
VA,WV	0207000402	Sleepy Creek	Ptilimnium nodosum	Harperella	LE	VA4
VA,WV	0207000402	Sleepy Creek	Haliaeetus leucocephalus	Bald eagle		VA4
VA,WV	0207000404	Back Creek	Ptilimnium nodosum	Harperella	LE	VA5
VA,WV	0207000404	Back Creek	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA5
VA,WV	0207000409	Opequon Creek	Antrolana lira	Madison Cave Isopod	LT	VA6

VA,WV	0207000504	Upper North River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA22
VA,WV	0207000505	Dry River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA23
VA,WV	0207000601	Shoemaker River-North Fork Shenandoah River	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	VA116
VA,WV	0207000601	Shoemaker River-North Fork Shenandoah River	Salvelinus fontinalis	Brook trout		VA116
VA,WV	0207000604	Stony Creek	Salvelinus fontinalis	Brook trout		VA27
VA,WV	0207000702	Long Marsh Run-Shenandoah River	Antrolana lira	Madison Cave Isopod	LT	VA117
VA,WV	0208020102	Back Creek-Middle Jackson River	Boechera serotina	Shale barren rock cress	LE	VA100
VA,WV	0208020102	Back Creek-Middle Jackson River	Myotis sodalis	Indiana Bat	LE	VA100
VA,WV	0208020102	Back Creek-Middle Jackson River	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA100
VA,WV	0208020102	Back Creek-Middle Jackson River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA100
VA,WV	0208020103	Dunlap Creek	Boechera serotina	Shale barren rock cress	LE	VA118
VA,WV	0208020103	Dunlap Creek	Echinacea laevigata	Smooth Coneflower	LE	VA118
VA,WV	0208020104	Potts Creek	Boechera serotina	Shale barren rock cress	LE	VA137
VA,WV	0208020104	Potts Creek	Myotis sodalis	Indiana Bat	LE	VA137
VA,WV	0208020104	Potts Creek	Pleurobema collina	James Spinymussel	LE	VA137
VA,WV	0208020104	Potts Creek	Scirpus ancistrochaetus	Northeastern Bulrush	LE	VA137
VA,WV	0208020104	Potts Creek	Myotis septentrionalis	Northern Long-eared Bat	LT	VA137
VA,WV	0208020106	Upper Cowpasture River	Boechera serotina	Shale barren rock cress	LE	VA119
VA,WV	0208020106	Upper Cowpasture River	Corynorhinus townsendii	Virginia Big-eared Bat	LE	VA119

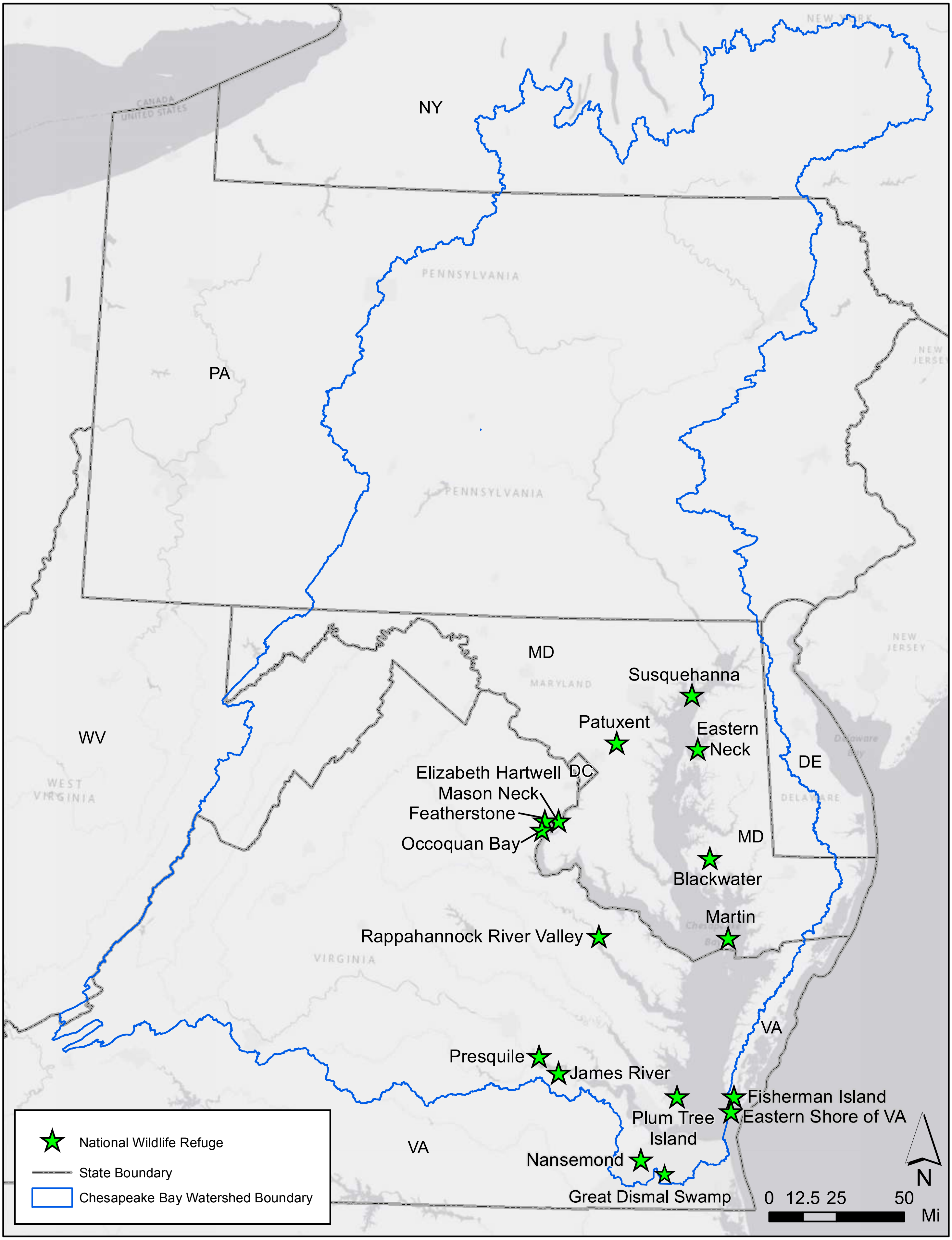
			virginianus			
VA,WV	0208020106	Upper Cowpasture River	Myotis sodalis	Indiana Bat	LE	VA119
VA,WV	0208020106	Upper Cowpasture River	Pleurobema collina	James Spinymussel	LE	VA119
VA,WV	0208020106	Upper Cowpasture River	Myotis septentrionalis	Northern Long-eared Bat	LT	VA119
VA,WV	0208020106	Upper Cowpasture River	Salvelinus fontinalis	Brook trout		VA119
VA,WV	0208020111	Johns Creek	Pleurobema collina	James Spinymussel	LE	VA142
VA,WV	0208020111	Johns Creek	Isotria medeoloides	Small Whorled Pogonia	LT	VA142
WV	0207000102	Lunice Creek	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	WV1
WV	0207000102	Lunice Creek	Myotis septentrionalis	Northern long-eared bat	LT	WV1
WV	0207000102	Lunice Creek	Haliaeetus leucocephalus	Bald eagle		WV1
WV	0207000102	Lunice Creek	Salvelinus fontinalis	Brook trout		WV1
WV	0207000104	South Mill Creek-Mill Creek	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	LE	WV2
WV	0207000104	South Mill Creek-Mill Creek	Haliaeetus leucocephalus	Bald eagle		WV2
WV	0207000104	South Mill Creek-Mill Creek	Salvelinus fontinalis	Brook trout		WV2
WV	0207000207	Patterson Creek	Myotis septentrionalis	Northern long-eared bat	LT	WV4
WV	0207000207	Patterson Creek	Haliaeetus leucocephalus	Bald eagle		WV4
WV	0207000207	Patterson Creek	Salvelinus fontinalis	Brook trout		WV4
WV	0207000306	North River	Haliaeetus leucocephalus	Bald eagle		WV6
WV	0207000306	North River	Salvelinus fontinalis	Brook trout		WV6

Appendix B. Maps

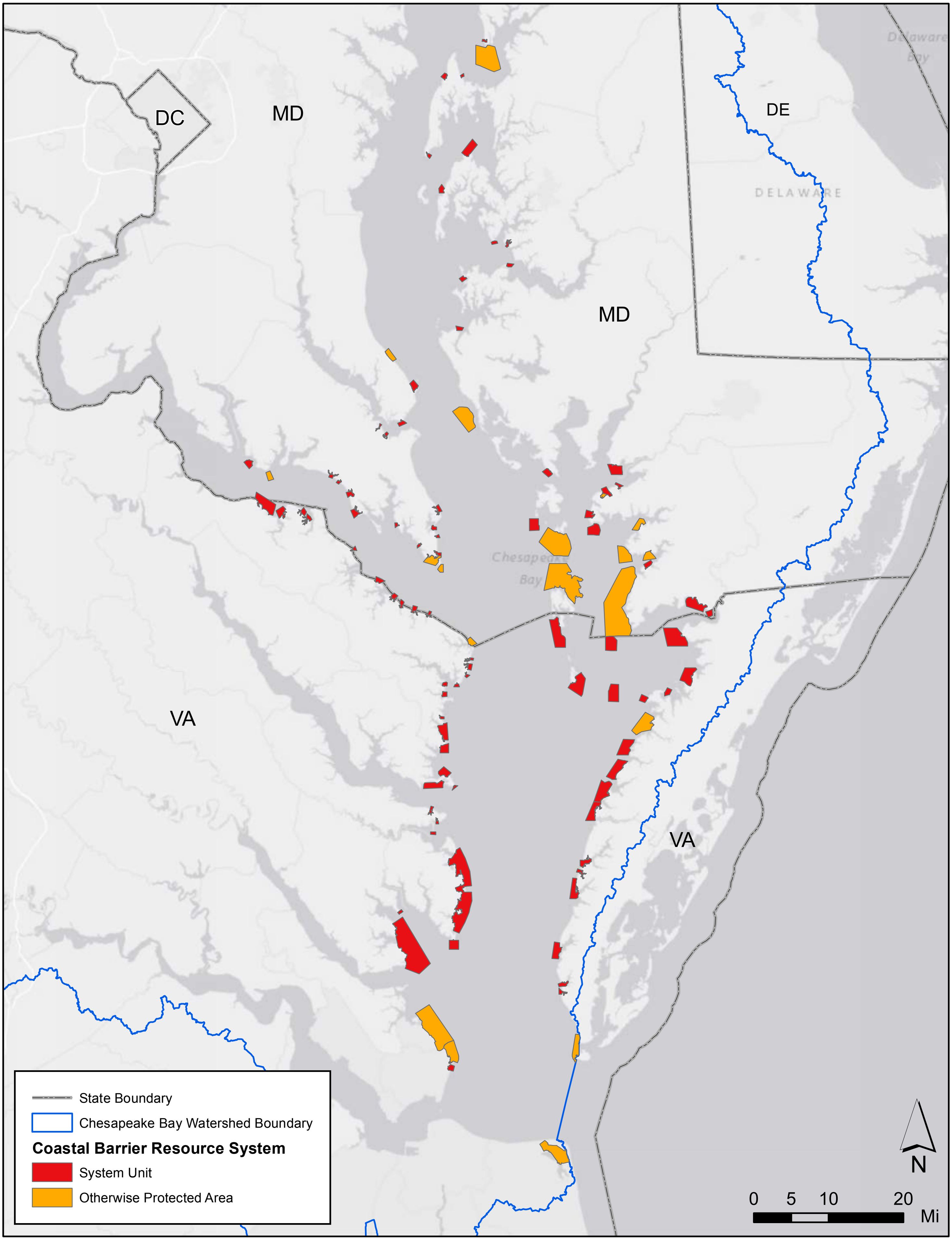
10-digit Hydrologic Units of the Chesapeake Bay Watershed



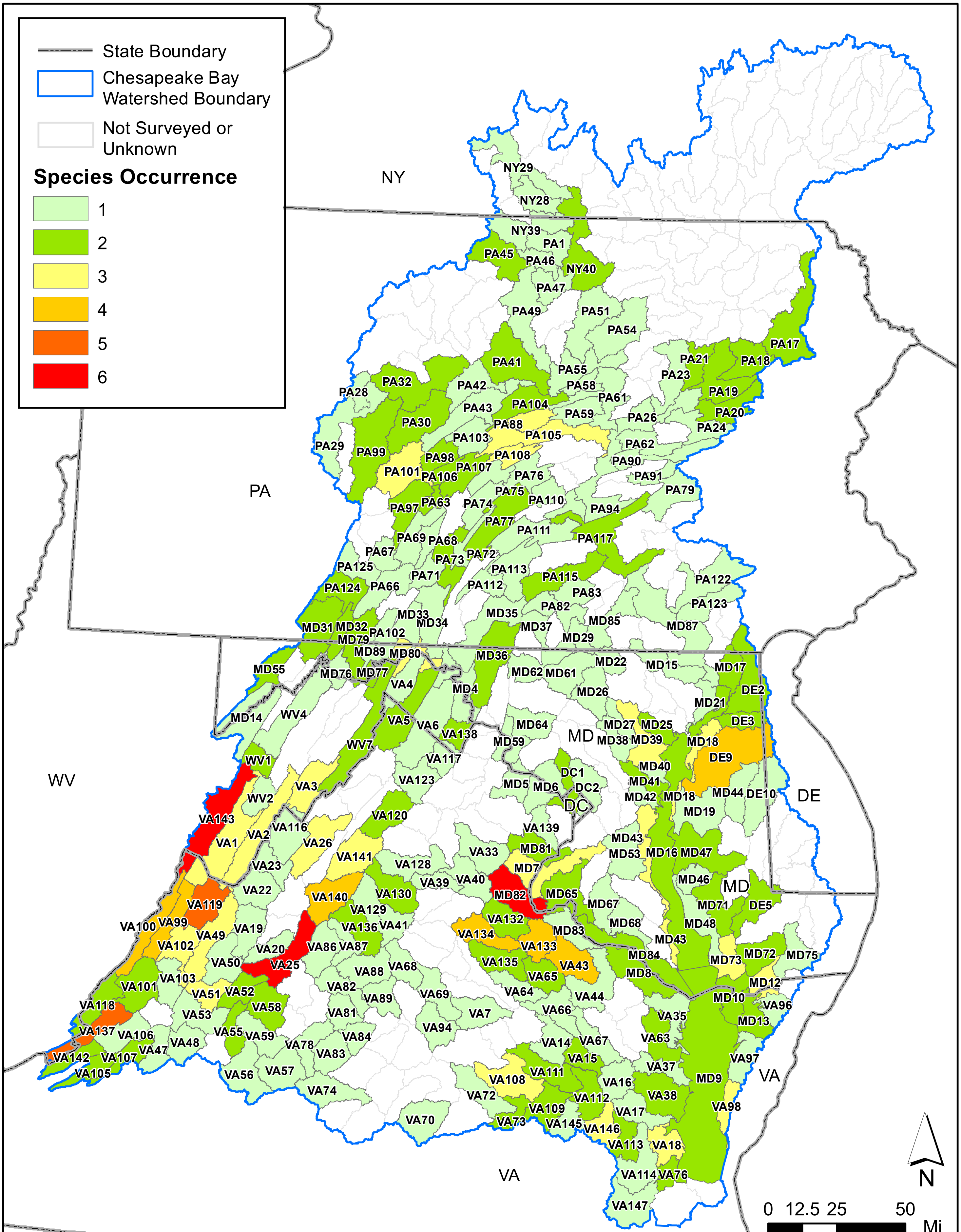
U.S. Fish and Wildlife Service Refuges in the Chesapeake Bay Watershed



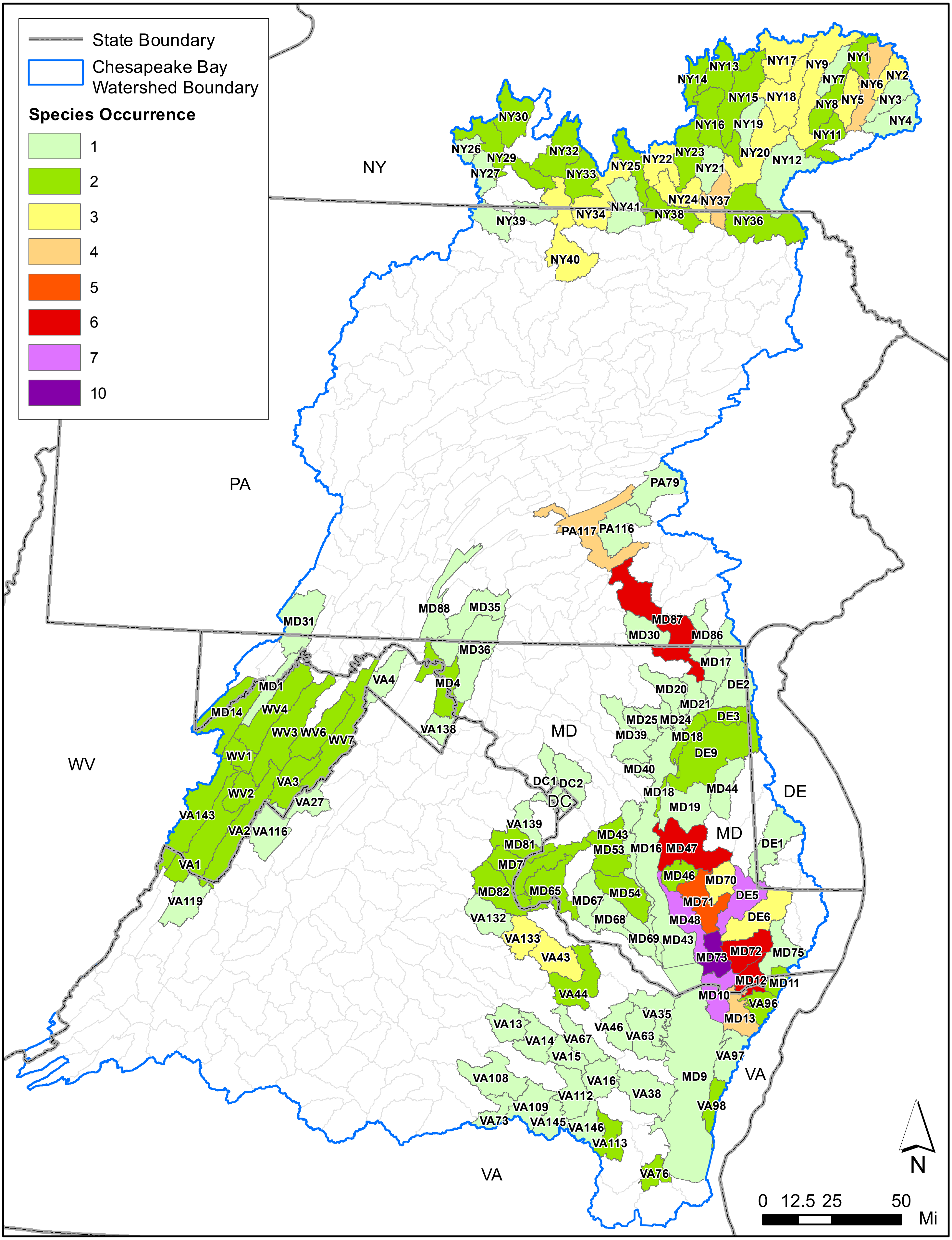
Coastal Barrier Resources Act Units of the Chesapeake Bay Watershed



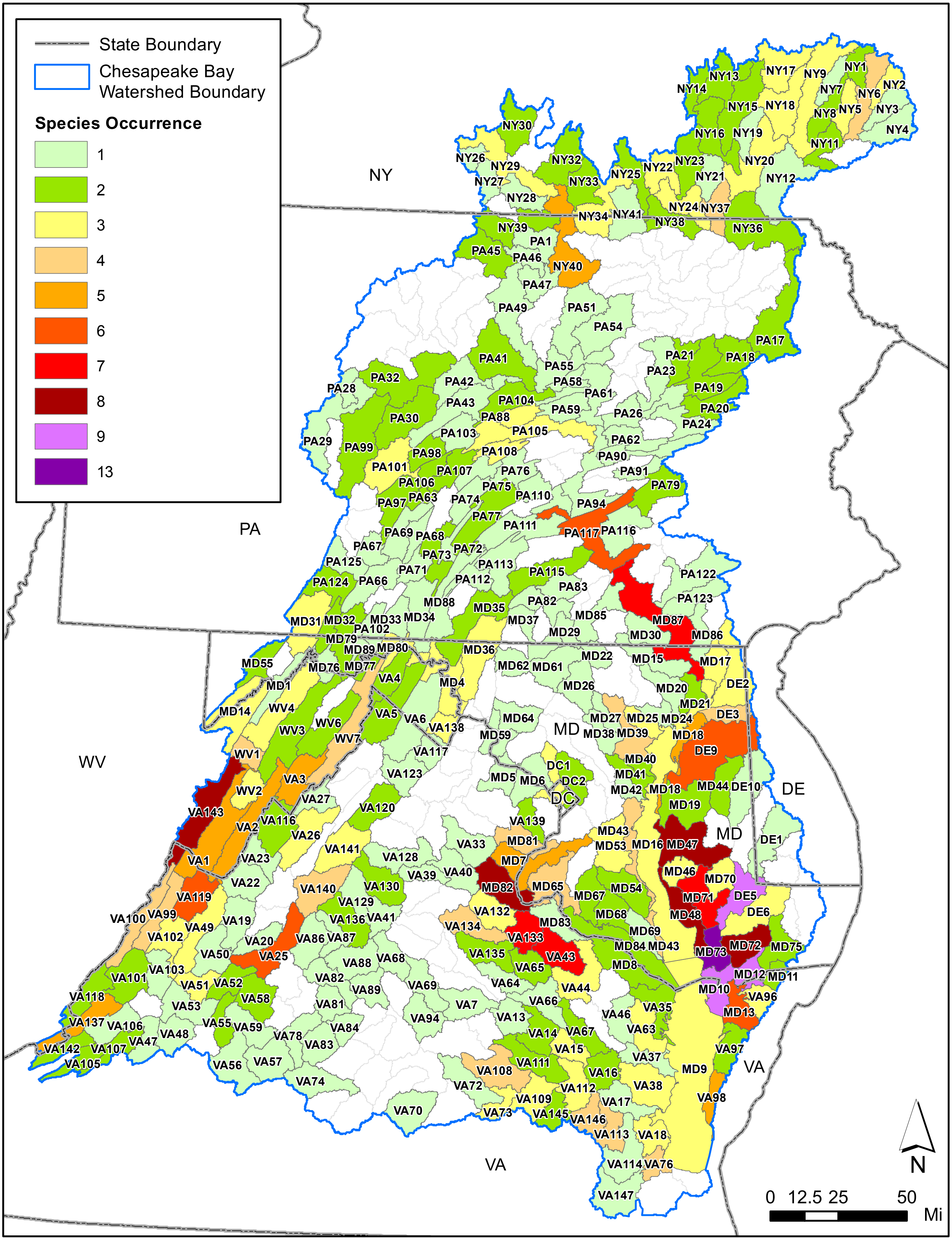
Federally Listed Theatened and Endangered Species of the Chesapeake Bay Watershed



USFWS Other Priority Species of the Chesapeake Bay Watershed



USFWS All Priority Species of the Chesapeake Bay Watershed



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