Resilient Coastal Sites
in Maryland & Virginia

The Nature Conservancy

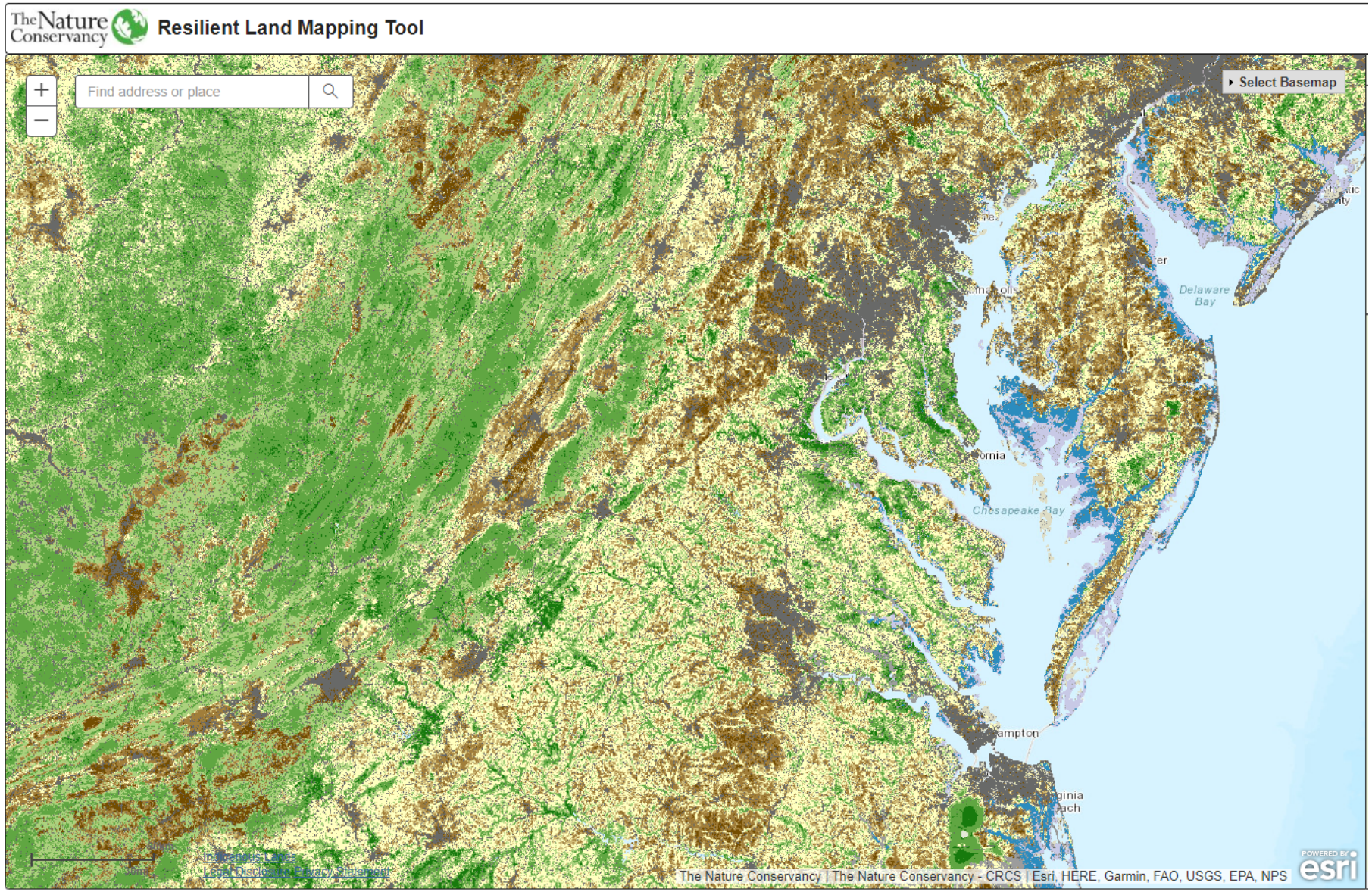
Protecting nature. Preserving life.

CBP Climate Resiliency Workgroup
October 17, 2022

Presentation Topics

- Overview of TNC's Resilient Land Mapping Tool
  - Terrestrial resilience
  - Resilient and Connected Network
- Details of Resilient Coastal Sites analysis for MD & VA
  - Physical Attributes
  - Condition Attributes
  - Resilience Score
  - Web Map
- Next steps for targeting conservation and restoration

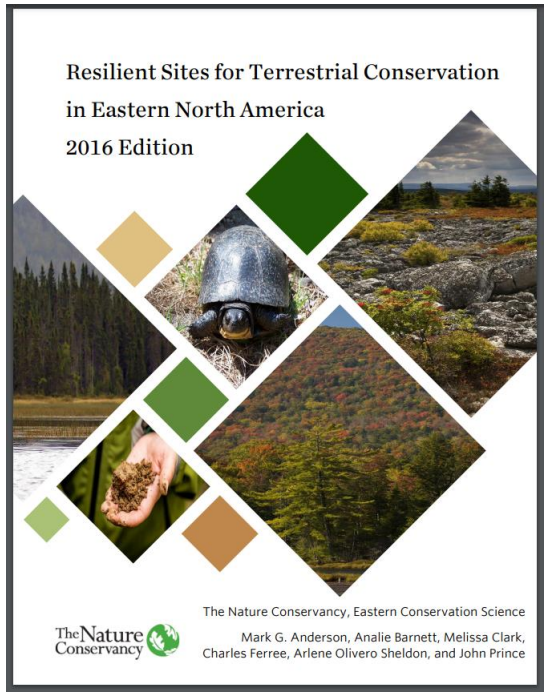
Resilient Land Mapping Tool



Resilient Sites
- Most resilient
- More resilient
- Slightly more resilient
- Average or Median Resilience
- Slightly Less Resilient
- Less Resilient
- Least Resilient
- Developed
- Migration Space for Tidal Habitat
- Resilient Tidal Habitat
- Vulnerable Tidal Habitat
- Sea Level Rise Area

https://maps.tnc.org/resilientland/

Resilient Terrestrial Sites

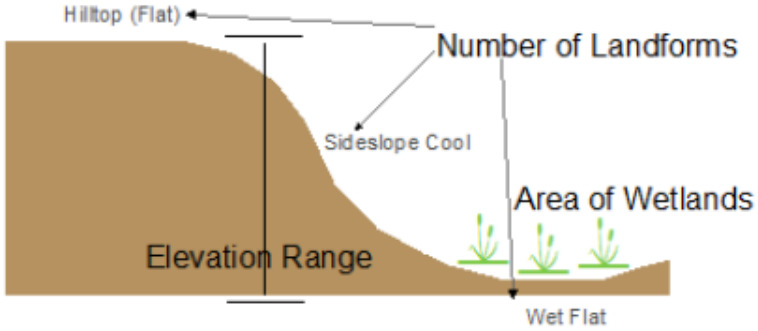


Available on the Conservation Gateway

Components of the resilience score (terrestrial sites)

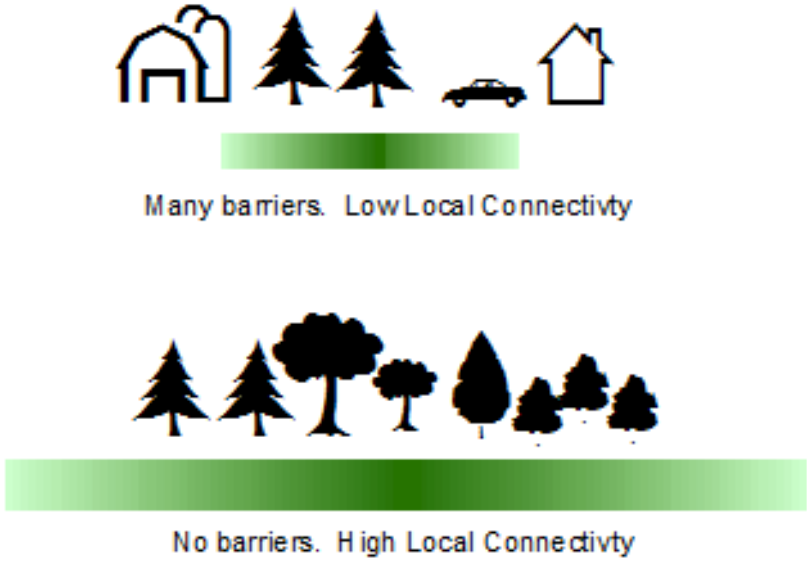
Landscape diversity:
- Landforms (topography)
- Elevation range
- Wetlands

Measured within a 100-ac neighborhood



Local connectedness:
- Major roads
- Development
- Energy Infrastructure
- Industrial farming & forestry land

Measured within a 3-km search radius



Compared to other sites within the same geophysical setting

Resilient & Connected Network

- Connectivity and Climate Flow (Continuous)
- Connectivity and Climate Flow (Categorical)
- Recognized Biodiversity Value
- Resilient and Connected Network (Simple)

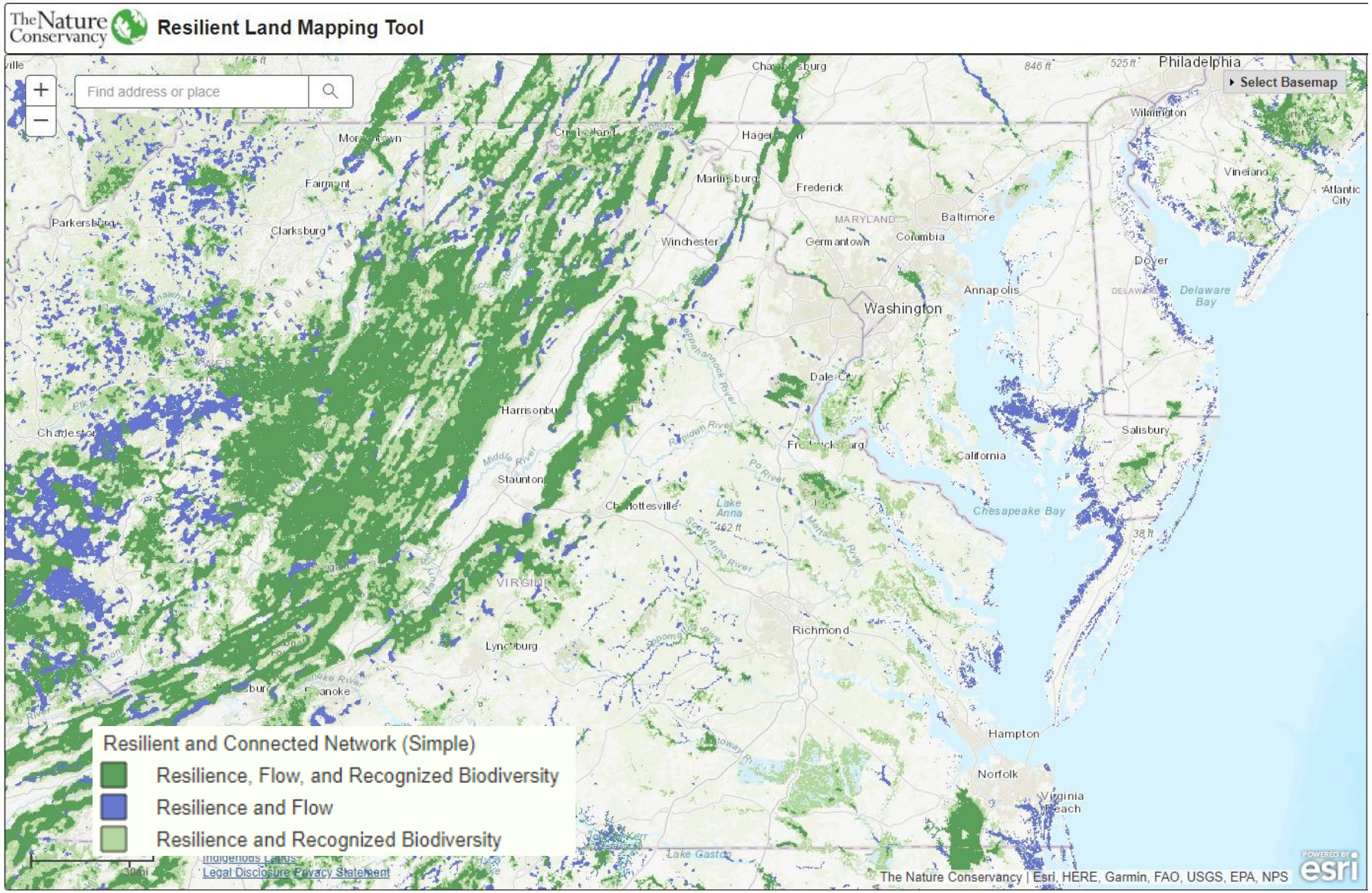
Explore Component Data

Resilient & Connected Network–
- Resilient and Connected Network (Detail)

Resilient Sites–
- Landscape Diversity
- Local Connectedness
- Fragmenting Features
- Geology and Soils
- Elevation
- Landforms
- Migration Space for Tidal Habitat

Recognized Biodiversity Value–
- Recognized Biodiversity Value (Categories)

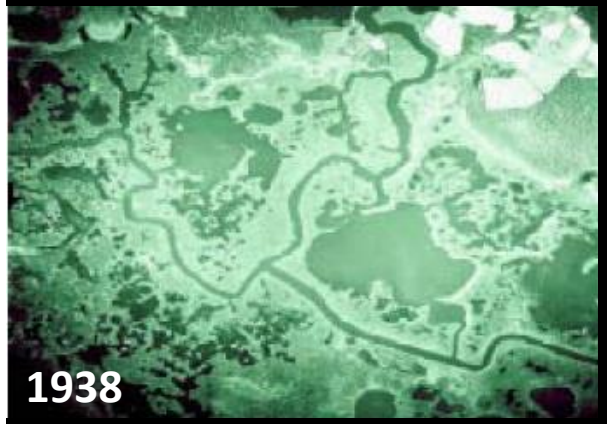
Carbon Estimates–
- Forest Ecosystem Carbon (2010)
- Forest Ecosystem Carbon (2050)
- Potential Forest Ecosystem Carbon Sequestration (2010-2050)
- Forest Types (2008)
- Soil Organic Carbon
- National Landcover Dataset (2019)

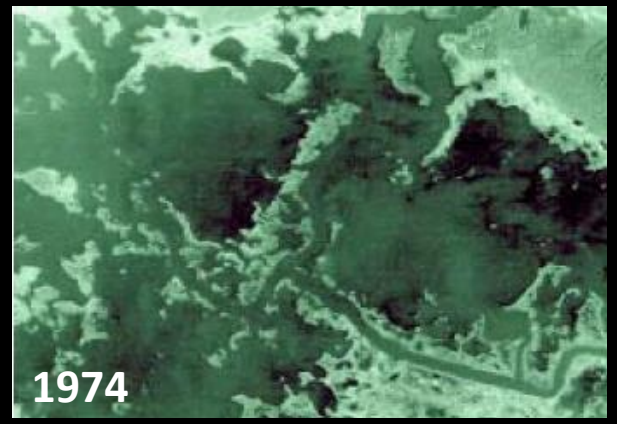


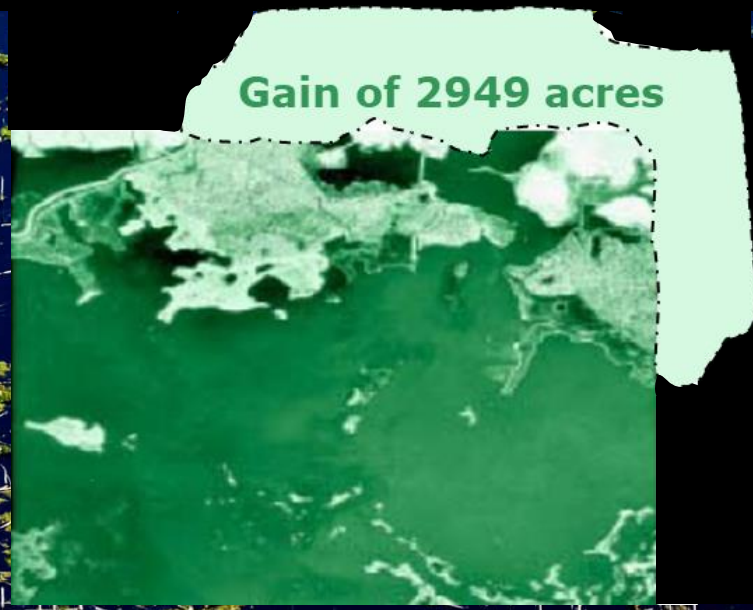
https://maps.tnc.org/resilientland/

The Challenge of Sea Level Rise

Blackwater National Wildlife Refuge (MD): Loss of 5,028 acres of marsh, but gain of 2,949 acres at upland edge with 1’ SLR over 68 years (Lerner et al. 2013)





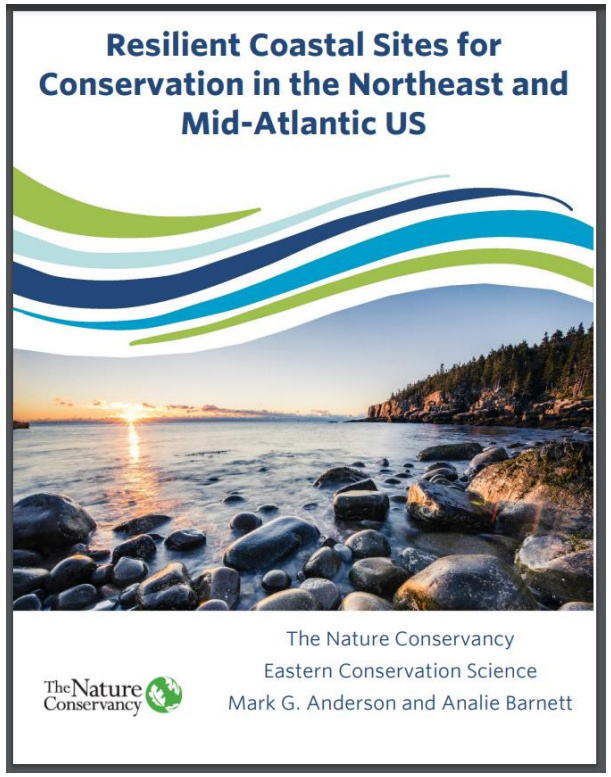


Dead loblolly pines cast shadows over salt marsh at Blackwater National Wildlife Refuge in Dorchester County, Md., on June 5, 2018. Rising seas result in salty water intruding on forested land and killing trees. (Photo by Will Parson/Chesapeake Bay Program)

Lerner, J.A., Curson, D.R., Whitbeck, M. & Meyers, E.J. 2013. Blackwater 2100: A strategy for salt marsh persistence in an era of climate change. The Conservation Fund (Arlington, VA) and Audubon MD-DC (Baltimore, MD).

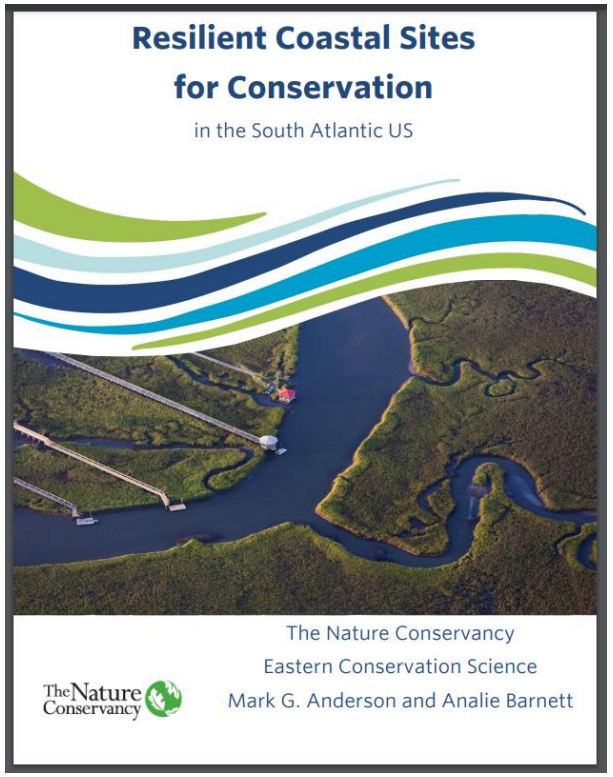
Resilient Coastal Sites

2017



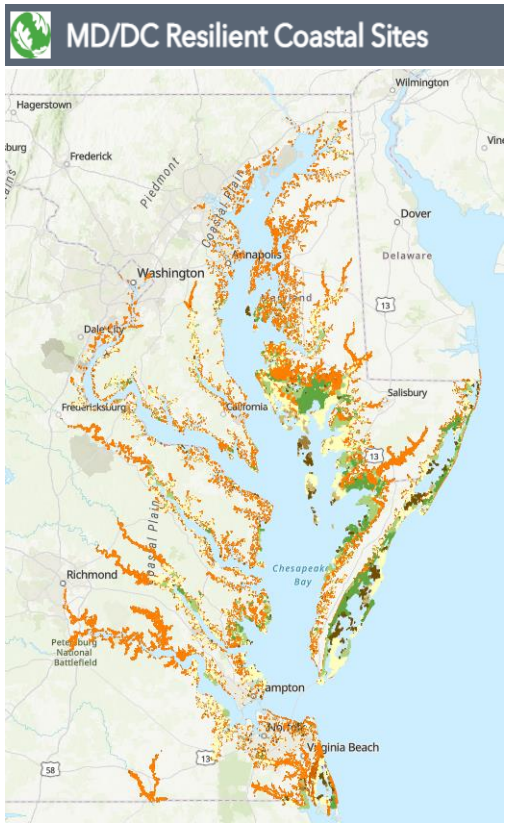
Original analysis that includes Chesapeake Bay – available on the Resilient Land Mapping Tool

2019



Later analysis for the South Atlantic – does not include Chesapeake Bay

2020



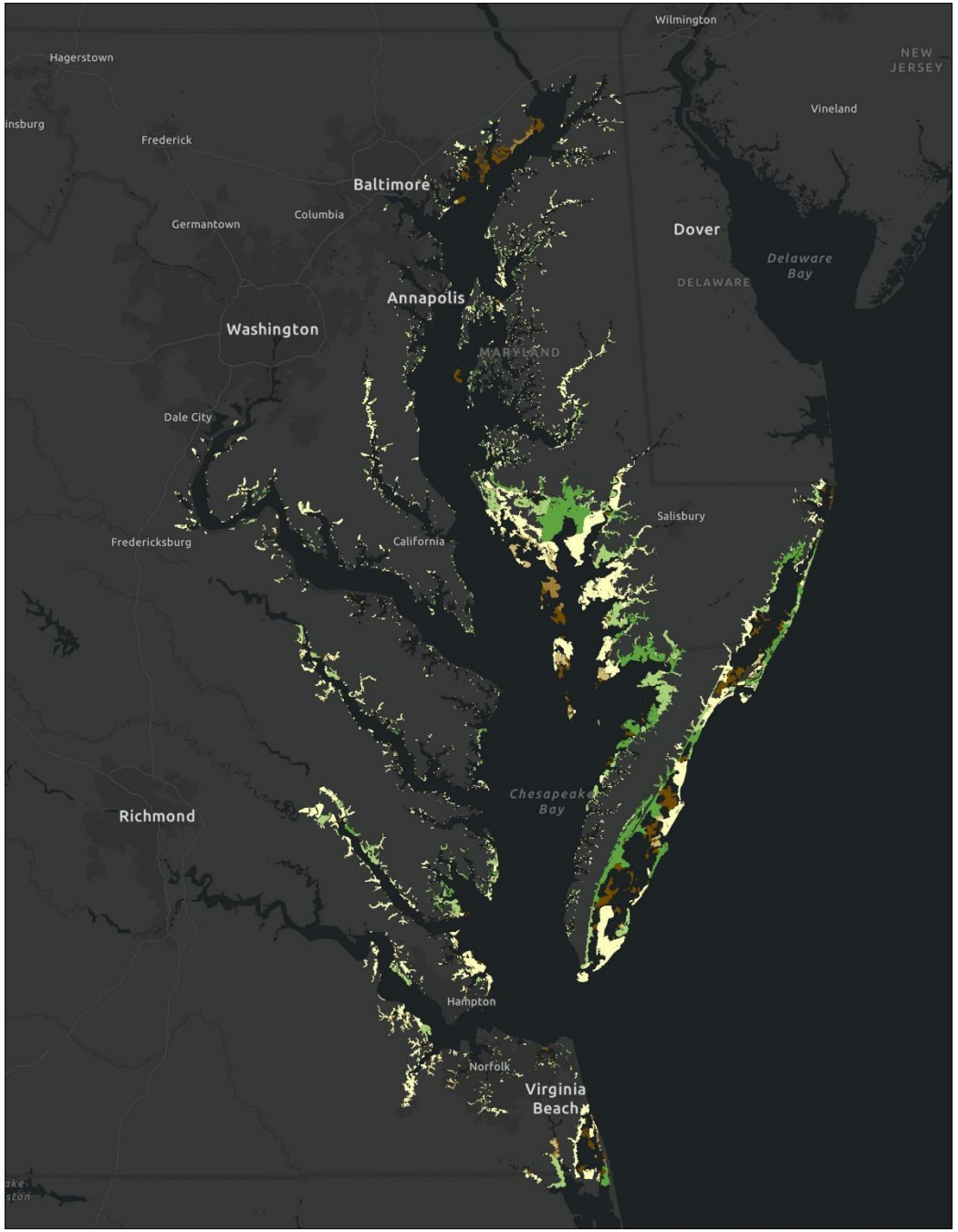
MD/VA analysis used methods from the South Atlantic

MD/DC web map

Resilient Land Mapping Tool and Conservation Gateway

Resilient Coastal Sites in MD & VA (2020)

Analie Barnett,
Center for Resilient Conservation Science,
The Nature Conservancy



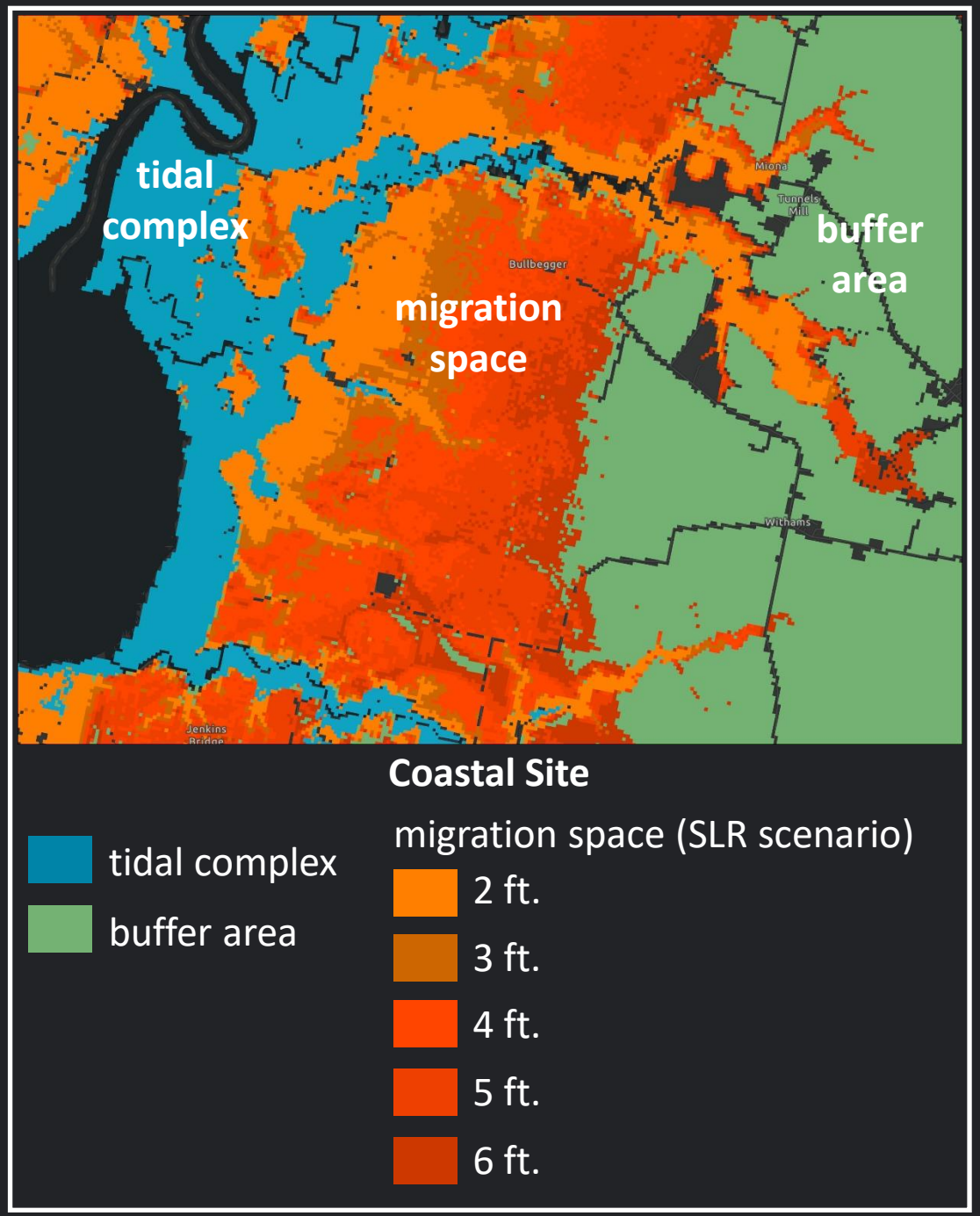
Resilient Coastal Site

A tidal marsh with characteristics that will allow it to migrate to adjacent lowlands, thereby maintaining diversity and key processes as it adapts to sea level rise.

Resilience Score, Stratified

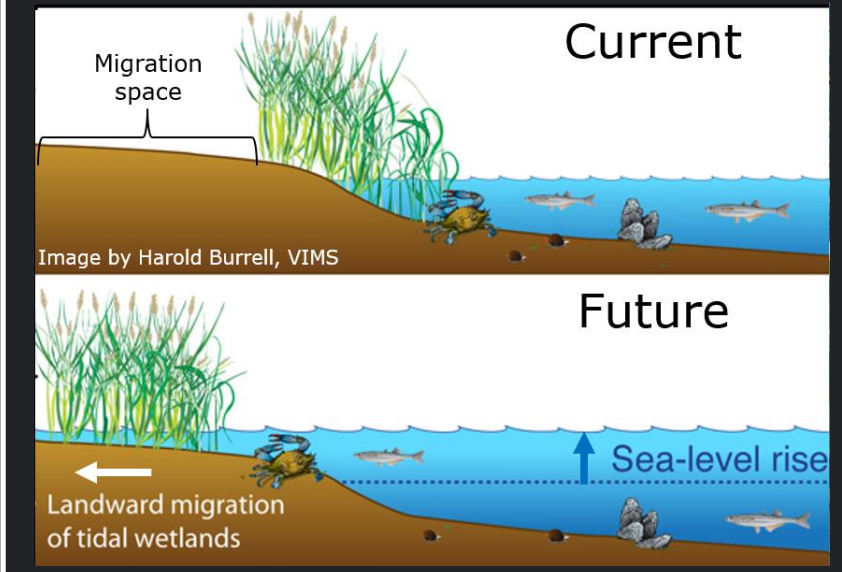
- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Coastal Sites



Tidal complex = primarily tidal marsh, with interconnected brackish marsh and unconsolidated shore.

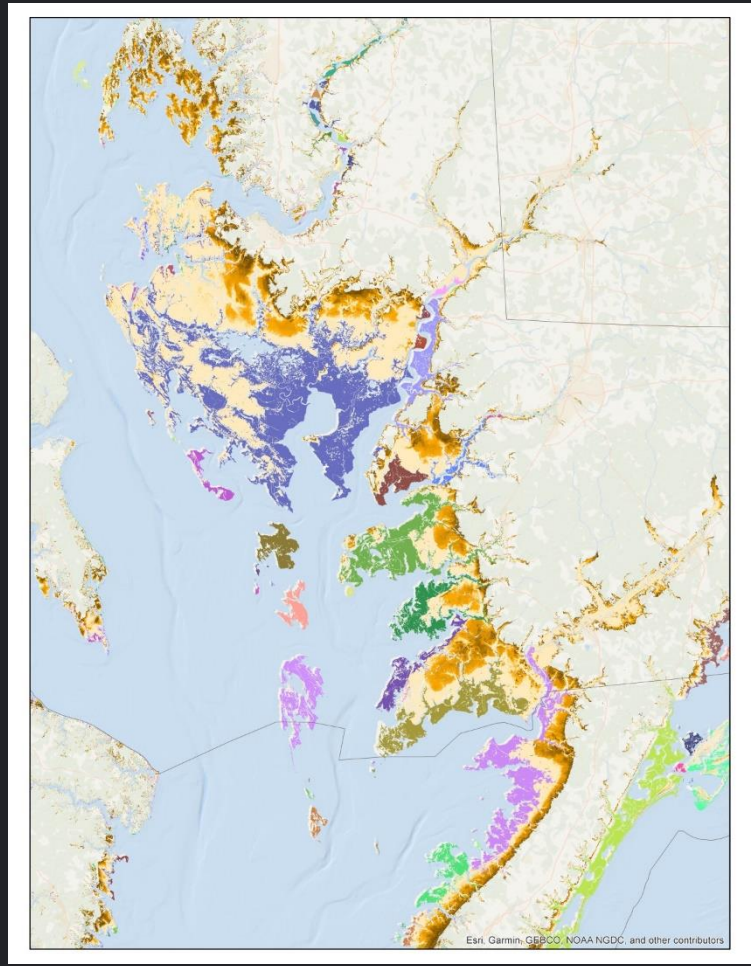
Migration space = suitable low-lying areas that could accommodate future tidal habitats



Buffer area = natural and agricultural lands surrounding the tidal complex and migration space

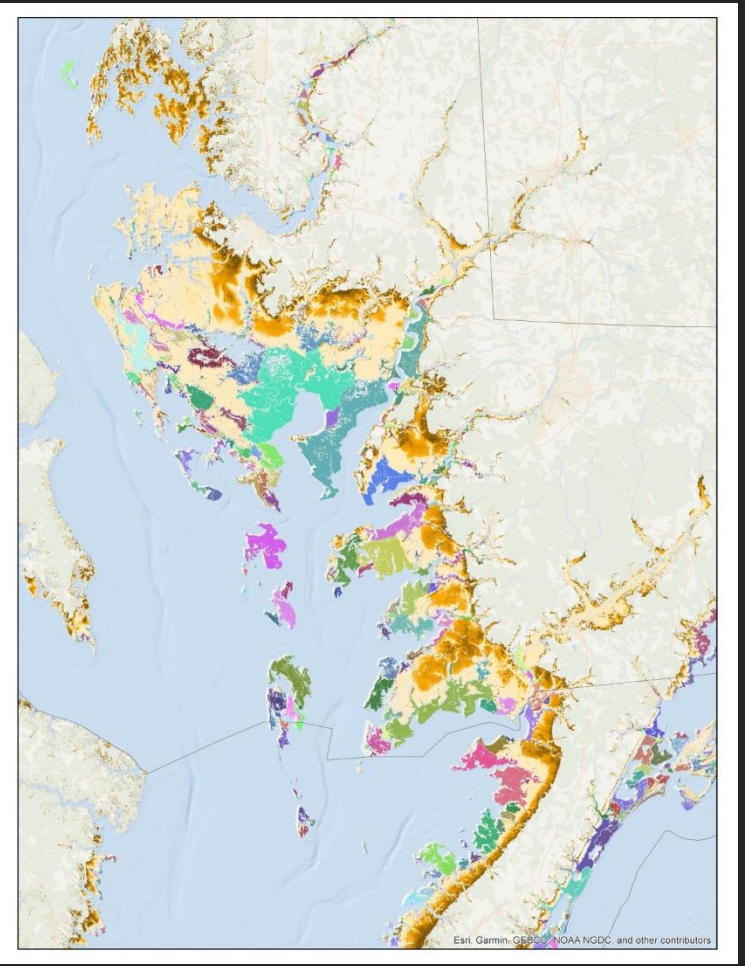
Tidal Complex Units

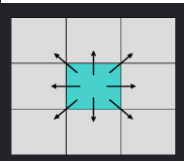
2017 Regional Analysis



Pixels within 150 meters of each other grouped into units.

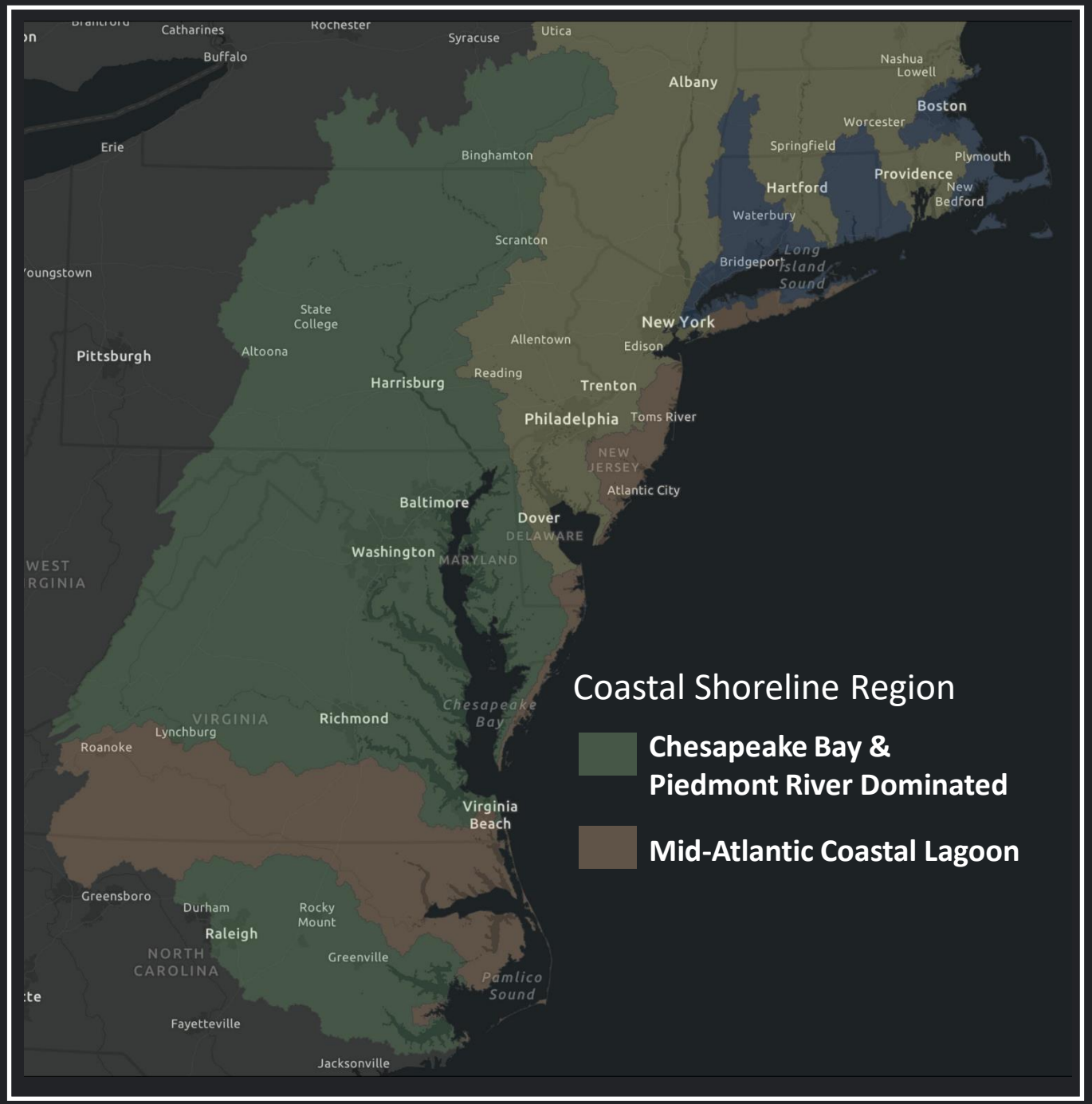
2020 MD/VA Analysis





Contiguous pixels grouped using 8-neighbor rule.

Coastal Shoreline Regions (CSRs)



The 2020 analysis was run for tidal marshes in the **MD & VA portions** of two Coastal Shoreline Regions

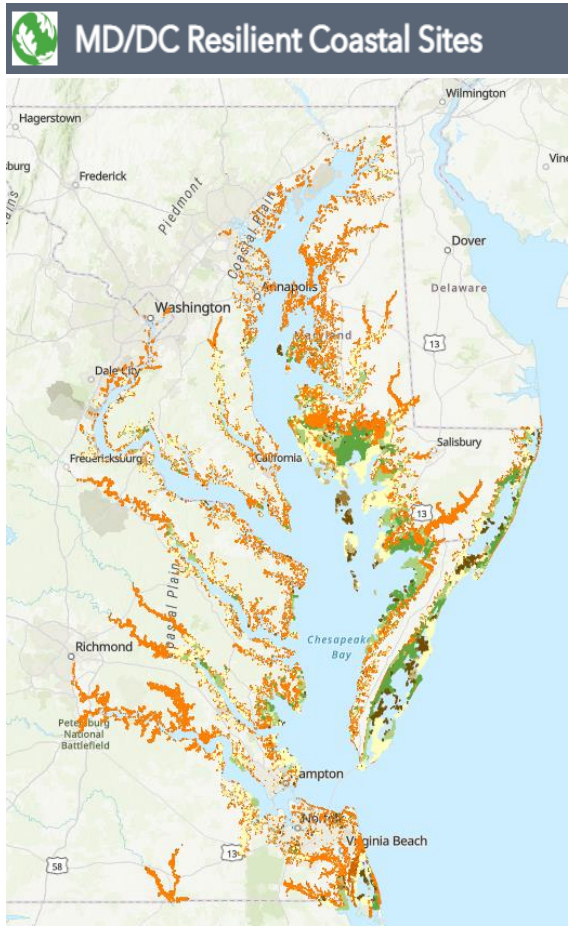
1) Chesapeake Bay & Piedmont River Dominated
2) Mid-Atlantic Coastal Lagoon

Sea Level Rise Scenarios

Table 2. Projected sea-level rise estimates above 2000 levels for Maryland based on the Baltimore tide-gauge station. Columns correspond to different projection probabilities and rows represent to time horizons and emissions pathways. See caveat in the text concerning potentially greater sea-level rise late this century under higher emissions pathways.

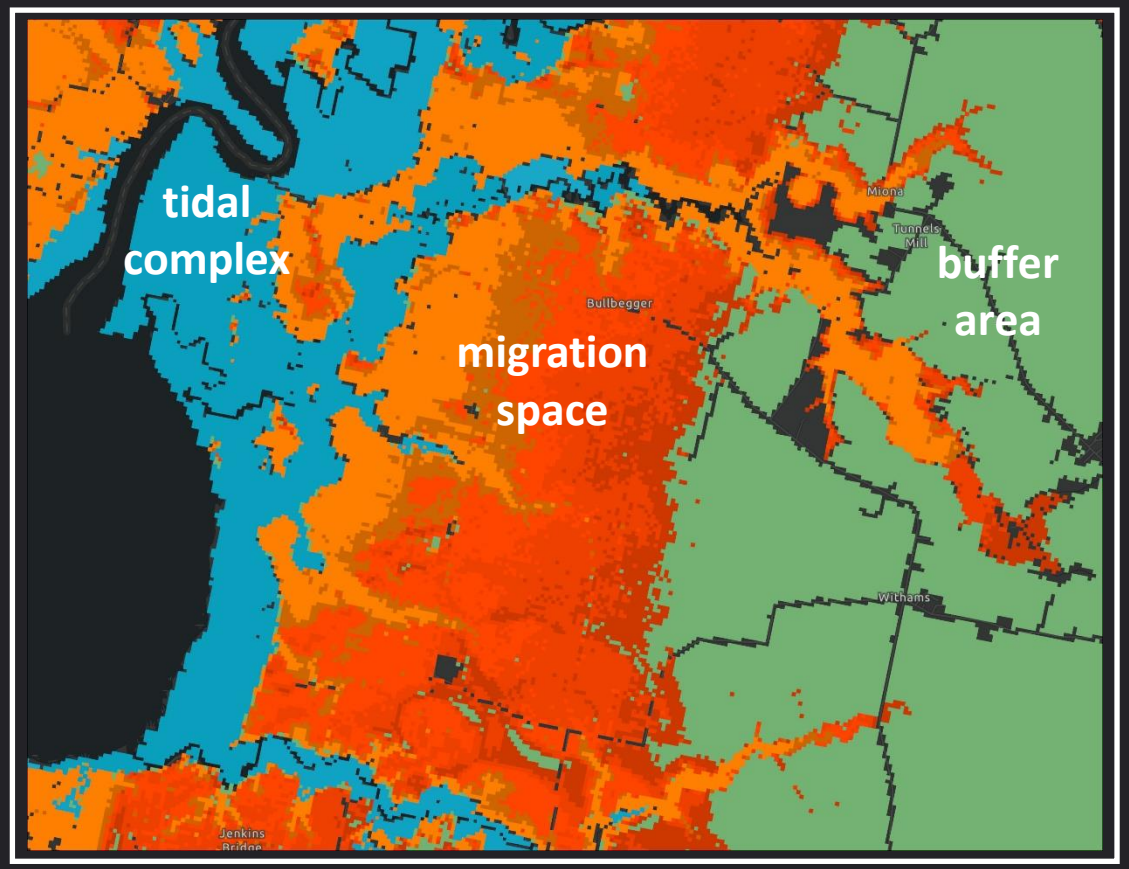
Year	Emissions Pathway	Central Estimate 50% probability SLR meets or exceeds:	Likely Range 67% probability SLR is between:	1 in 20 Chance 5% probability SLR meets or exceeds:	1 in 100 Chance 1% probability SLR meets or exceeds:
2030		0.6 ft	0.4 – 0.9 ft	1.1 ft	1.3 ft
2050		1.2 ft	0.8 – 1.6 ft	2.0 ft	2.3 ft
2080	Growing	2.3 ft	1.6 – 3.1 ft	3.7 ft	4.7 ft
	Stabilized	1.9 ft	1.3 – 2.6 ft	3.2 ft	4.1 ft
	Paris Agreement	1.7 ft	1.1 – 2.4 ft	3.0 ft	3.2 ft
2100	Growing	3.0 ft	2.0 – 4.2 ft	5.2 ft	6.9 ft
	Stabilized	2.4 ft	1.6 – 3.4 ft	4.2 ft	5.6 ft
	Paris Agreement	2.0 ft	1.2 – 3.0 ft	3.7 ft	5.4 ft
2150	Growing	4.8 ft	3.4 – 6.6 ft	8.5 ft	12.4 ft
	Stabilized	3.5 ft	2.1 – 5.3 ft	7.1 ft	10.6 ft
	Paris Agreement	2.9 ft	1.8 – 4.2 ft	5.9 ft	9.4 ft

[SLR Projections for MD – Boesch et al 2018]



[MD/DC web map]

Resilience Attributes

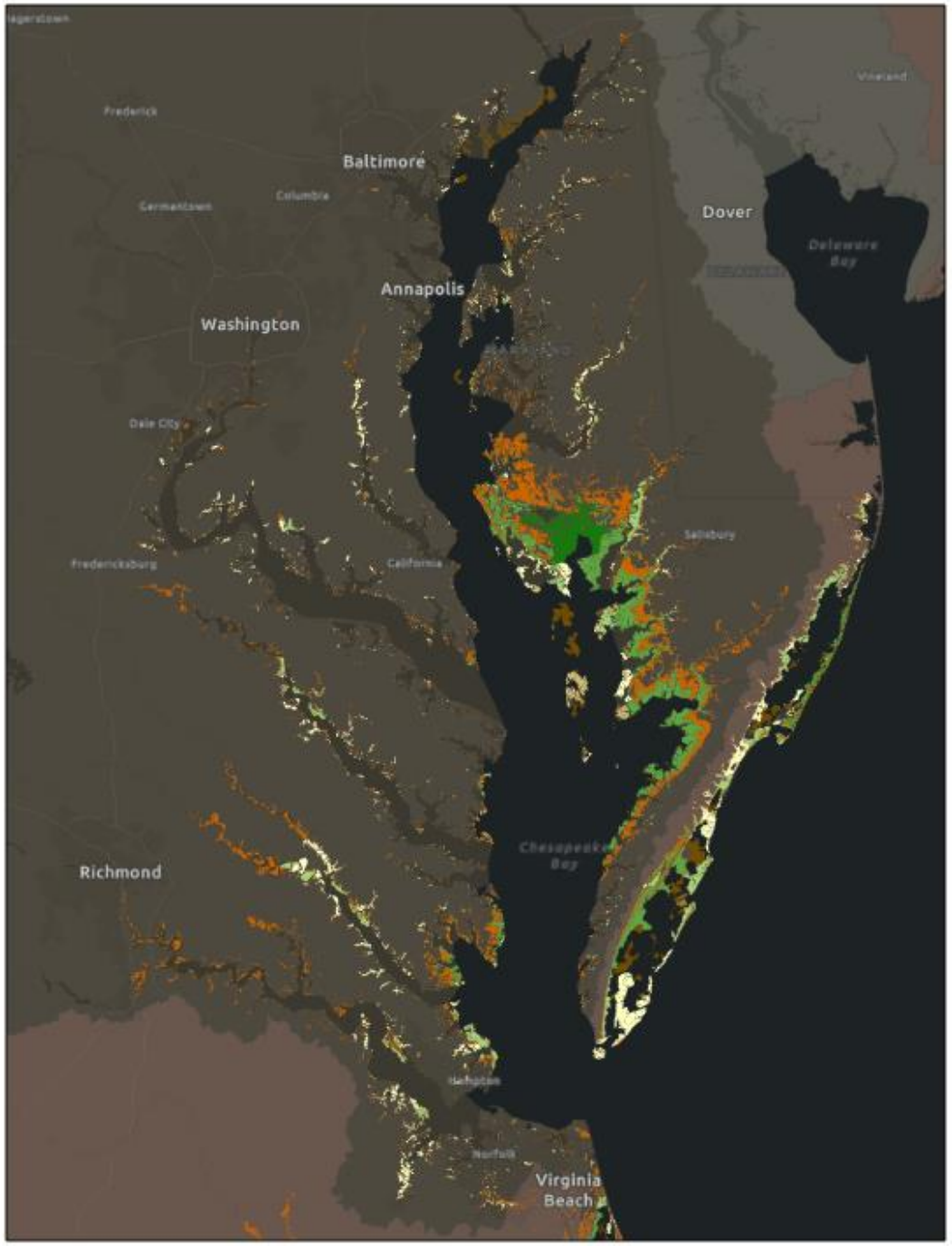


PHYSICAL ATTRIBUTES

- Large migration space
- Many future tidal classes
- Lots of shared upland edge with migration space
- Large tidal complex
- Large buffer area with diverse coastal landforms and maritime highlands

CONDITION ATTRIBUTES

- Few anthropogenic barriers to marsh migration (low development of upland edge)
- Positive sediment balance
- Good water quality index
- Minimal freshwater flow alteration
- Natural buffer area with high wetland connectivity



Physical Attribute: Migration Space Size

Migration Space Size, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

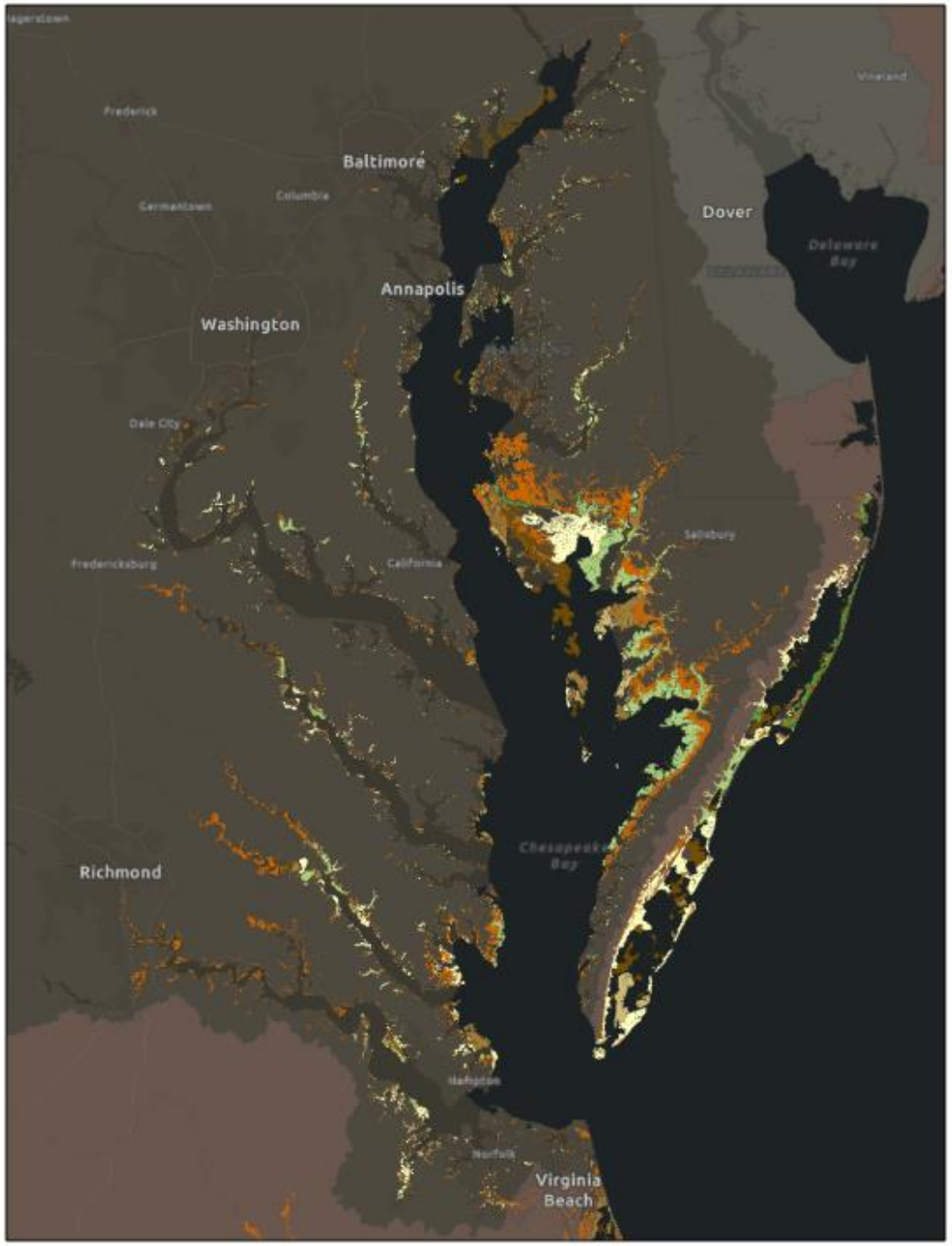
Migration Space

- SLR = 3.0 ft.

Coastal Shoreline Region
(70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine

Data source:
NOAA SLR Viewer –
Marsh Migration Data



Physical Attribute: Tidal Class Diversity & Evenness

Tidal Class Variety & Evenness, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

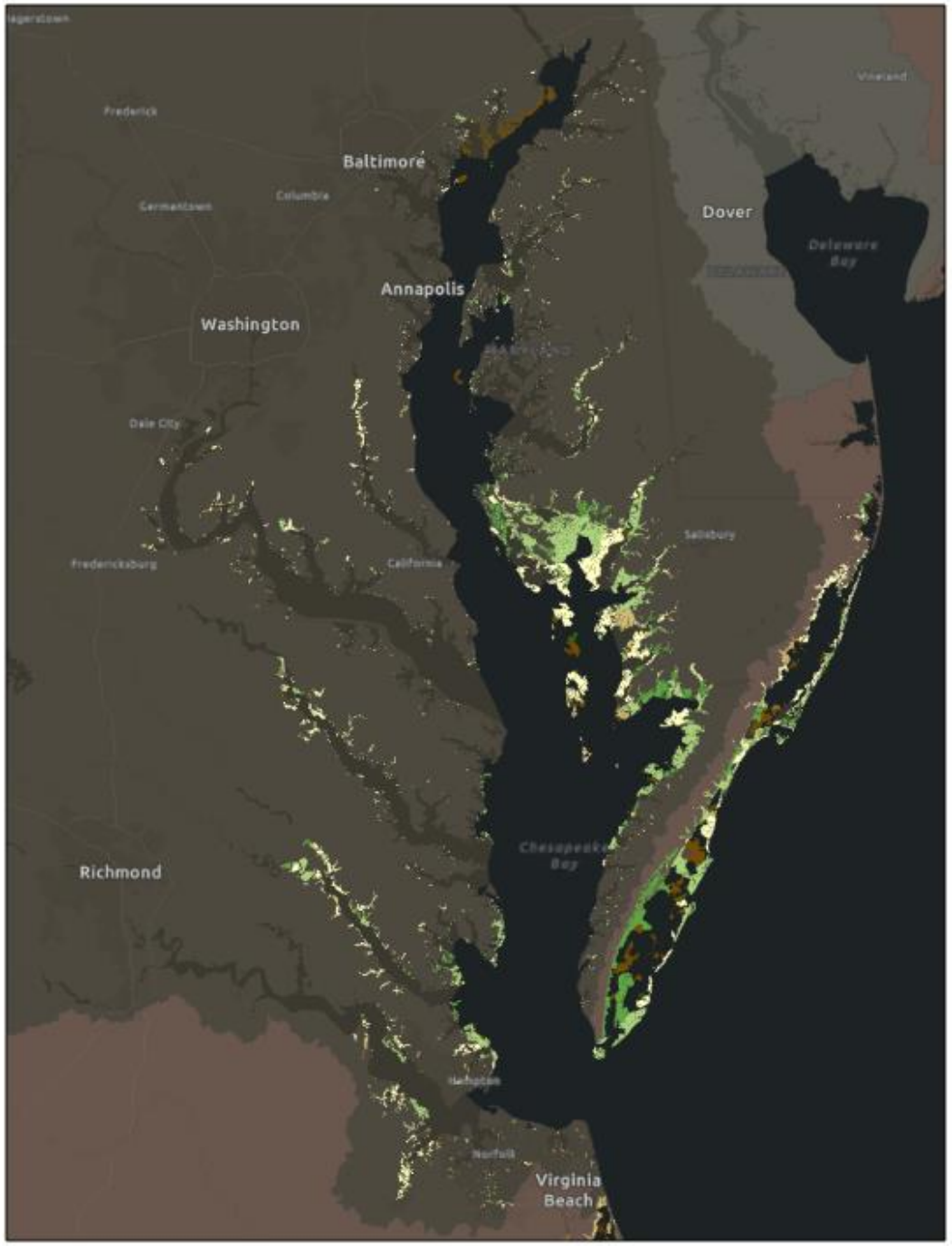
Migration Space

- SLR = 3.0 ft.

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine

Data source:
NOAA SLR Viewer – Marsh Migration Data



Physical Attribute: Shared Upland Edge

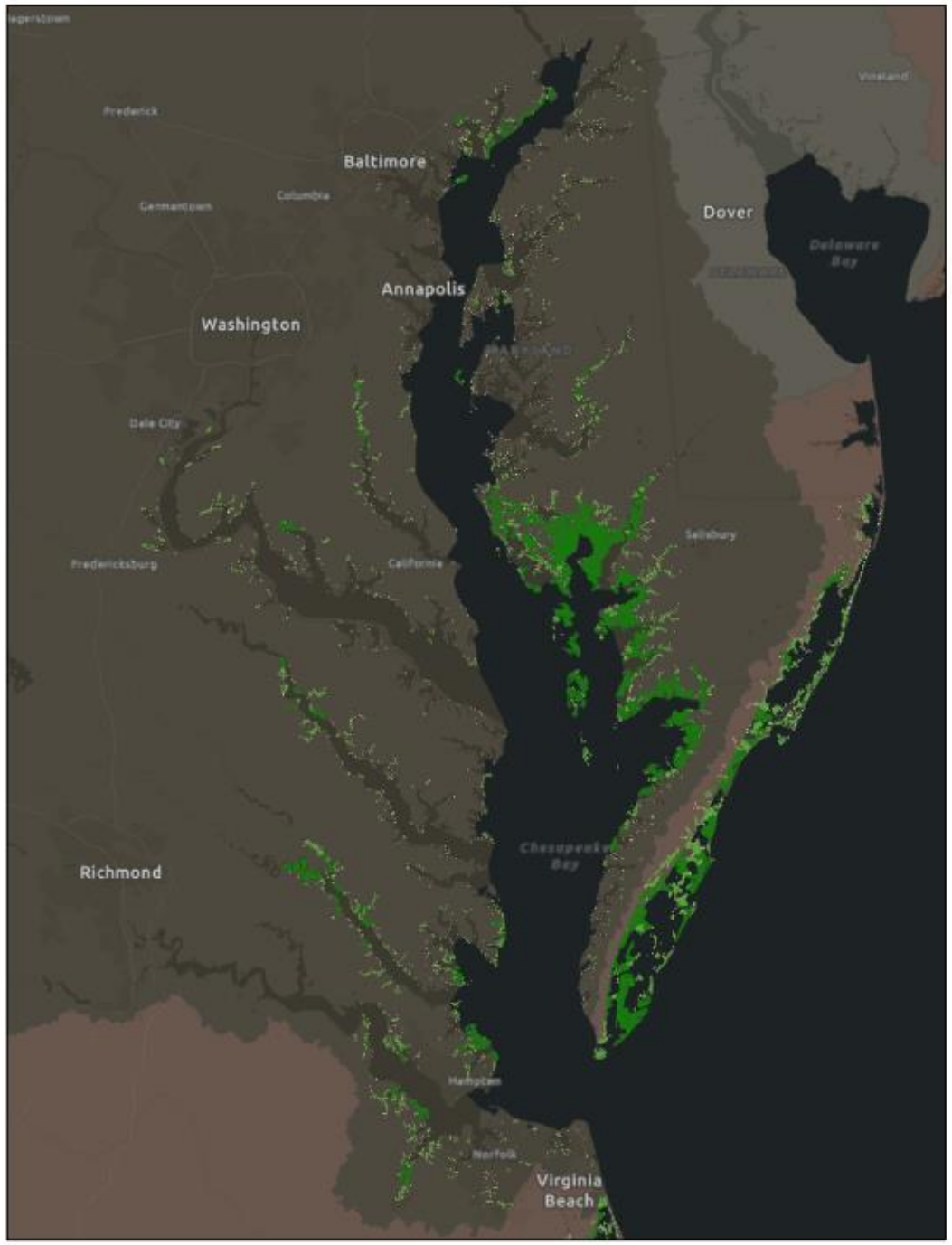
Shared Upland Edge, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Data source:
NOAA C-CAP Land Cover

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Physical Attribute: Tidal Complex Size

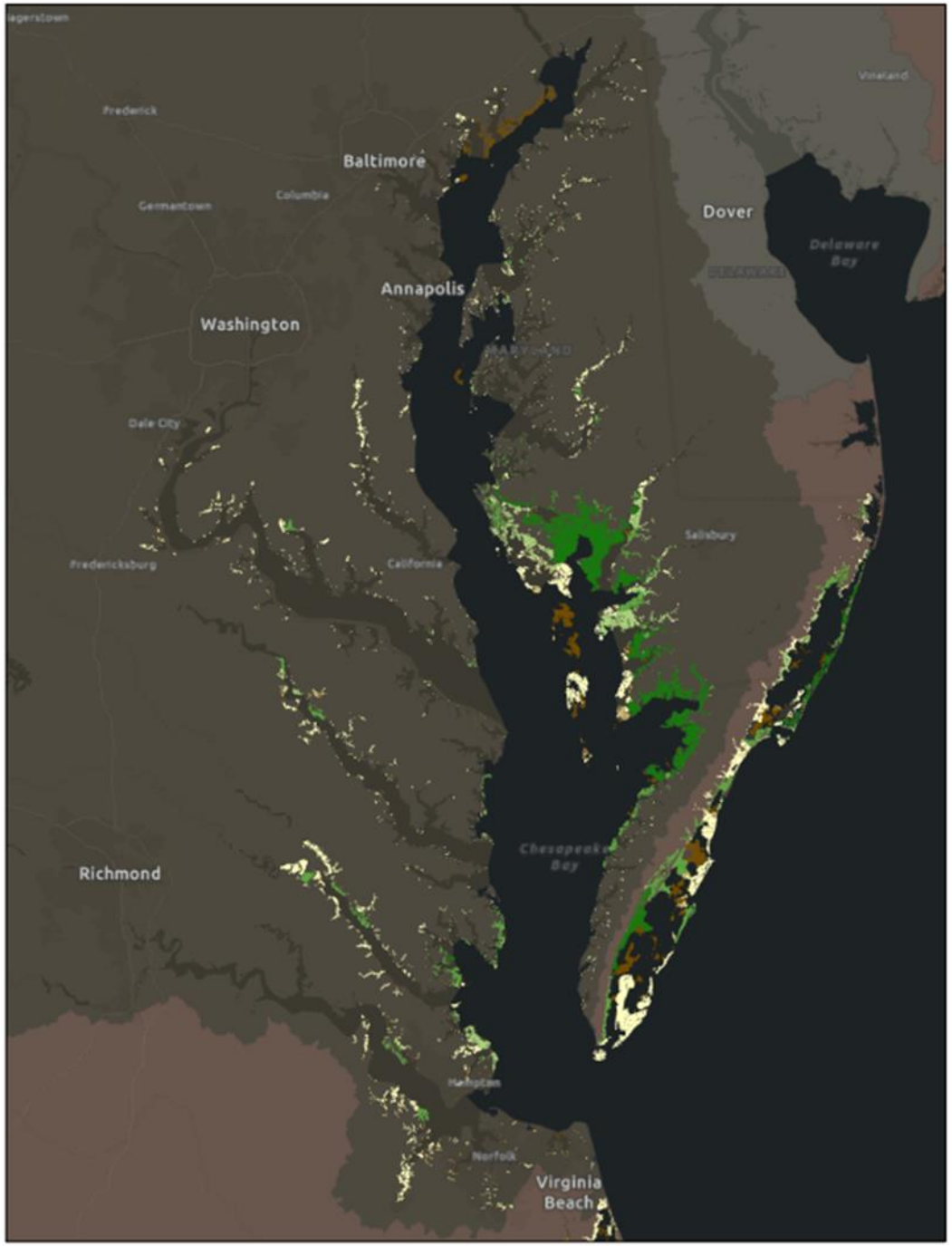
C-CAP Class	Name	Acres
16	Estuarine forested wetland	29
17	Estuarine scrub/shrub wetland	5,859
18	Estuarine emergent wetland	396,893
19	Unconsolidated shore	15,929

Tidal Complex Size, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Coastal Shoreline Region
(70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Physical Score

Physical Score, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Coastal Shoreline Region (70% transparency)

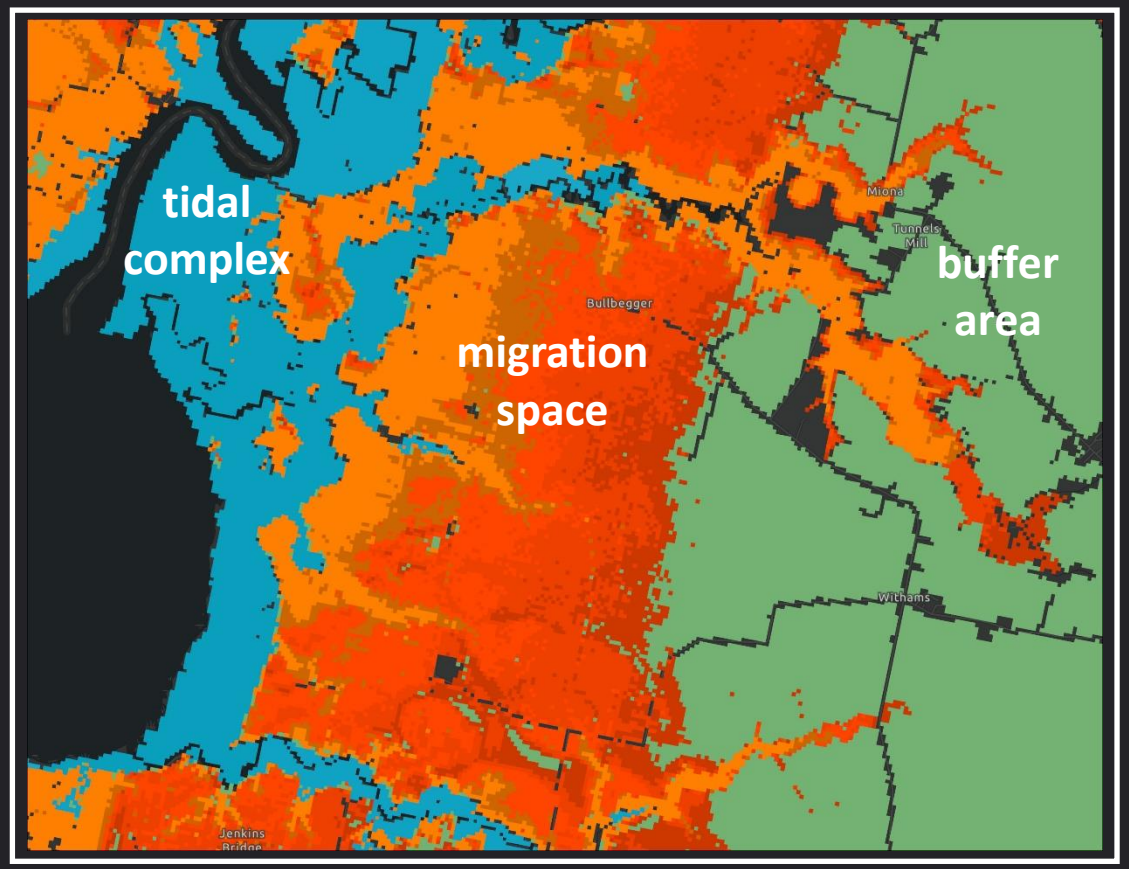
- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine

Calculated from the physical attributes:

- Migration Space Size (weight = 5)
- Tidal Class Diversity & Evenness
- (weight = 3)
- Upland Edge Shared with Migration Space (weight = 2)
- Tidal Complex Size (weight = 2)

*Physical Score = (5*MS + 3*TC+ 2*SE+ 2*SC)/12*
Where MS = size of migration space, TC = tidal class, SE = shared upland edge, and CS = tidal complex size

Resilience Attributes

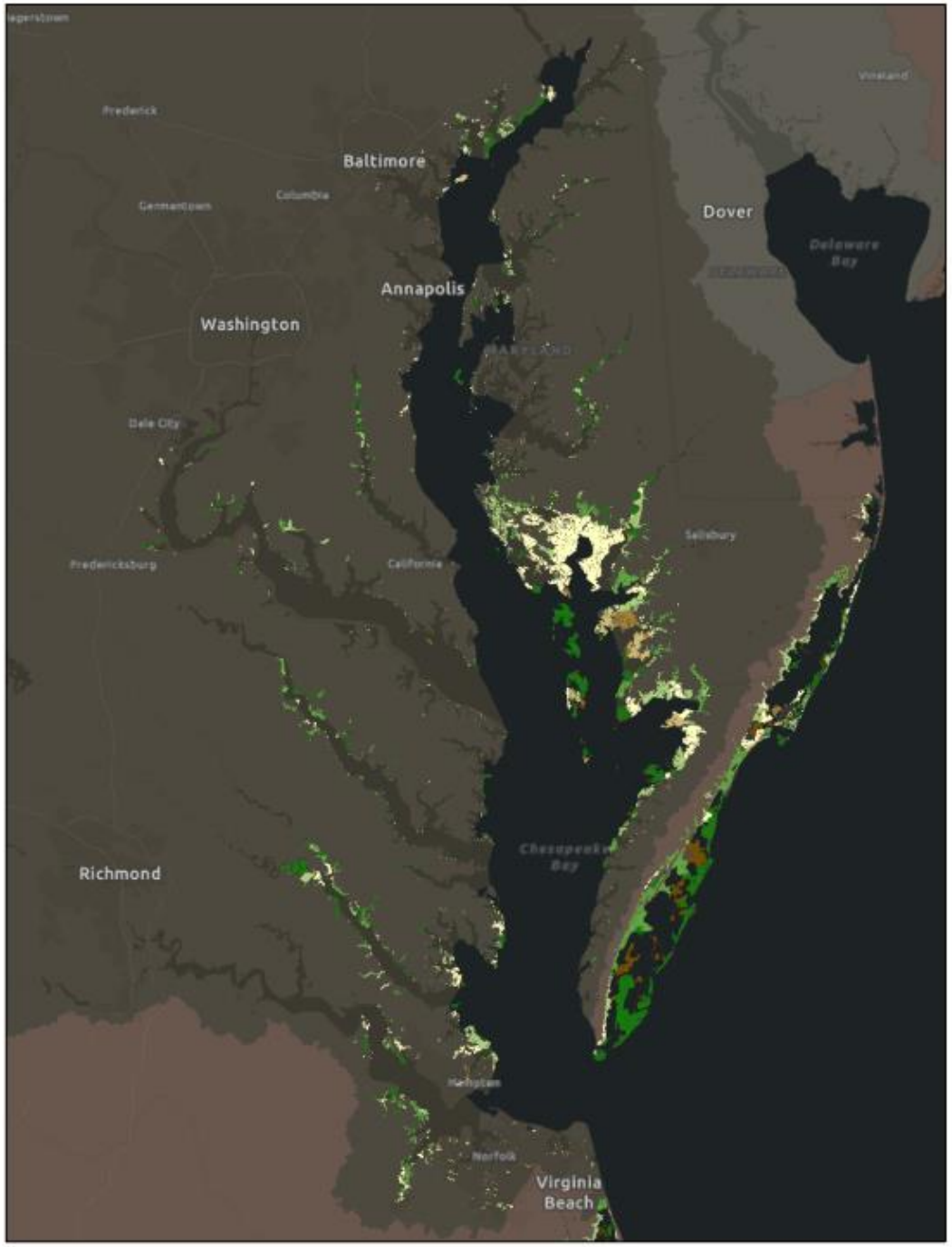


PHYSICAL ATTRIBUTES

- Large migration space
- Many future tidal classes
- Lots of shared upland edge with migration space
- Large tidal complex
- Large buffer area with diverse coastal landforms and maritime highlands

CONDITION ATTRIBUTES

- Few anthropogenic barriers to marsh migration (low development of upland edge)
- Positive sediment balance
- Good water quality index
- Minimal freshwater flow alteration
- Natural buffer area with high wetland connectivity



Condition Attribute: Developed Upland Edge

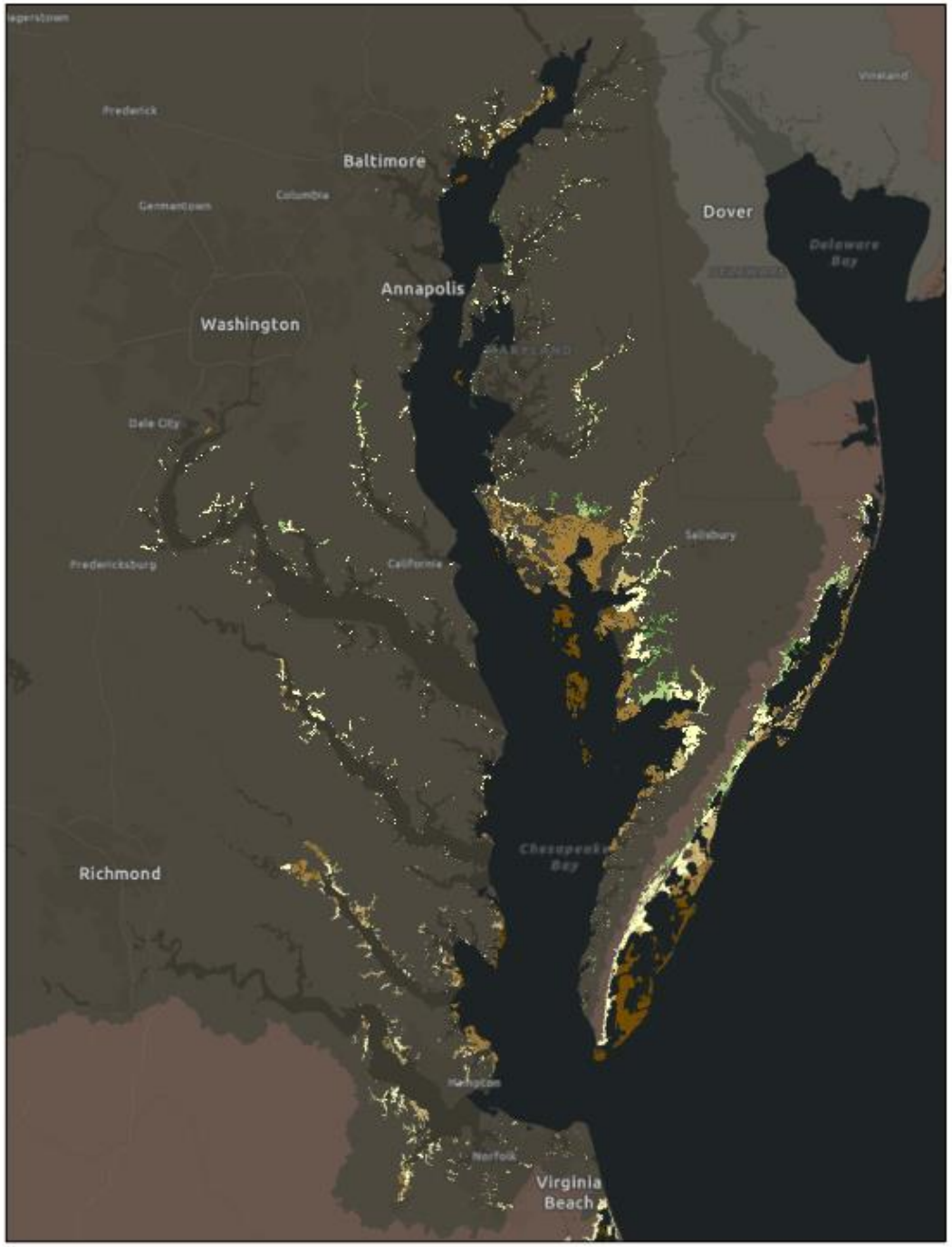
Developed Upland Edge, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Data source:
NOAA C-CAP Land Cover

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Condition Attribute: Sediment Balance

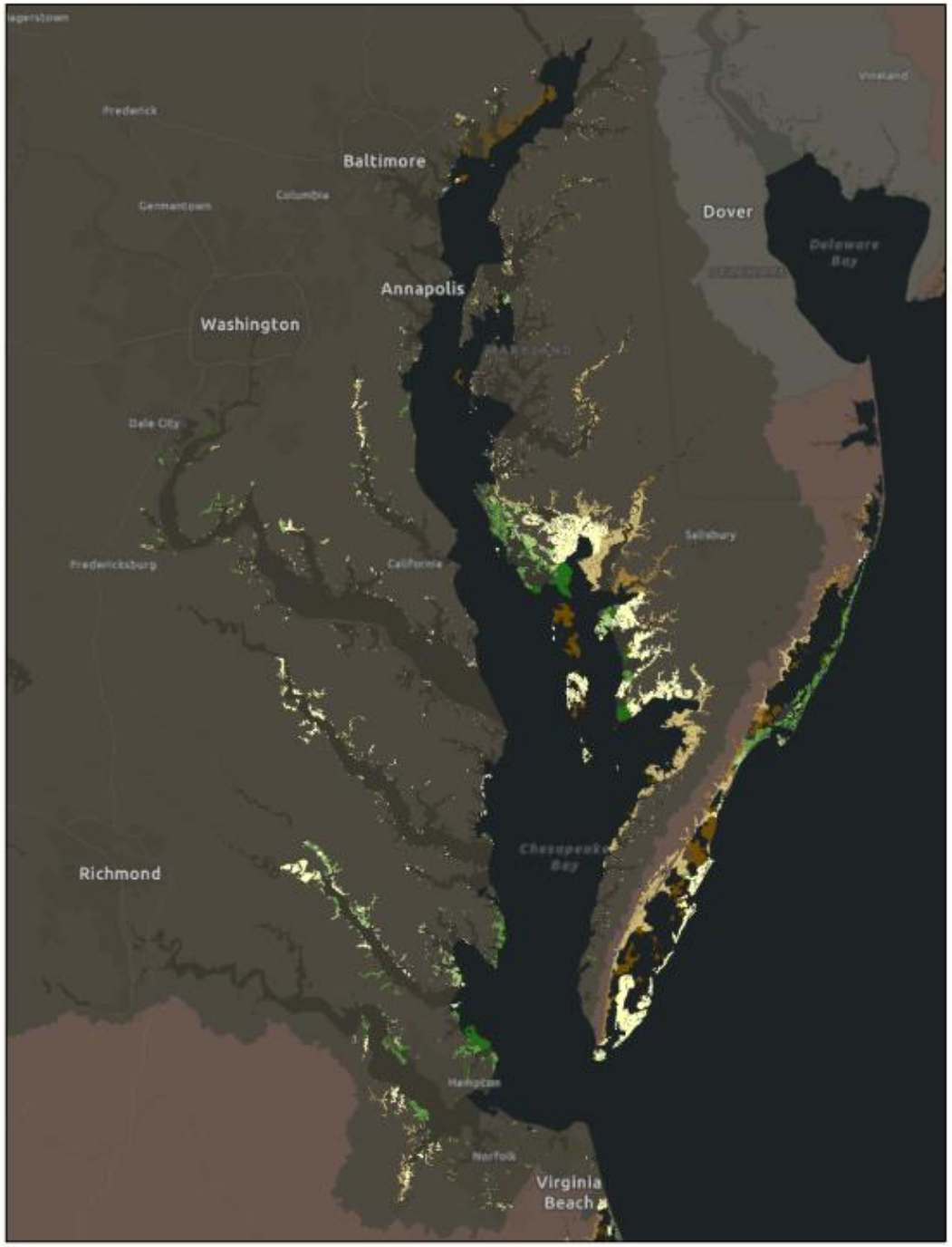
Sediment Concentration, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Data source: USGS SPARROW

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Condition Attribute: Water Quality Index

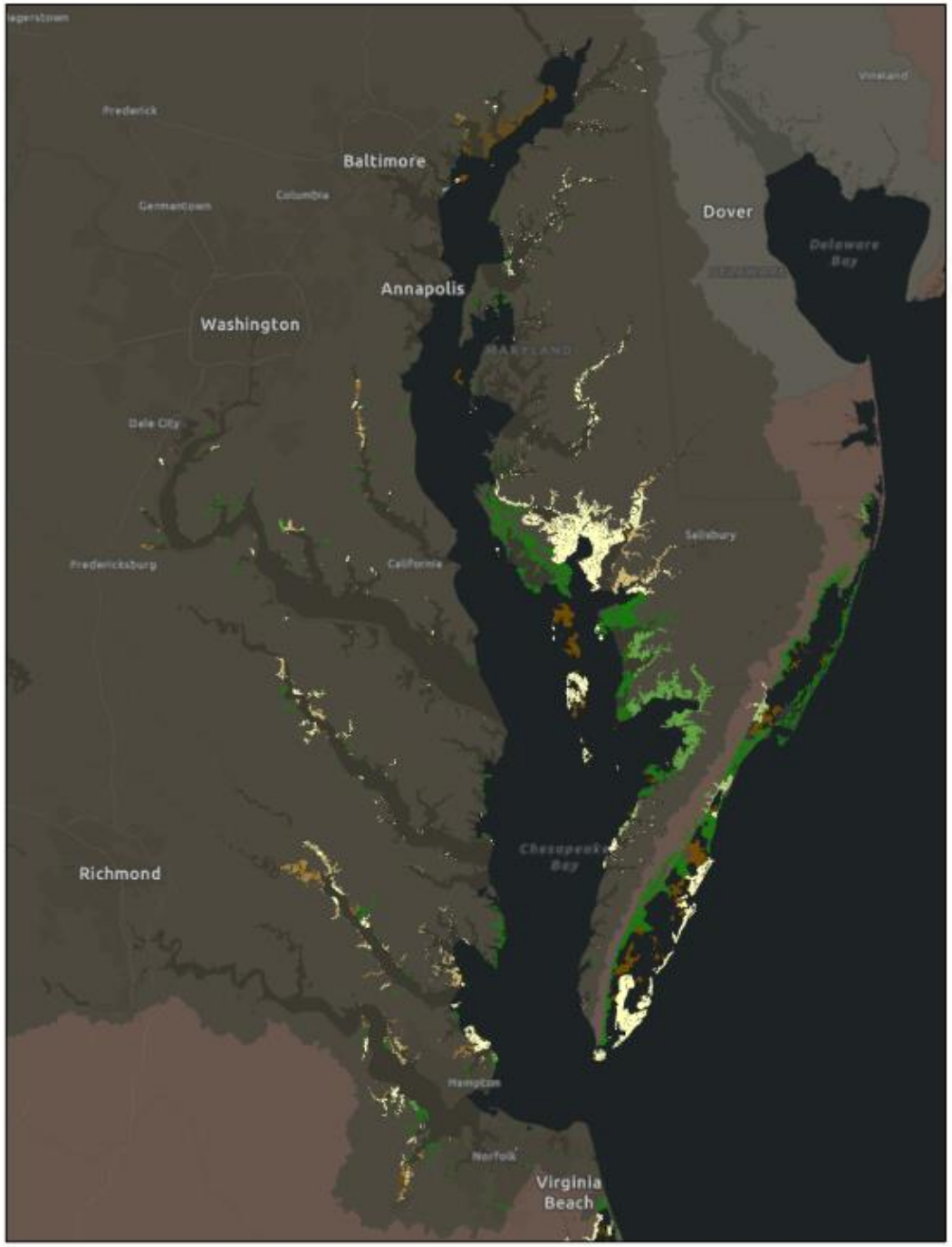
Water Quality Index, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Data source: [EPA StreamCat]

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Condition Attribute: Flow Alteration

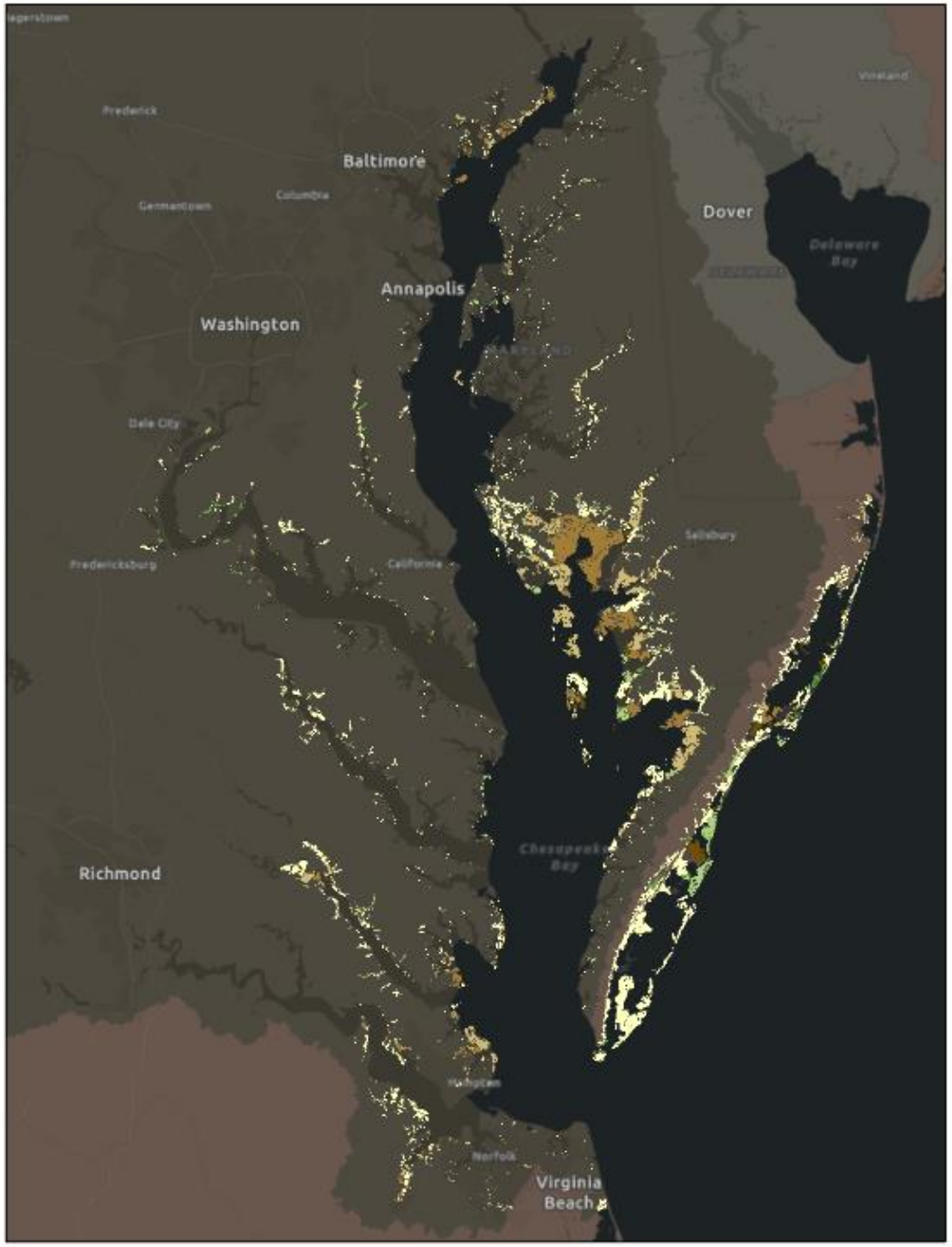
Flow Alteration, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Data source: [EPA StreamCat]

Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine



Condition Score

Condition Score, Stratified by CSR

- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

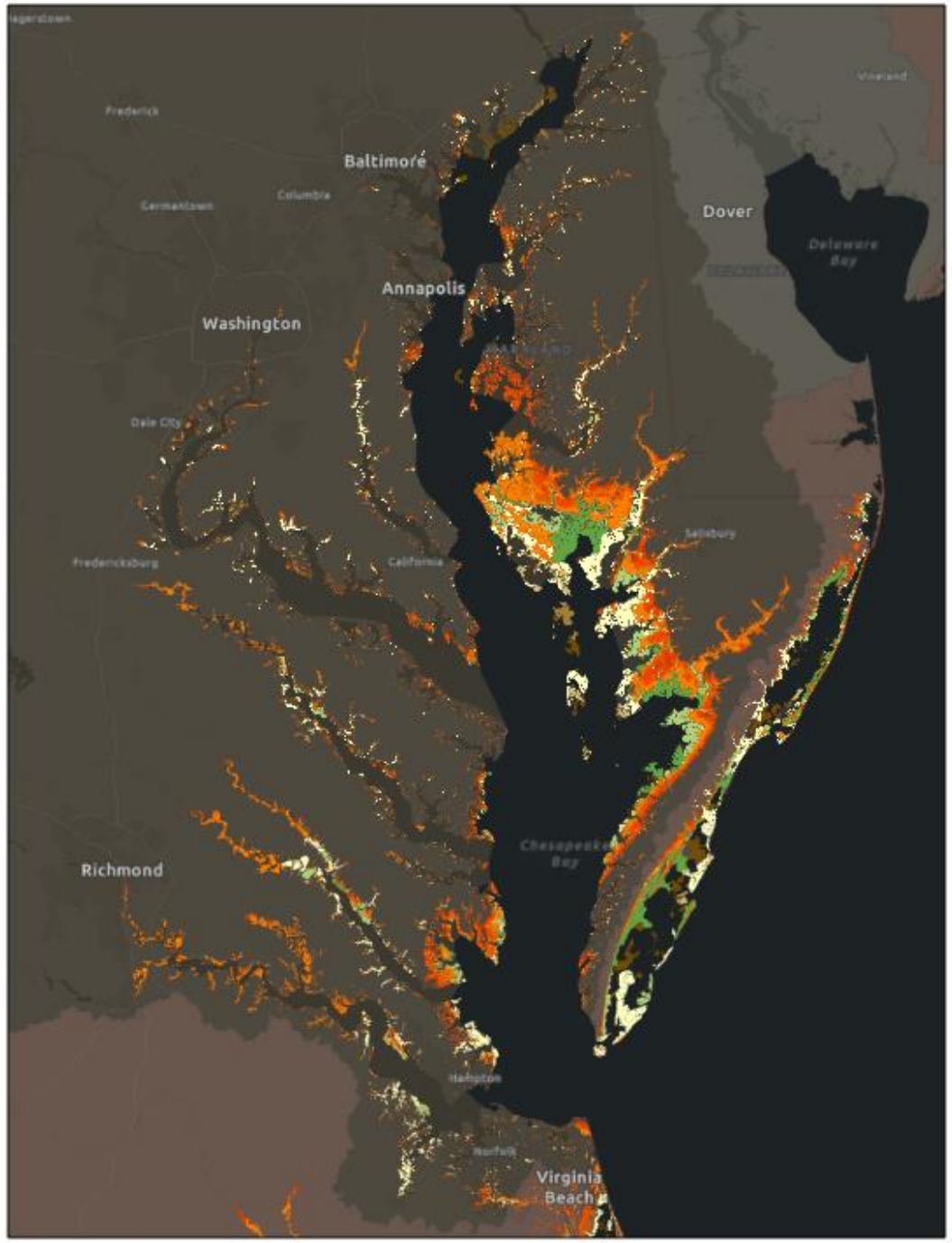
Coastal Shoreline Region (70% transparency)

- Chesapeake Bay & Piedmont River
- Coastal Lagoon
- Northeast Riverine

Calculated from the condition attributes:

- Undeveloped Upland Edge (weight = 5)
- Sediment Balance (weight = 2)
- Water Quality Index (weight = 1)
- Unaltered Flow (weight = 1)

*Condition Score = (5*DE + 2*SB+ 1*WQ+ 1*FA)/9*
Where DE = developed upland edge, SB = sediment balance, WQ = water quality, and FA = flow alteration



Final Resilience Score

SLR = 3.0 feet
Resilience Score, Stratified by CSR

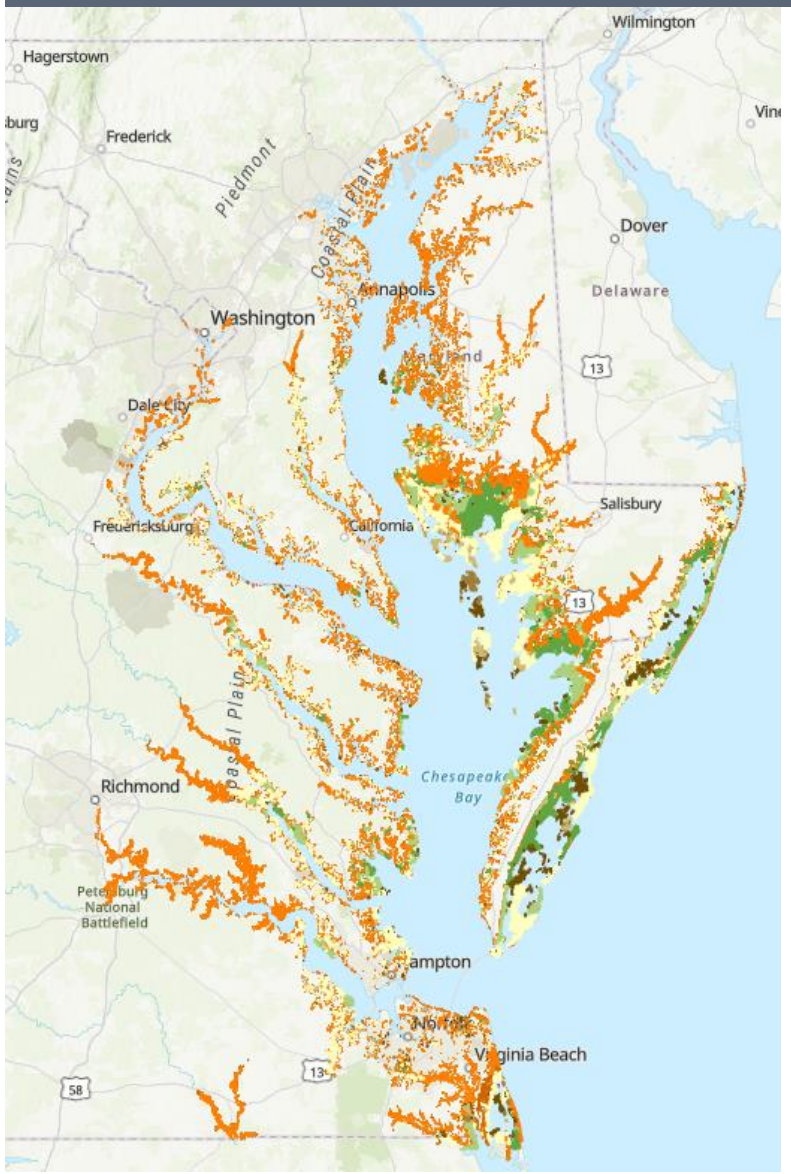
- Far Above Average (most resilient)
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average (most vulnerable)

Migration Space

- SLR = 2.0 ft.
- SLR = 2.5 ft.
- SLR = 3.0 ft.
- SLR = 4.0 ft.
- SLR = 5.0 ft.
- SLR = 6.0 ft.

Tidal Complex and Migration Space Score (90% of Final Resilience Score)	Buffer Area Score (10% of Final Resilience Score)
Physical Attributes (Weight) • Amount of migration space (5) • Tidal class variety and evenness (3) • Shared upland edge between tidal complex and migration space (2) • Size of existing tidal complex (2)	Physical Attributes (Weight) • Adjusted buffer area size (5) • Landform diversity (5)
Condition Attributes (Weight) • Developed upland edge (5) • Sediment balance (2) • Water quality index (1) • Flow alteration (1)	Condition Attributes (Weight) • Wetland connectedness (5) • Percent natural cover (5)

MD/DC Resilient Coastal Sites



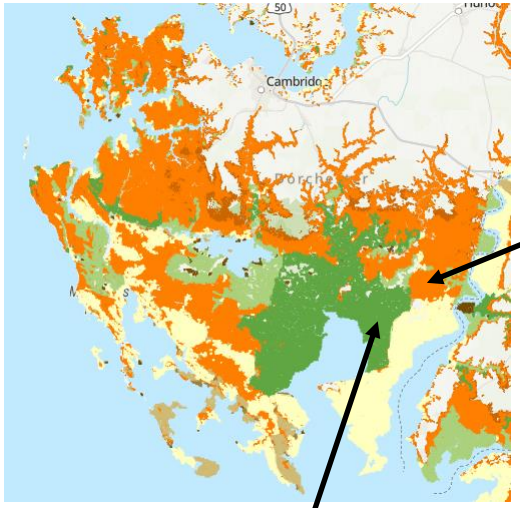
Legend

Resilience Scores - SLR 3 ft

- Far Above Average
- Above Average
- Slightly Above Average
- Average
- Slightly Below Average
- Below Average
- Far Below Average

Migration Space - SLR 2 ft

Migration Space - SLR 3 ft



Migration Space - 3 ft SLR

SLR Scenario	3 ft
Resilience Score	Above Average
Acres	8473.910156

Site Resilience - 3 ft SLR

Resilience Score	Above Average
Physical Score	Far Above Average
Condition Score	Below Average
Tidal Complex Acres	23,129.10

Web Map: interact with the datasets and zoom to areas of interest.

Next steps

- Use in conjunction with other targeting tools
  - e.g., Sea Level Affecting Marshes (SLAMM) for Maryland
- To Identify sites for conservation action
  - Large-scale marsh restoration projects (for habitat resilience)
  - Many small-scale marsh restoration projects (for community resilience)
- And guide effective and equitable use of funding opportunities
  - Bipartisan Infrastructure Law aka Infrastructure Investment and Jobs Act (IIJA)

Targeting Action

- Where is resilient migration space currently unprotected? Are these areas under threat of development or other disturbance?
- Where are the marshes that that score well on other metrics, but have roads or other development along their upland edge? Can we remove or mitigate those barriers?
- Where are vulnerable populations located in resilient migration space? What additional resources can be provided to increase resilience in these communities?

Thank you!

Michelle Canick
mcanick@tnc.org