Saltmarsh Adaptation:
Planning and Implementation in Maryland Marshes

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Envision the Choptank
October 22, 2024

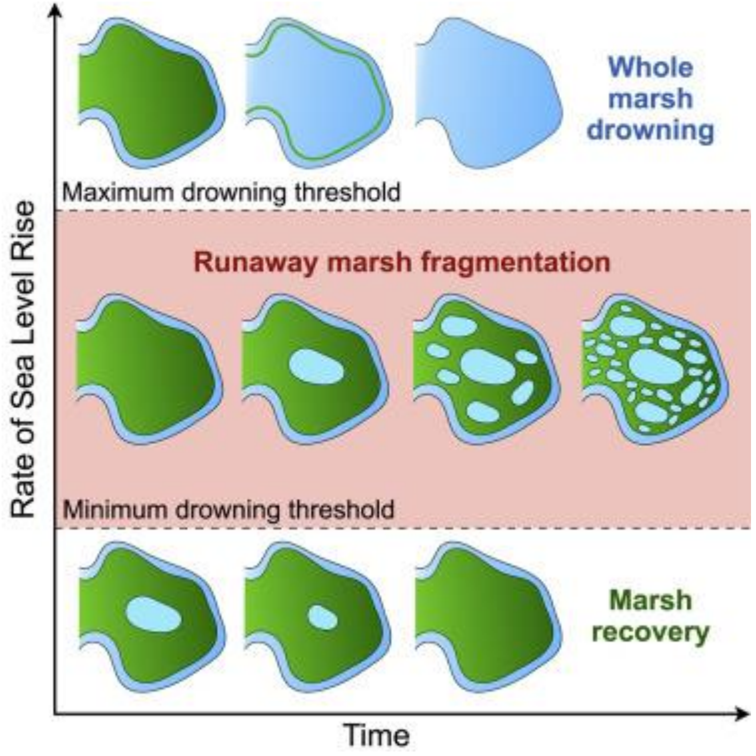
MARYLAND DEPARTMENT OF NATURAL RESOURCES

What is Saltmarsh Adaptation?

Incorporating climate change information and resilience strategies when planning, designing, implementing, and managing restoration and conservation projects to enhance longevity of saltmarsh areas and health.

When is Saltmarsh Adaptation Needed?

- Sea level rise/storm events or other disturbances
- Vegetation Dieback
- Interior ponding expansion
- Fragmentation
- Erosion/Sediment Loss and Reduced Carbon storage
- Low elevation capital
- Open water conversion

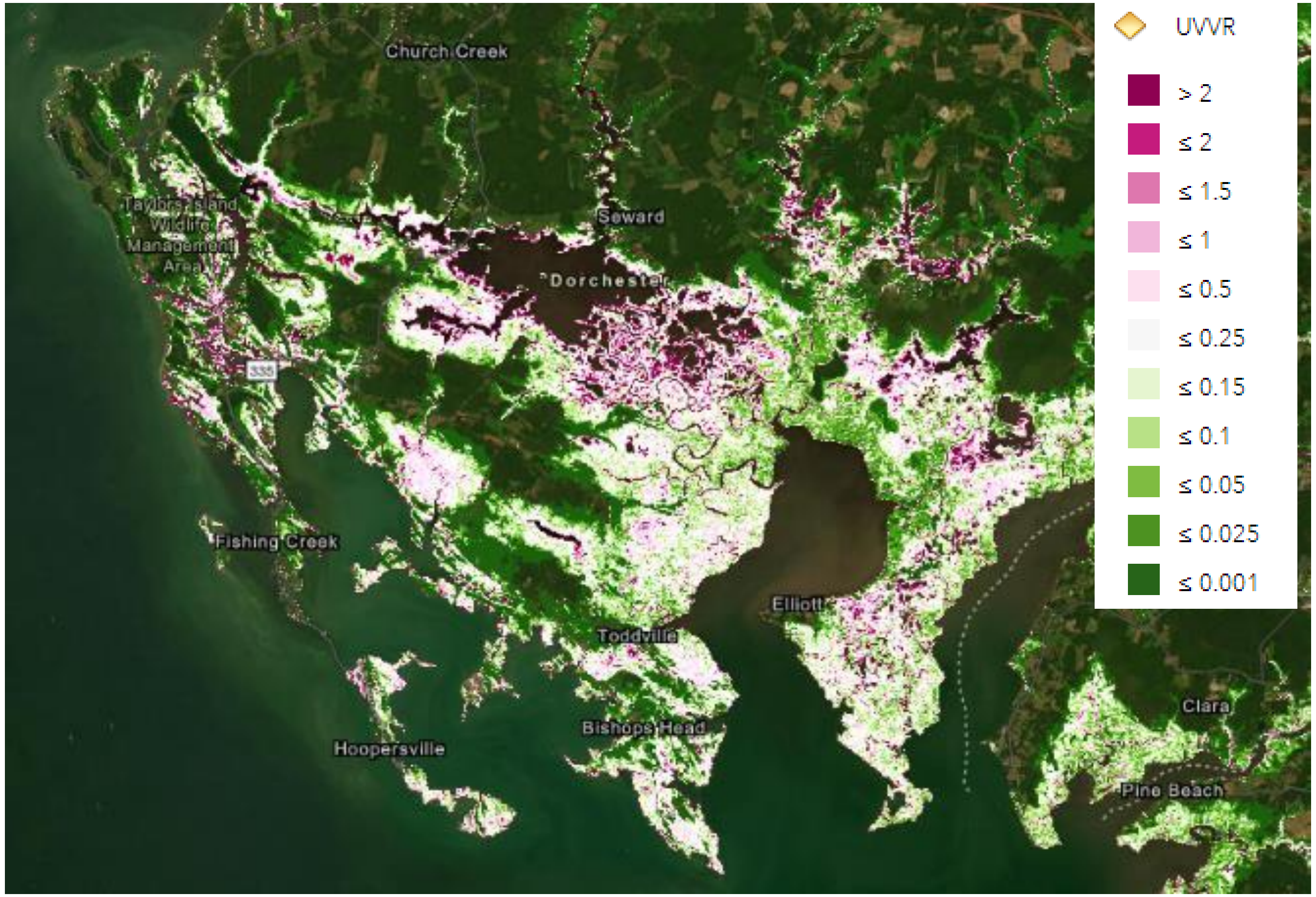


Vinent et al. 2021

Saltmarsh Adaptation: MD Targeting & Tools

Topic	Data	Link
Health	USGS Unvegetated to Vegetated Ratio	https://www.usgs.gov/tools/national-uvvr-map
Lifespan	USGS Chesapeake Bay Marsh Lifespan Units	https://www.usgs.gov/data/lifespan-chesapeake-bay-salt-marsh-units
Future Wetland Extent	Sea Level Affecting Marshes Model	https://warrenpinnacle.com/prof/SLAMM/EESLR_MD/
Migration Corridors	DNR Wetland Adaptation Areas	https://dnr.geodata.md.gov/CoastalAtlas/
Coastal Protection	DNR Marsh Protection Index	https://dnr.geodata.md.gov/CoastalAtlas/
Marsh Management	TNC Chesapeake Bay Marsh Management Decision Tool	https://www.maps.tnc.org/marsh-management/

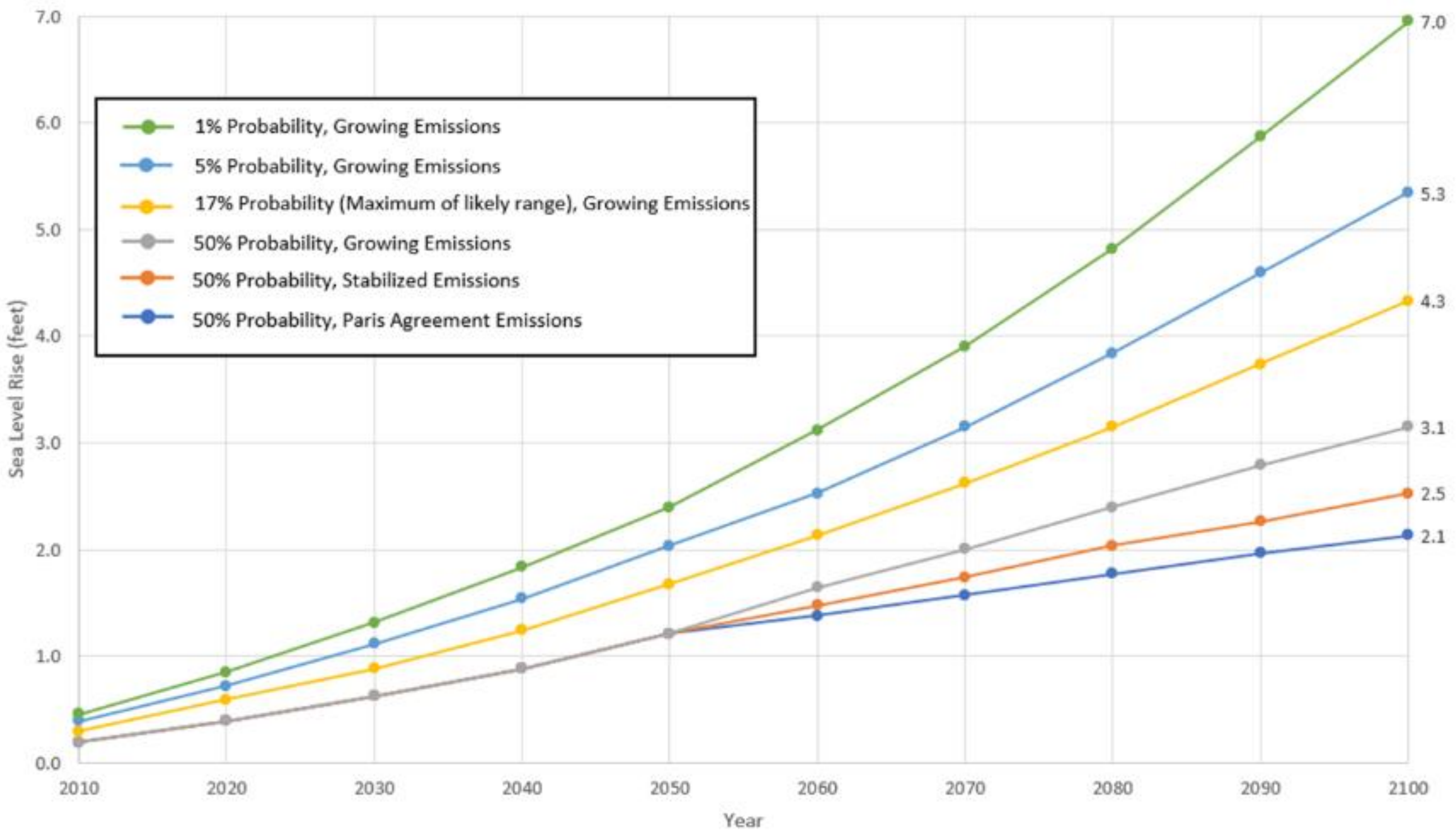
USGS Marsh Health & Lifespan



Blackwater NWR areas with Unvegetated to Vegetated Ratio >1.5 (stability threshold)

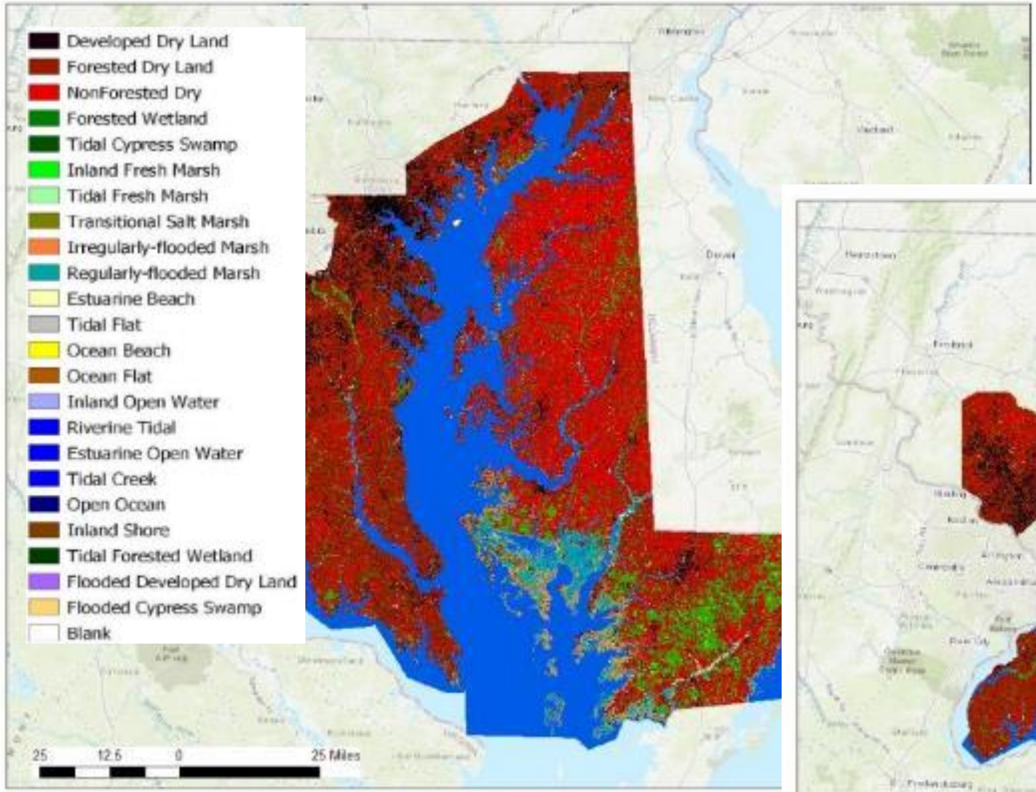
UVVR, Elevation, and Sea level Rise Vulnerability as indicators of marsh lifespan

Sea Level Affecting Marshes Model (SLAMM) rerun using 6 sea level rise scenarios

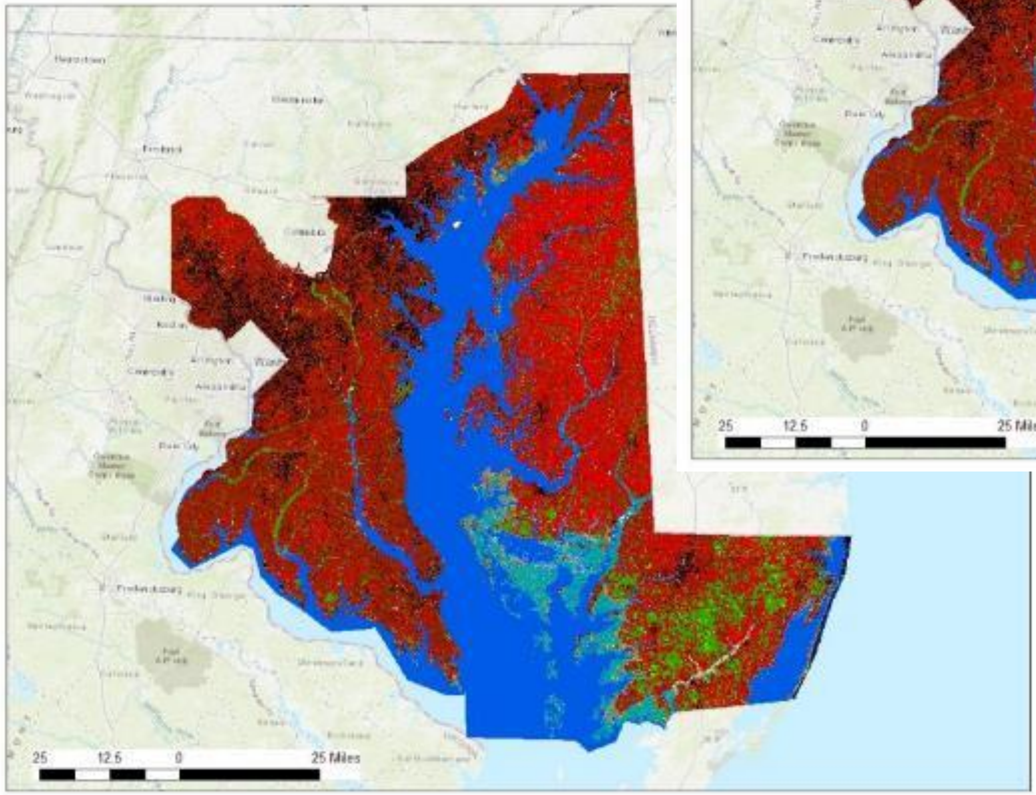


- Range of GHG emissions and likelihood scenarios representing 2-7 ft SLR by 2100
- Scenarios represent different risk tolerances
- Low risk tolerance = risk averse (ex: critical infrastructure planning)
- High risk tolerance = some risk is OK (ex: habitat planning that is adaptable)

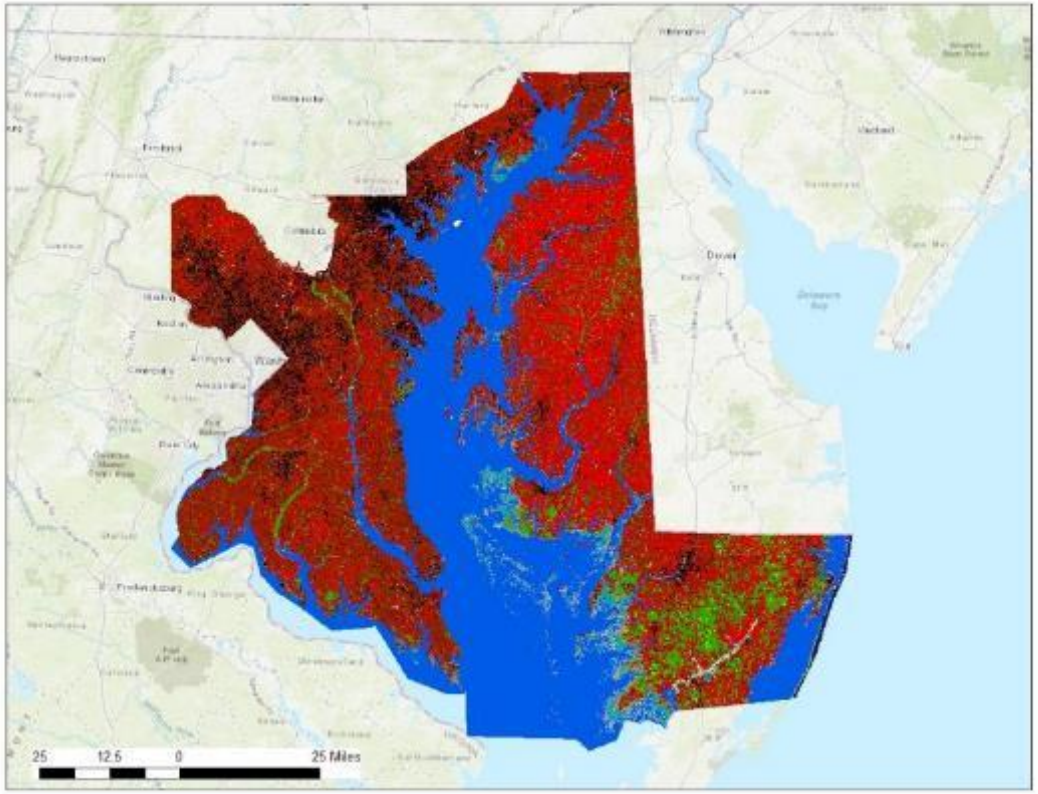
SLAMM Results for 17% Growing 2050, 2070, & 2100



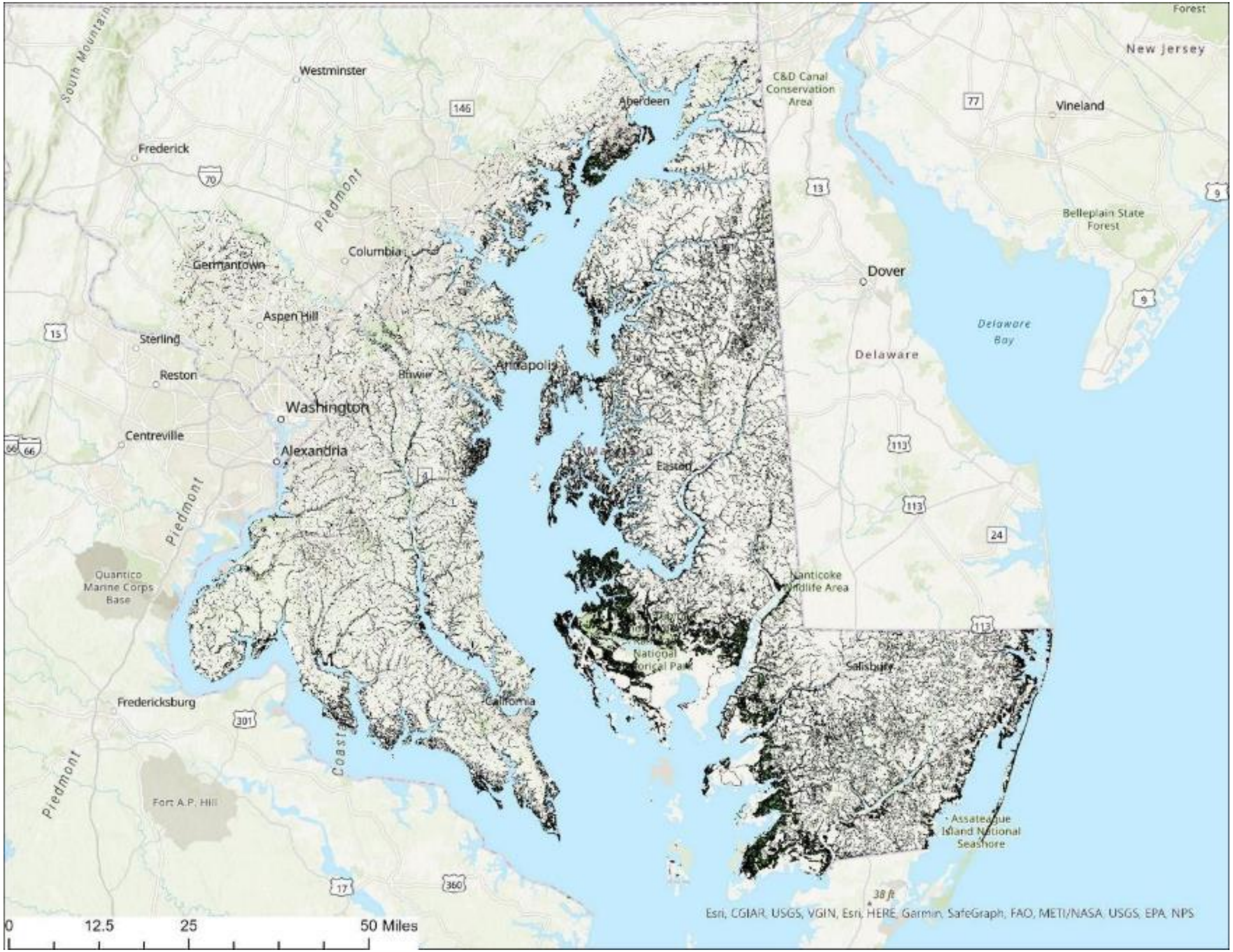
2050 (2.0 ft. SLR)



2070 (2.8 ft. SLR)



2100 (4.3 ft. SLR)



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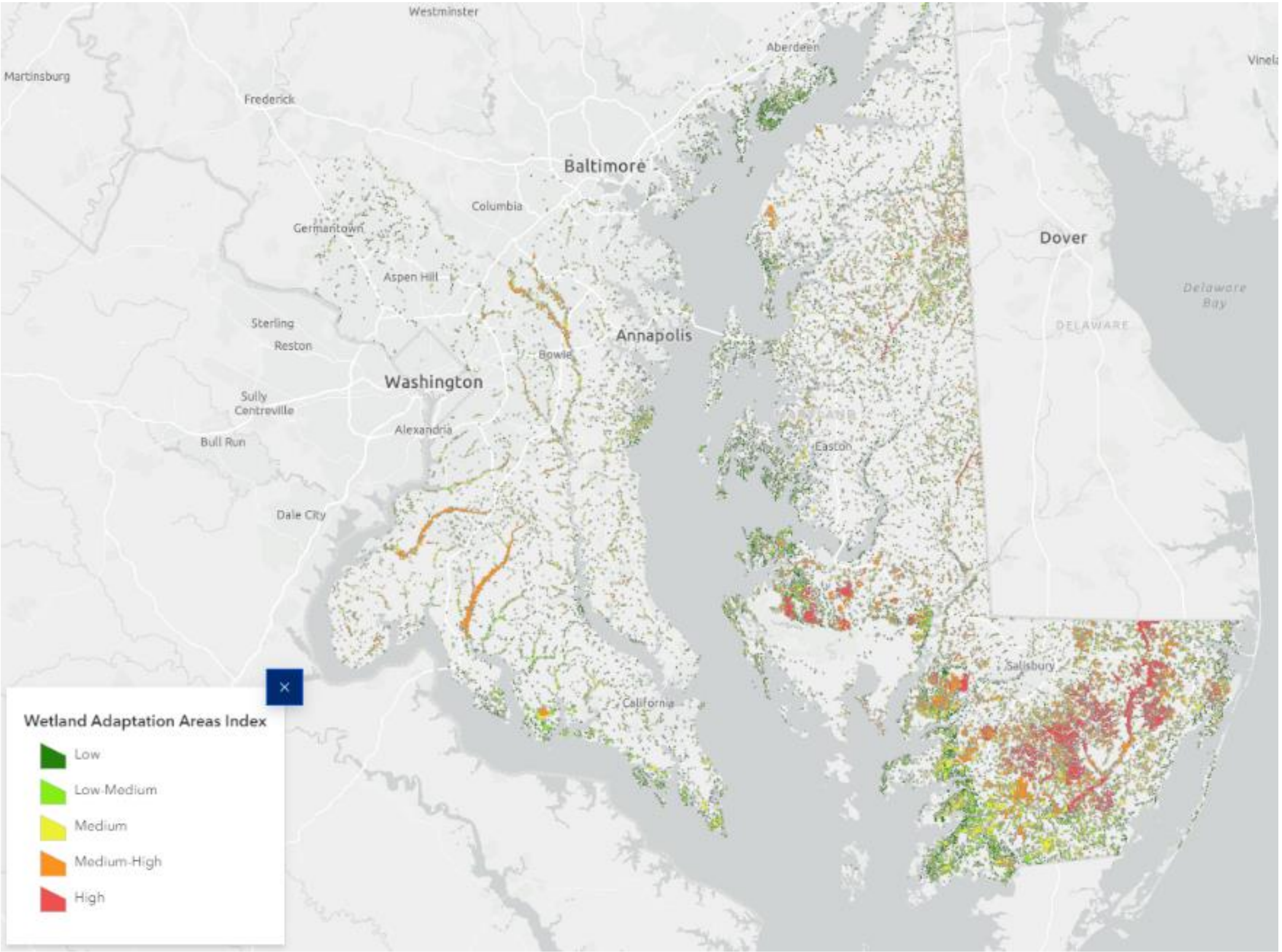
Wetland Adaptation Areas Combined-Migration Corridor

(2050, 2070, & 2100)



https://storymaps.arcgis.com/stories/b97fcfa6836c42dcafd64be91ad2f1fe

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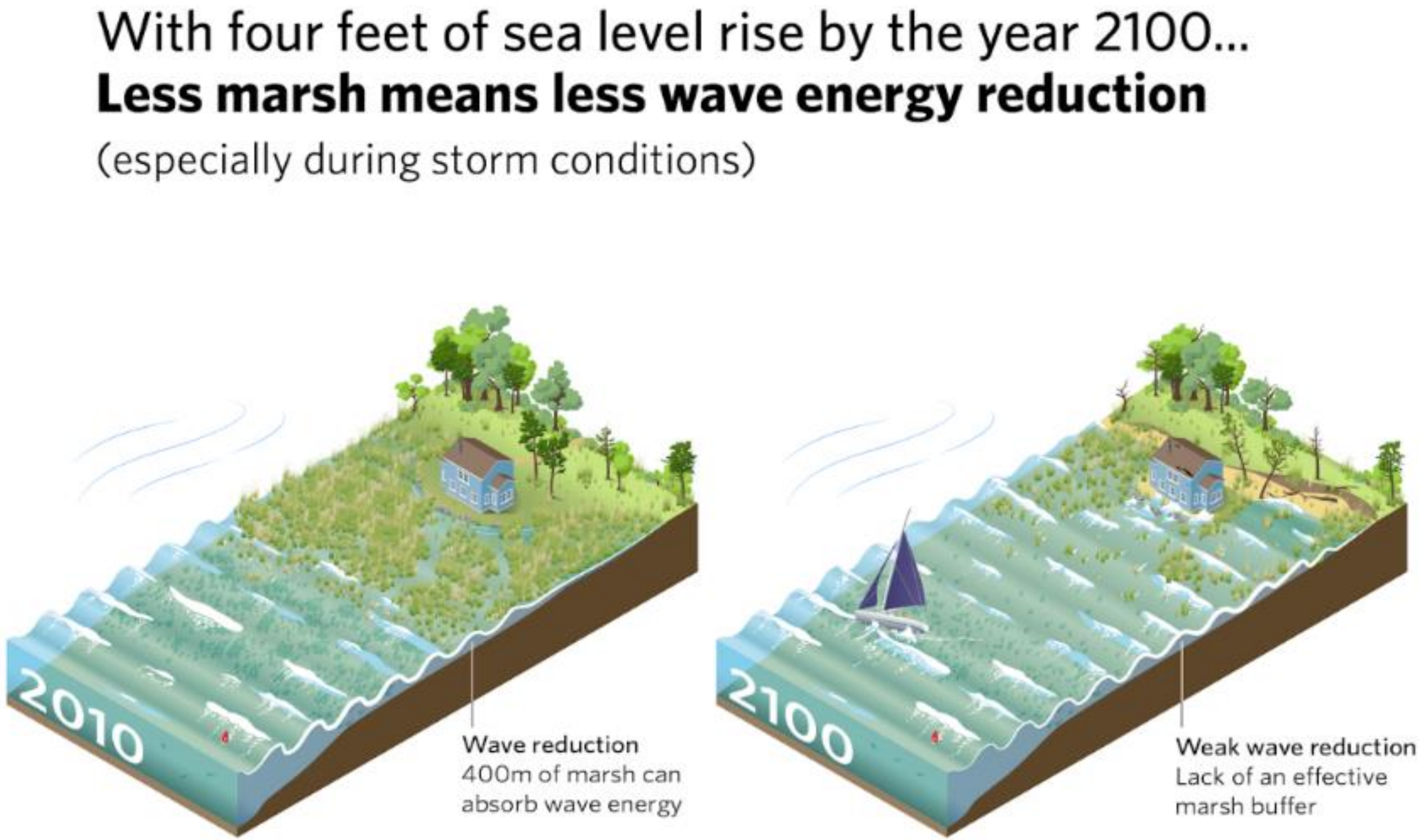
Wetland Adaptation Areas Index

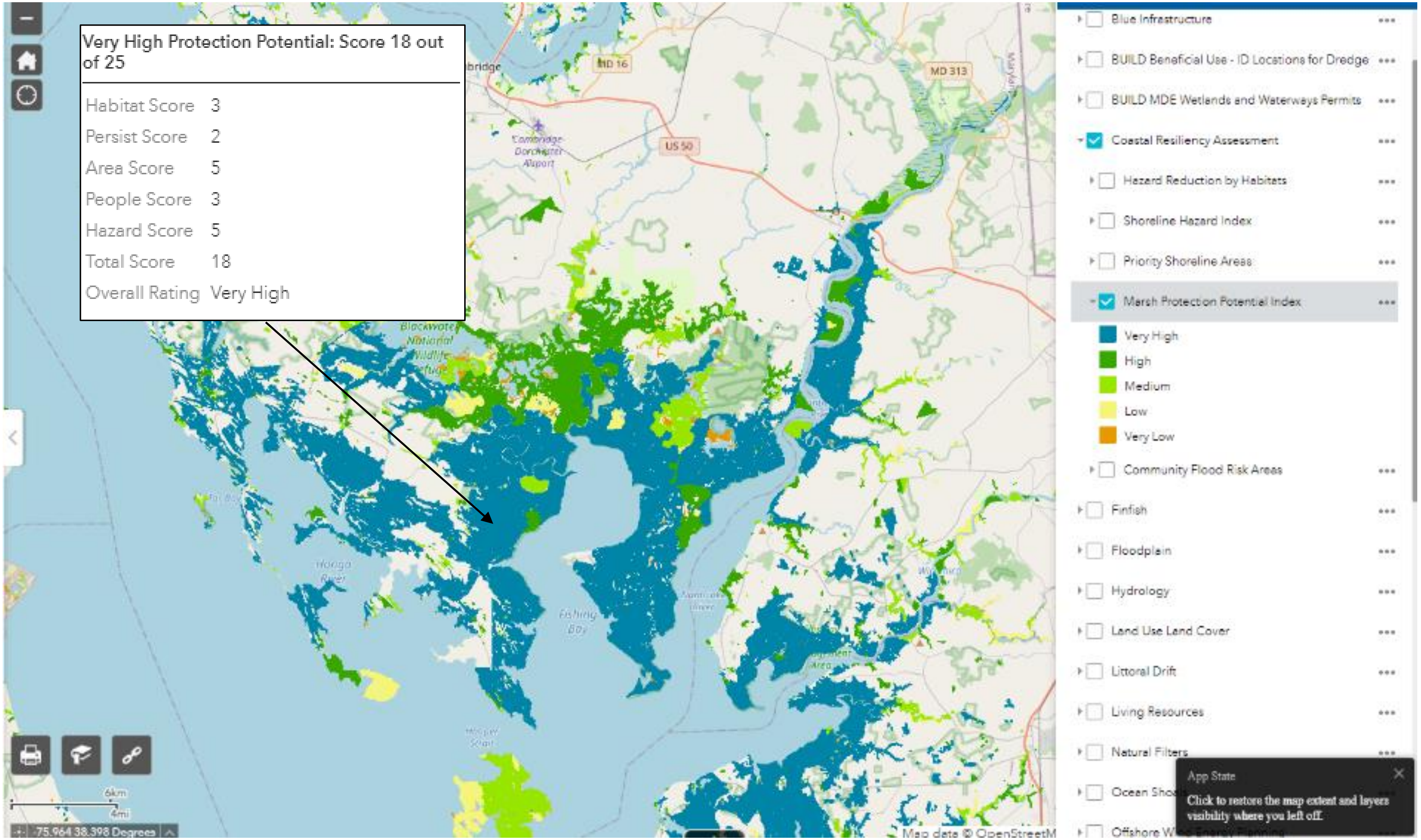
(2100)

Coastal Protection Benefits



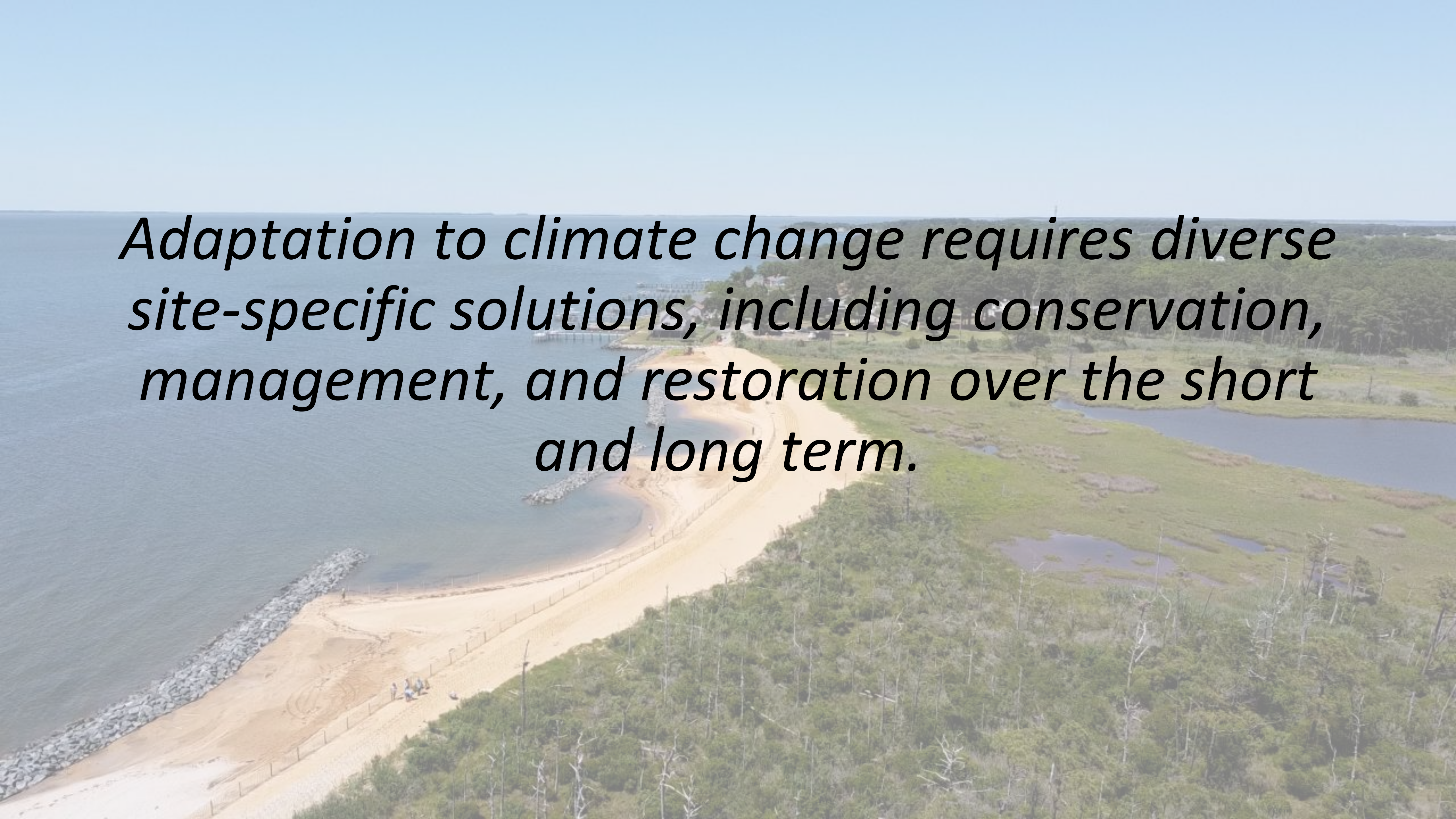
- Where are wetlands buffering people from coastal hazards?
- How will these ecosystem services change over time?
- Where should we prioritize restoration to preserve these benefits?

Marsh Protection Potential Index



__2024 Update to Consider:__

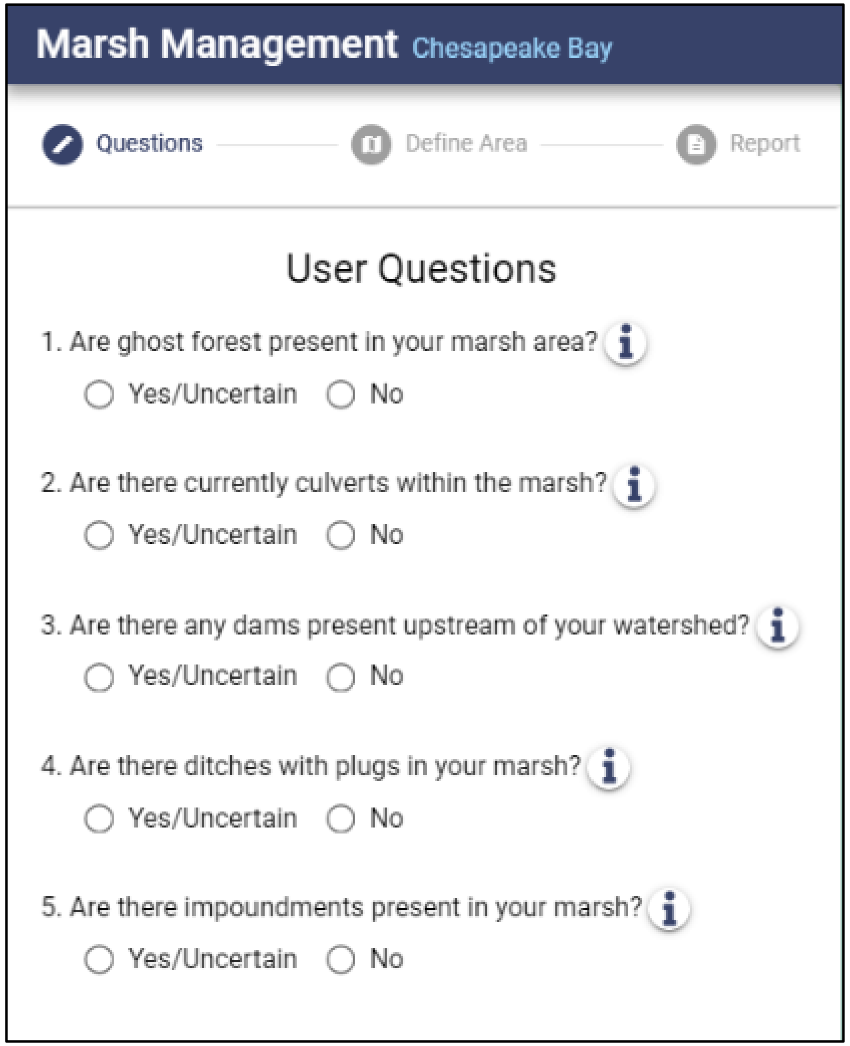
- Population, Social Vulnerability & Flood risk data
- USGS UVVR & Marsh Lifespan
- Marsh Width
- Wetland Adaptation Areas



Adaptation to climate change requires diverse site-specific solutions, including conservation, management, and restoration over the short and long term.

Chesapeake Bay Marsh Management Decision Tool

- Shoreline protection (ex: living shorelines)
- Hydrology/Improvements in hydrological connectivity (ex: runnels, ditch filling/cleaning, channel alteration, culvert replacement)
- Sediment management (ex: beneficial use of dredged material/thin layer sediment placement)
- Marsh migration buffer zones (ex: easements)
- Water quality improvements
- Endangered species management
- Invasive species removal/treatment
- Vegetation enhancement



The Nature Conservancy

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Management Strategy: Shoreline Protection

Shoreline protection is a management strategy that can be used to restore and protect at-risk coastlines. This strategy includes several different restoration techniques such as creating marsh sills, maintaining headland features, restoring oyster beds, constructing bank revetments, and creating living shorelines. Each of these techniques aim to reduce shoreline erosion, recover lost land cover, and enhance the resilience of a coastline. The appropriate technique for a given property will depend on the condition, specifically wave energy and tidal flow velocity, the structure of the marsh, the project budget, and/or management goals for the property. It is important to consider that in addition to initial design and construction, shoreline stabilization projects may require adaptive management and maintenance. Read through the following techniques below to see which ones may be best suited for your marsh complex.

- **Marsh Sill (shoreline stabilization)**
  - **Site Wave Energy:** Medium
  - **Installation Cost:** $2,000-$5,000 per linear foot

A marsh sill is a low-elevation structure, typically made from stone or bagged oyster shells, that is built in the water adjacent to an existing shoreline[1]. A marsh sill shields a shoreline from wave energy and reduces erosion by causing waves to break on the structure instead of the shore itself and by holding sediment in place. Along with protecting the marsh area behind the sill from erosion, marsh sills also promote the accumulation of sediment along the shore which can facilitate the recovery of lost marsh area. A marsh sill project will typically cost between $2,000-$5,000 per linear foot for initial construction[1]. The construction costs can be mitigated by using less expensive or locally sourced materials, such as oyster bags which cost between $5-$20 per bag[7]. For example, the North Carolina Coastal Federation created oyster reefs, planted over 100,000 marsh plants, and installed 1,200 ft of oyster shell bag marsh sill on the Jones Island shoreline.[2]

Figure 1. An oyster shell bag marsh sill at Jones Island, North Carolina. Source: Living Shorelines Academy.

- **Maintain or establish headland features**
  - **Site Wave Energy:** Medium to high
  - **Installation Cost:** $5,000-$10,000 per linear foot

Figure 2. Two stone headland breakwaters at VIMS in Gloucester Point, Virginia. Source: Chesapeake Bay Program.

Headland features are coastal landforms where sections of land, typically made of rock, extend out into a body of water and in between them form horseshoe-shaped, sandy bay areas[4]. Headland features protect the enveloped shoreline and interior marsh from erosion by intercepting and slowing oncoming waves.[4] In areas where no headland features are present, manmade breakwaters can be strategically placed and shaped to mimic the protective function of natural headland features. Breakwaters are offshore structures typically made from rock, oyster shell, or concrete that lay parallel to the shoreline and reduce the energy of a wave before it reaches the shore.[7] In contrast to marsh sills, breakwaters are designed to be placed further offshore and are typically taller structures.[8] By controlling erosion, these structures can stabilize a wetland and provide shelter for marsh habitat.[7] Breakwater projects are typically more expensive and involved than other shoreline protection measures due to the additional material costs and required design and engineering expertise. These projects range from $5,000-$10,000 per linear foot for initial construction.[7] When breakwaters are being used to create headland features, additional sand must be brought in to form a sandbar that connects the breakwater to the shore; this will add additional costs.[4] An example of a headland breakwater project can be found on the York River in Gloucester point, Virginia. At this site, the Virginia Institute of Marine Science (VIMS) installed two stone headland breakwaters which have protected their shoreline through two major hurricanes.

Management Strategy: Improving Hydrological Connectivity

Marsh management techniques to improve hydrological connectivity aim to restore physical, chemical, and biological components of the marsh that have been altered due to construction of human settlements, roads, or negative impacts from previous filling and diking of the marsh. Examples of these techniques are culvert sizing for tidal passage, ditch plug removal, creek extension, conversion of impoundments to saltmarsh, and runneling or tidal channel restoration.

- **Culvert sizing for tidal passage**

Expansion of culvert size in saltmarshes is used to restore hydrology of aquatic habitats that have partial or completely restricted tidal flow. Construction of dikes, causeways, and coastal development has inevitably resulted in loss of saltmarsh habitat, species, and primary productivity. Therefore, culvert expansion can improve marsh health by enhancing hydrological connection and allowing marsh ecological functions to be enhanced[1]. For marsh health, sizing should also consider placement of the culvert to be aligned as much as possible with the natural stream to avoid turbulence and allow fish migration, type of culvert (open-box culverts as opposed to pipe culverts are preferred for fish), including bank-edge areas that weak-swimming organisms can use, as well as internal habitat provision[2].

An example where culvert expansion was used to enhance tidal flow is a project in Egery Flats, Texas. Egery Flats has lost significant area of saltmarsh habitat due to road construction since 1945[3]. Following the construction of the new culverts, they planted marsh grass to impulse the recovery of the vegetation. The cost to replace culverts can differ by location and restoration objectives, but on average planning, construction, and monitoring can range from $20,000 to $5,000,000. Anticipated effort to apply this type of management technique can be categorized as 4, based on the time and construction work required to complete a replacement of culverts. Is it important to consider that restoration of ecological functions in a marsh can take from years to decades and monitoring should be included as a part of the management strategies post-construction.

Figure 1. Culverts before and after expansion for tidal passage in Egery Flats saltmarsh, Texas. Source: Building Conservation Trust.

- **Ditch plug removal**

Ditch plugs are small earthen dams across a drainage ditch, that were used previously in farming practices. Removing ditch plugs in marshes is a technique used to restore the tidal flow and drain the excess of water, reducing flooding and inundation in high marshes. It consists of using small excavators to remove the sediment blocking the ditch, carefully creating a channel to improve hydrological connection. The Parker Wildlife refuge on Plum Island in New England removed a total of 23 ditch plugs in 2019. This project resulted in tidal flow restoration and improved re-vegetation on the marsh[4]. Cost of this technique is low compared to other restoration projects as small excavators can be rented at $200-$500 per day, in addition to labor costs.

Figure 2. Ditch plug removal at the Parker Wildlife Refuge in New England. Source:

- **Creek extension**

This restoration practice consists of constructing, extending, or modifying areas of the marsh to connect it with the nearest creek. This technique could also involve, modifications in the length of a creek, bed, channel, or bank with the goal of reducing ponding in the marsh transition zone. Creek extension is achieved by connecting the wettest part of the marsh to a network of already existing creeks and then to open water. Farm Creek Marsh in Maryland is a case example where creek extension was implemented in 2018. This project had a cost of $475,000 and constructed a 500-foot (150 m) extension to connect the deteriorating marsh with the nearby creek, using a low ground pressure excavator[5].

- **Convert impoundments to saltmarsh**

Marsh impoundment was a technique used in the early 1970s to control mosquitoes, by flooding areas of the marsh. However, impoundments also alter or prevent natural tidal exchange, which can result in less sediment and nutrient supplies to the marsh[6]. The process of converting

Management Strategy: Marsh Migration Buffer Zones

Marshes globally are being threatened by rapid sea level rise, which was on average 4.1 mm yr^{-1} in 2014 for the Chesapeake Bay and continues to accelerate[1]. When marshes are not able to accumulate enough sediment to keep up with sea-level rise, marshes respond by either migrating upland or drowning. Drowning of marshes, or "coastal squeeze" results when there are barriers or coastal development that inhibits marsh from migrating inland[2]. A healthy marsh migration is key for the conservation of these vulnerable ecosystems and their ecosystem services for coastal communities. Landscape characteristics, marsh fragmentation, and biophysical processes influence marshes' ability to migrate, however, some modifications may facilitate marsh migration in areas that are more vulnerable to drowning. Examples of marsh migration buffer zones techniques include land protection, removal of barriers, upland space conversion, ditch remediation, and contouring of adjacent slopes.

- **Land protection (Easements and Purchases)**

Conservation easements are voluntary legal agreements designed to ensure the long-term viability and protection of the natural resources within a surveyed and recorded boundary. The easement planning process establishes allowances and restrictions that are beneficial to the landowner, the easement holder, and the environment. Conservation easements are perpetual or 30-year term and remain in place with each change in land ownership. The Prince George tract in South Carolina is an example of conservation easement, which protects 1,066 acres of saltmarsh from future development[4]. Stewardship of a conservation easement generally includes initial costs (e.g., documentation and signs), annual monitoring, landowner communications, legal, easement enforcement, amendments, and indirect costs. According to reports of land trusts, the annual stewardship costs ranges from $435 to $1500 per easement (excluding costs to resolve major violations)[5].

Figure 1. The Blackwater National Wildlife Refuge in Maryland is an example of land protection. Credits: Will Parson/Chesapeake Bay Program

Purchased land protection refers to land that is purchased from the owner and is publicly owned or managed by a government agency. There are not agreements or restrictions in this type of land protection (may allow resource extraction, subdivision/sale). Typically, purchased land protection later becomes public conservation land (such as State Park, or Wildlife Management Area), whereas a conservation easement protects land that remains private property[4]. The Blackwater National Wildlife Refuge in Maryland is an example of purchased land protection and is currently managed by the U.S. Fish and Wildlife Service. The first 8,241 acres were acquired from Delmarva Fur Farms in 1933, to provide sanctuary for the migrating birds.

- **Convert upland space (e.g., farmland to marsh)**

Many coastal marshes are bordered inland by agricultural fields. As sea levels rise, agricultural fields are becoming inundated with salt water, limiting the land available for farmers to grow the crops that they grew previously. Conversion of upland space to marsh is an opportunity for farmers to both protect their future finances and create space for inland marsh migration. Allowing marshes to migrate into salt-impacted farms can protect crops further inland by absorbing flooding events and preventing salt-water intrusion of cropland, allowing farmers to continue to farm some of their land as sea level rises. This management approach requires collaborative work with farmers, farmer compensation, and technical support to prevent invasive species from encroaching on land[4].

Figure 2. Marsh migration into agricultural fields in Dorchester county, Maryland. Credits: Jay Fleming

An example of this management technique is a project of the U.S. Department of Agriculture's Natural Resource Conservation Service conducted in the Chesapeake and Delaware Bay starting in 2017. This project pays landowners to create American black duck habitat that will also serve as migration buffer for the marsh[4].

https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/md/Pages/marsh-management-decision-support-tool.aspx

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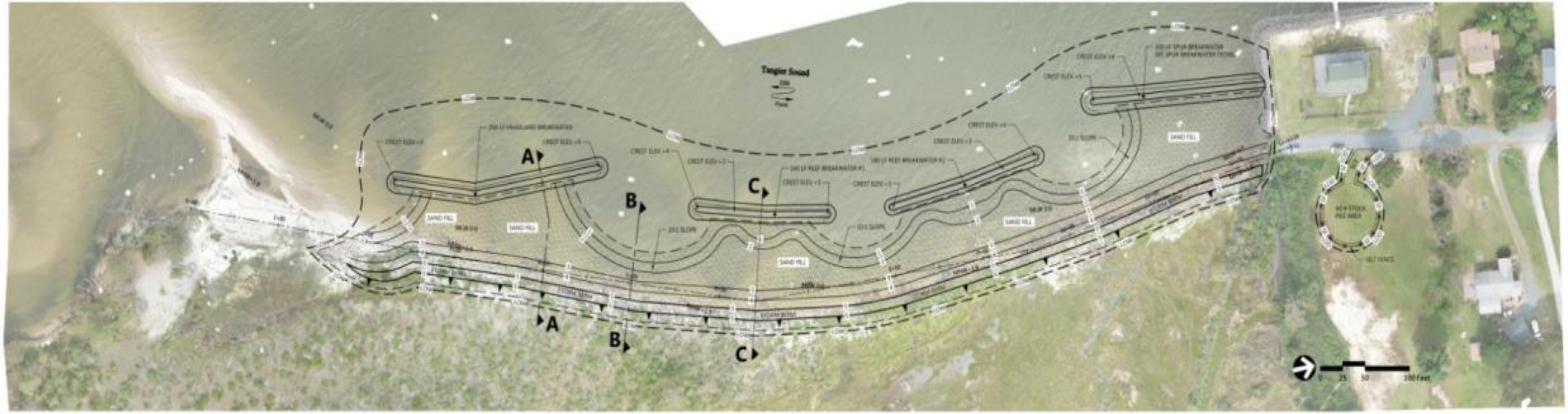


Project:
Deal Island
Somerset County

- 1,100 linear-foot living shoreline
- Dunes with high marsh and dune grass plantings
- Breakwaters with pocket beaches

Project:

Tilghman on the Chesapeake
Talbot County

- ~975 linear-foot (vented marsh sill, concrete oyster break, **marsh migration corridor**, sand dune) living shoreline
- Upland stormwater features (meadow, non-tidal wetland)

Beneficial Use of Dredged Material: Wicomico River Maintenance Dredging

https://www.nab.usace.army.mil/Missions/Civil-Works/Wicomico-River-Maintenance-Dredging-Project/

- Somerset County
- 161 yd3 dredged material
- Target elevation +3-3.5 MLLW (1.8ft – 2.3ft NAVD88)

Thin Layer Sediment Placement: Chesapeake Bay Environmental Center

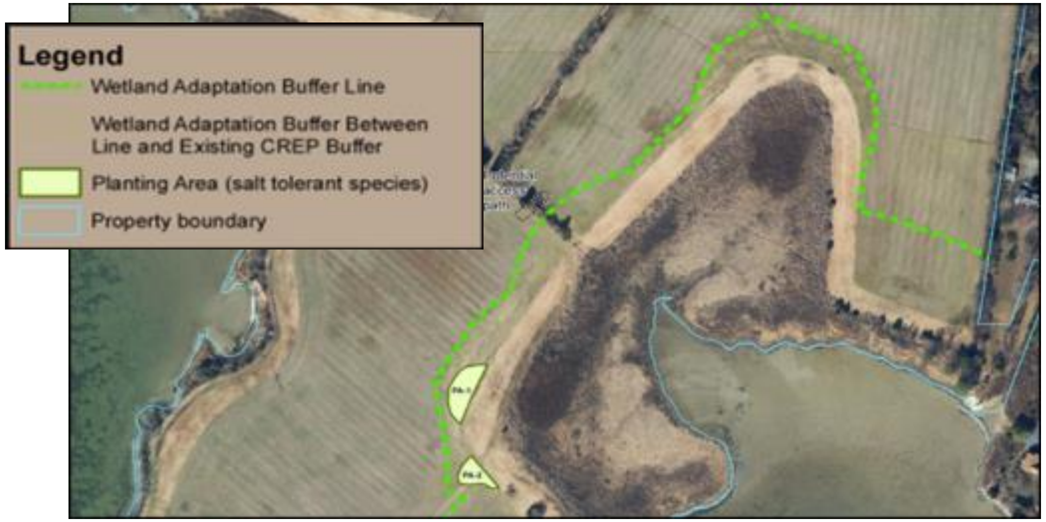
- Queen Anne’s County
- 8,494 cubic yards of dredged material
- 4 acres wetlands

- Elevation target based on existing high marsh vegetation/elevation and contingent on available material/settlement (expecting 4-6 inches)

Coastal Resilience Easement Example

Conservation easements to protect existing saltmarsh, manage marsh migration corridors, and facilitate land transition to healthy salt marsh on parcels subject to sea level rise.

- 10-year Management Plan
- Development setbacks and impervious surface limits
- Delineate wetland migration buffer
- No conversions, fertilizer or pesticide applications
- Identify viable restoration opportunities (living shorelines, vegetated buffers)
- Seeding and planting
- Control of Phragmites and other invasives
- Reduce mowing turf grass up to the water's edge in favor of native buffer plantings

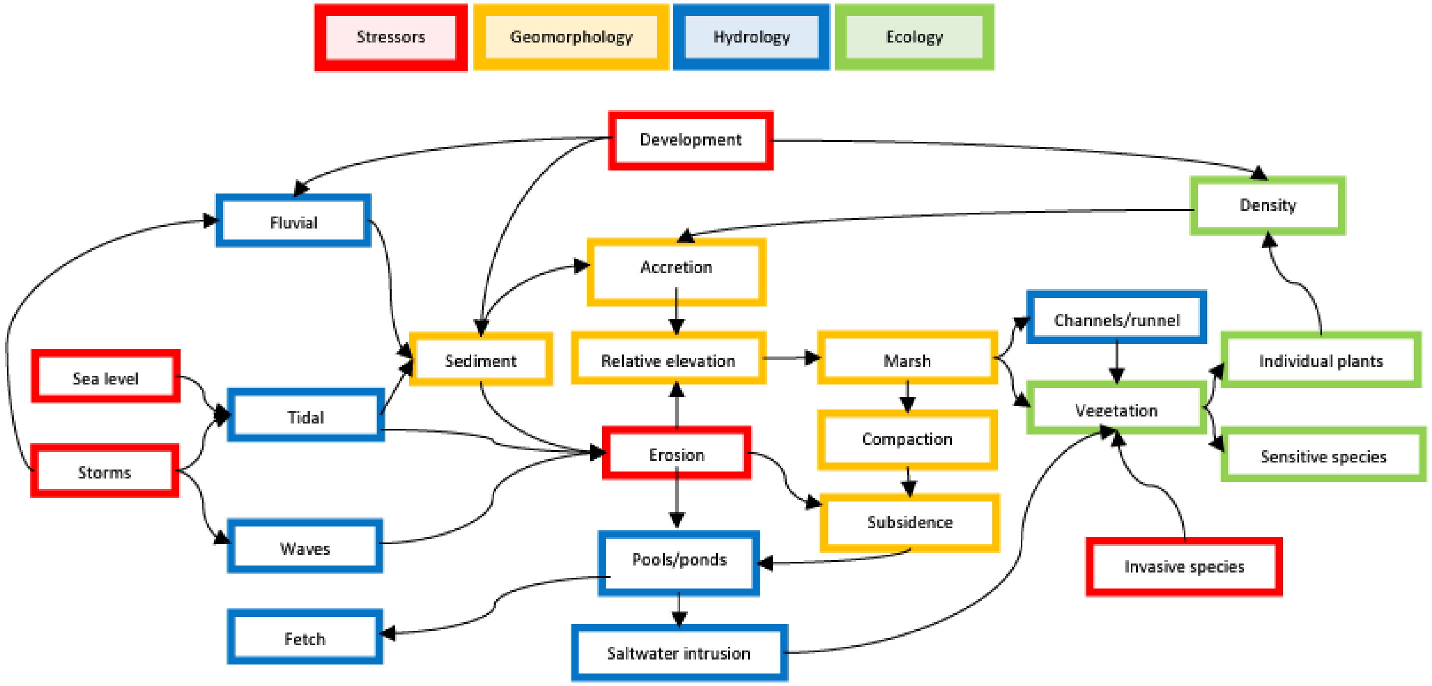


Change Point Easement, Talbot County, 2021

Selecting Adaptation Options

Consider:

- Site Conditions (elevation, vegetation)
- Sediment Availability
- Cost
- Lifespan of practice
- Local Buy-in
- Prioritization/Funding



TNC Marsh Management Conceptual model

Data available on the MD Coastal Atlas

Thank you! Questions?

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