

**SHIFTING SHORELINES,
SHIFTING CONSERVATION STRATEGIES:
ASSESSING WETLAND CONSERVATION
PRIORITIES IN MARYLAND**

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
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Introduction

Conserving wetland habitat is one way that coastal managers at federal, state, local, and nonprofit organizations can work together to protect a way of life in coastal communities. These habitats sustain and benefit fish, wildlife, and plants that in turn support coastal communities' fishing economies, improve water quality, provide floodwater storage, and buffer communities from the impacts of storms.

Global sea level is on the rise, which shapes and alters coastal habitats, including wetlands. Through the 20th century, observations from tide gauges indicate that global average sea level has risen between 4.8 and 8.8 inches—an average rate of about two-thirds of an inch per decade. Scientists expect this rate to increase as global temperatures warm. Even a small vertical rise can result in seawater covering large areas of flat beaches and low-lying land. If sea level rises quickly, the encroaching ocean can drown coastal marshes and disrupt seaside ecosystems. Higher seas also enable storm surges to travel farther inland, putting more lives in danger and increasing the risk to property when powerful storms come ashore.

As with all management strategies, conservation planning and management must continually adjust to new knowledge and shifts in climatic, ecological, and socioeconomic conditions. Preparing for and coping with the effects of sea level rise on coastal communities and the wetland habitats they rely on is an important consideration.

When considering sea level rise, conservation strategies for coastal wetlands must incorporate present wetland conditions as well as potential future conditions in vulnerable areas. In addition to providing all the benefits of conservation today, this can increase the potential for wetland habitats to shift inland so that they can continue to provide protection for developed areas and refuge for wildlife as conditions change in the future. This document presents spatial considerations incorporating best practices for conserving coastal wetlands in this context.

This document also shares an on-the-ground approach to applying these practices used by the State of Maryland. The state has historically been very progressive in its conservation efforts, and as sea level changes are becoming a greater concern, efforts are increasingly focused on conserving land for sea level rise adaptation using current best practices. These best practices would enable the inland retreat of coastal wetlands and maintain the ecological functions and buffering capacity that wetlands provide.

Spatial Best Practices

Size and Proximity

Protecting large areas that represent a range of habitat types will help provide biological connection and biodiversity, as well as an array of ecological functions. Larger protected areas hold greater potential to include a variety of species and functions that can help ensure adaptability to future changes. Where conserving large areas is not achievable, identifying multiple smaller wetland areas in close proximity to one another is another strategy. If one area is impacted by sea level rise, there will be other wetlands nearby to fulfill similar functions. Protecting wetlands outside of vulnerable areas can also provide a place of refuge for species that rely on that habitat type.

Buffers

Conserving buffer areas around wetlands helps to lessen current stressors on these systems, increasing their resilience to an additional disturbance such as rising seas over the short term. For example, a buffer may decrease impacts from encroaching development and increased pollutant loads. Protected wetlands and surrounding natural areas also serve, in turn, as protection for nearby developed areas from rising sea

levels, floods, and storms. In the long term, buffer areas may have potential to become inland migration areas for wetlands as sea levels continue to rise.

Connectivity

To facilitate wetland migration in response to sea level rise, protected areas must be connected from the shoreline inland. Identifying and protecting corridors to connect these areas (such as forests, freshwater wetlands, or agricultural or other undeveloped lands with restoration potential), will enable wetland migration to occur. Conservation focus on future migration corridors can protect current wetlands and transitional areas, and provide for future wetlands.

Applying Best Practices In Maryland

Over the last century, sea level rise in the Mid-Atlantic region has been greater than the global average. Baltimore, Maryland, tide gauges show the average 20th-century sea level rise to be nearly double the global average, exacerbated by the subsidence of land. In Maryland, future sea level rise is also predicted to be twice the average global rate. The state is anticipating impacts that include the submersion of land, transportation routes, and historic areas, and effects on agriculture, fisheries, water quality, and other important services from natural resources. Maryland has already experienced some of these impacts, including the disappearance of 13 Chesapeake Bay islands and approximately 580 acres of shoreline lost to erosion each year. In 2010, the Maryland Department of Natural Resources (DNR) adopted the Building Resilience to Climate Change policy to establish procedures for addressing climate change issues identified in the state's "Climate Action Plan." The policy includes procedures for the DNR's land acquisition activities to target areas that will minimize the effects of sea level rise and storm impacts.

Developing Objectives

Because coastal wetlands provide a natural buffer against sea level rise and associated impacts such as storm surge, flooding, and erosion, the DNR sought to identify lands that would enable the inland retreat of coastal wetlands and therefore maintain the ecological functions and buffering capacity wetlands provide. To accomplish this goal, Maryland DNR used input received through a stakeholder workshop and information from literature reviews to develop objectives for identifying coastal lands at a landscape scale with the highest potential to aid in adapting to sea level rise.

Choosing Tools and Data

To better understand the projected impacts of sea level rise on the state's coastal wetland system, the DNR used the Sea Level Affecting Marshes Model (SLAMM), one of several methods used to predict wetland migration. The DNR used National Wetlands Inventory (NWI) data from the U.S. Fish and Wildlife Service as the base data for SLAMM.

Maryland also benefitted from an existing statewide *green infrastructure* plan identifying high-priority habitat for protection to promote habitat function and connection. Using geospatial techniques, large areas of intact habitat *hubs* and connecting *corridors* were identified. The resulting network of high-priority

Wetland Migration Models

These models provide planning scenarios visualizing where inundation might occur when sea level rises and how wetland habitat might shift, taking into account the sea level rise inundation, accretion, tide, and other important factors. Several resources are available to help create or provide these scenarios:

- [Sea Level Rise Affecting Marshes Model \(SLAMM\)](#)
- [Sea Level Rise and Coastal Flooding Impacts Viewer](#)
- [Coastal Resilience Project](#)

areas became an input layer for assessing future wetland protection priorities under sea level rise conditions.

Similarly, the state conducted an analysis of statewide *blue infrastructure*, identifying watersheds containing important aquatic and nearshore habitats of high conservation interest. Maryland’s coast-wide blue infrastructure results also became an input layer for the wetlands protections analysis under sea level rise conditions.

Analyzing the Data

The SLAMM model was run using a sea level rise scenario of 1.04 meters by year 2100, as identified by Maryland’s Commission on Climate Change, and provided a way to visualize the potential future changes to coastal wetlands and shorelines.

Using a combination of the SLAMM outputs, Maryland’s statewide green and blue infrastructure plans, and sea level rise adaptation objectives, the DNR developed specific criteria and conducted an extensive geospatial analysis to identify high-priority coastal lands that provide sea level rise adaptation opportunities. Sea level rise adaptation best practices, considering size and proximity, buffers, and connectivity, were incorporated in the criteria to guide the geospatial analysis. Table 1 shows Maryland’s sea level rise adaptation objectives and the spatial analysis criteria they used to identify lands meeting these objectives that will be added to the state’s priorities for protection. Additional information on the spatial analyses is available in Appendix B.

Green and Blue Infrastructure in Maryland

In 2003, Maryland established a Green Infrastructure Network that prioritized areas for public land acquisition to promote habitat function and connectivity. Similar analyses were conducted in 2010 for aquatic nearshore environments and watersheds containing high-priority habitats, or blue infrastructure. The green and blue infrastructures became reference data layers for assessing important areas in the future. View Maryland’s green infrastructure protection priorities in the state’s online [GreenPrint](#) application.

Table 1. Sea Level Rise Adaptation Objectives for Coast-Wide Spatial Analysis

Objective	Spatial Analysis
Identify potential future wetlands in year 2100	Sea Level Affecting Marshes Model (SLAMM) with National Wetlands Inventory (NWI) data
Identify upland areas that may shift to wetland in year 2100	SLAMM with NWI data
Maintain future diversity of wetland types	Use SLAMM 2100 analysis results to compare current and future acreage for each wetland type to identify which wetlands types will be most at risk in the future
Identify large wetlands that will be intact in 2100 to conserve today, to avoid future habitat fragmentation	Use SLAMM 2100 analysis results to classify wetlands by size
Identify high-priority wetlands based on habitat size and ecological importance	Use SLAMM 2100 analysis results to <ul style="list-style-type: none"> – Prioritize future emergent wetlands ≥ 150 acres for breeding birds – Further prioritize future emergent wetlands ≥ 650 acres for northern harrier – Prioritize future irregularly flooded and transitional marshes for bird species dependent on high marsh habitat
Identify nearshore wetlands associated with watersheds identified as high priority in the blue infrastructure plan	Compare SLAMM 2100 analysis results with blue infrastructure analysis results to prioritize wetland areas coincident with currently identified high-priority coastal watersheds
Identify inland wetlands associated with hubs and corridors identified in the green infrastructure assessment and with “forest interior dweller” habitat	Use SLAMM 2100 analysis results to <ul style="list-style-type: none"> – Prioritize wetland areas coincident with hubs and corridors identified in the green infrastructure assessment – Prioritize wetland areas coincident with currently identified forest interior dweller habitat
Identify potential wetland transition areas associated with hydric soils	Use SLAMM 2100 analysis results and soil data to identify future potential wetlands areas coincident with current suitable hydric soils to support future wetland establishment and transition

Using the Results

The data resulting from the geospatial analysis will be used to update the targeted ecological areas currently displayed in Maryland’s [GreenPrint](#) application to encourage conservation efforts in areas suitable for sea level rise adaptation. These results add sea level rise impacts to wetlands as another component in the state’s overall priorities for land conservation.

The results from SLAMM were incorporated into Maryland DNR’s [Coastal Atlas: Shorelines mapper](#). The Coastal Atlas is used in conjunction with a qualitative, parcel-level climate change evaluation form that Maryland DNR developed to assess parcels for potential sea level rise adaptation benefits before recommending approval for land conservation by the Maryland Board of Public Works. The DNR is using this form and the Coastal Atlas data to encourage coastal land trusts to incorporate sea level rise adaptation into their conservation efforts. The “Parcel-Level Climate Change Evaluation Form” is included in Appendix C.

Land conservation efforts that target areas identified through Maryland's analysis will allow for the inland movement of coastal wetlands and will help maintain natural storm surge buffers, wildlife habitat, wetland-dependent human activities, water filtration, and other ecosystem services that wetlands provide. Maryland's progressive objectives, spatial analyses, and qualitative considerations shared here can help other coastal conservation organizations that are looking for concrete ways to incorporate sea level rise adaptation into their conservation priorities.

Appendix A: Bibliography

U.S. Climate Change Science Program and Subcommittee on Global Change Research. 2009. *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*. Synthesis and Assessment Product 4.1. J.G. Titus, lead author. U.S. Environmental Protection Agency. Washington D.C.

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Appendix B: Geospatial Analysis Details

Sea Level Affecting Marshes Model (SLAMM) Analysis

SLAMM uses elevation, accumulation of sediments, wetland accretion and erosion rates, and sea level rise to predicatively model long-term wetland and shoreline change. In Maryland, SLAMM was run using the best available science, including a sea level rise rate identified by the Maryland Commission on Climate Change of 1.04 meters by the year 2100.

The SLAMM model relies on the National Wetlands Inventory classification. National Wetlands Inventory data that ranged from year 1976 to 2000 were used, and Table B-1 shows the 20 land cover classes that Maryland DNR incorporated in its analysis.

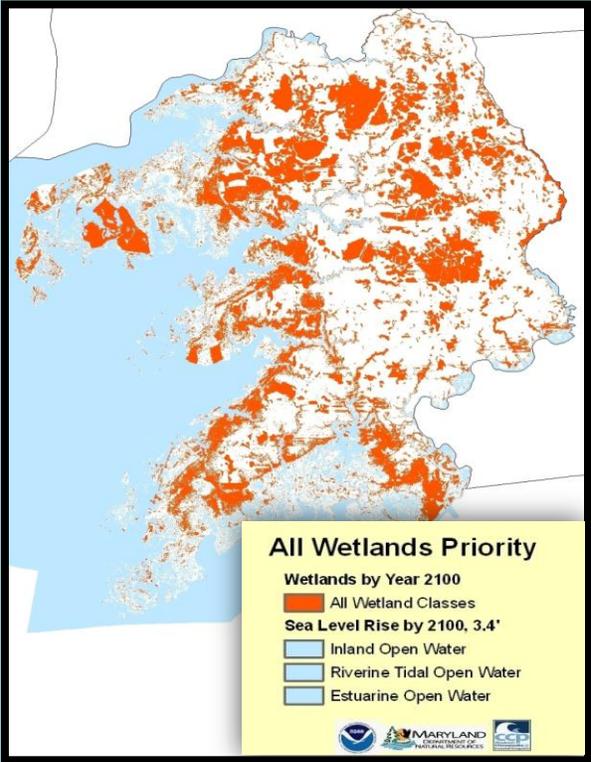
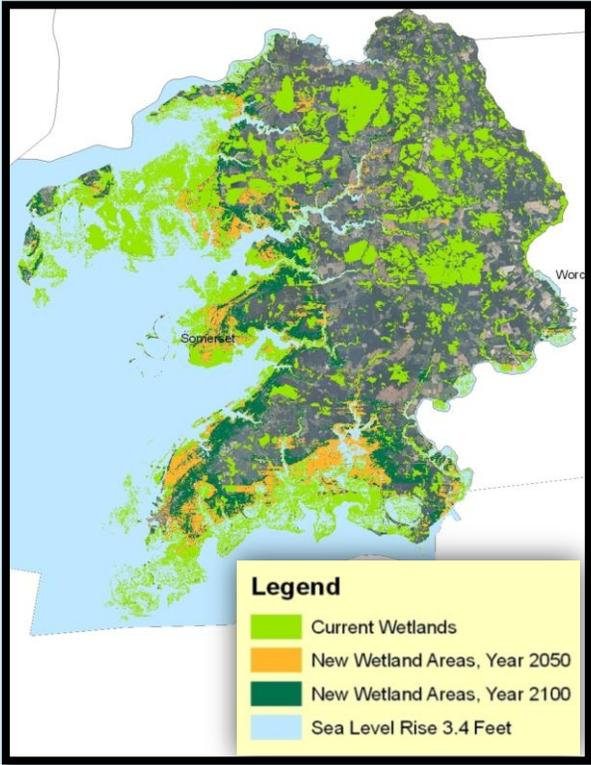
Table B-1. National Wetlands Inventory Land Cover Classes Used for Maryland DNR Analysis

Non-Wetland Classes	Wetland Classes
Developed dry land	Swamp
Undeveloped dry land	Cypress swamp
Estuarine beach	Inland freshwater marsh
Tidal flat	Tidal freshwater marsh
Ocean beach	Transitional marsh
Rocky intertidal	Regularly flooded marsh
Inland open water	Irregularly flooded marsh
Riverine tidal open water	Tidal freshwater swamp
Estuarine open water	
Tidal creek	
Ocean	
Freshwater shoreline	

Geospatial Analysis Details

Table B-2 provides sea level rise adaptation objectives, analyses conducted, and scores assigned to each objective to identify priority coastal lands for sea level rise adaptation. For each criteria, the analysis results were classified (for example, by size or coincidence with other features of interest) to show lower to higher priority areas. This enabled DNR to look for coincidence of high-priority areas identified across all the criteria.

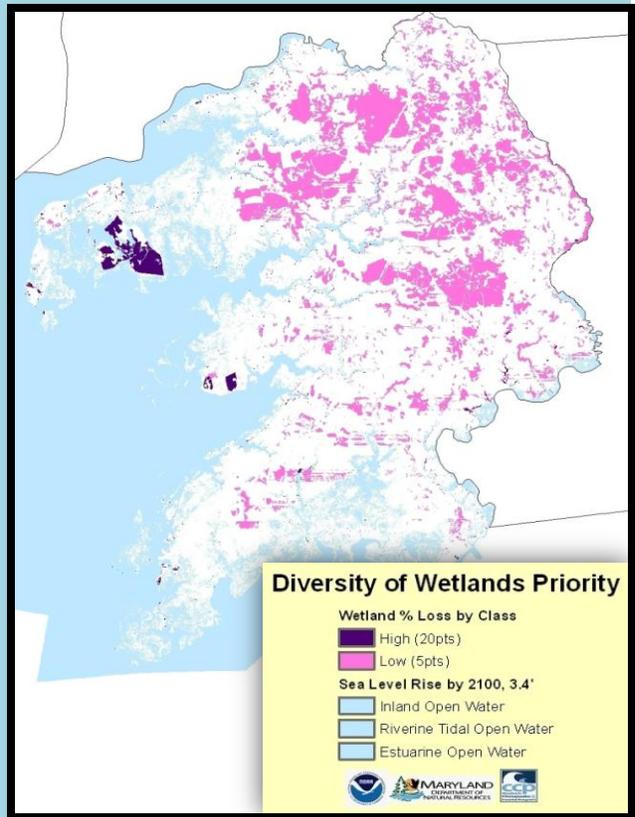
Table B-2. Geospatial Analysis

Objective	Analysis	Classification	Example Map Output
<p>Identify all future wetlands for year 2100</p>	<p>Extract all wetland classes from the 2100 SLAMM output</p>	<p>All wetland classes (+5)</p>	
<p>Identify uplands that will shift to wetland by 2100</p>	<p>Overlay current undeveloped dry upland with wetland classes predicted for 2100</p>	<p>New wetlands by 2100 (+20)</p>	

Maintain diversity of wetland types

Calculate current acreage of each wetland class and compare to acreage predicted for each wetland class by 2100; divide loss into quartiles

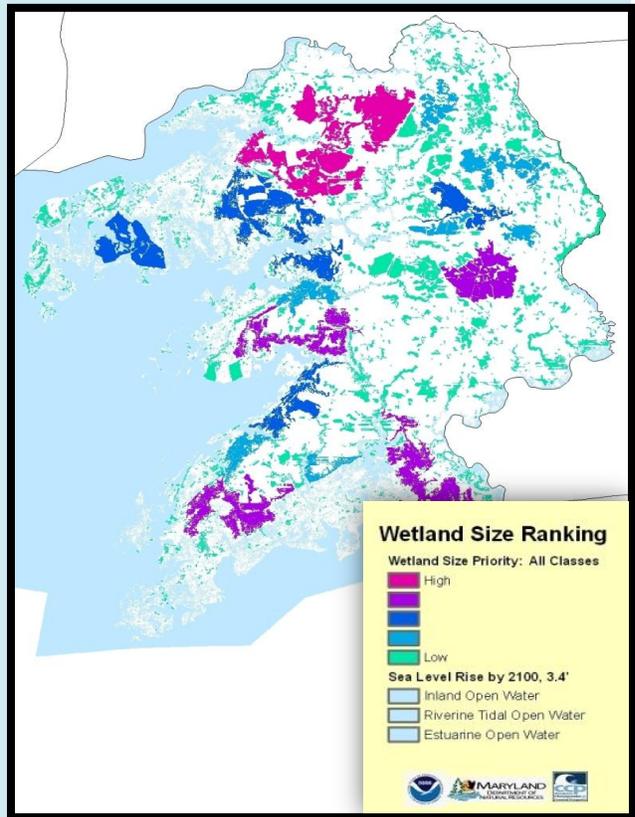
Wetland diversity
 Quartiles % loss
 <25% (+5)
 25.1 – 50% (+10)
 50.1 – 75% (+15)
 75.1 – 100% (+20)



Identify large wetlands that will be intact in 2100 to conserve today, avoiding habitat fragmentation

Using 2100 wetland classes, find large (>1 acre) continuous wetlands; acreage of continuous wetlands broken into 5 classes

Class 1 – Low (+5)
 Class 2 (+10)
 Class 3 (+15)
 Class 4 (+20)
 Class 5 – High (+25)



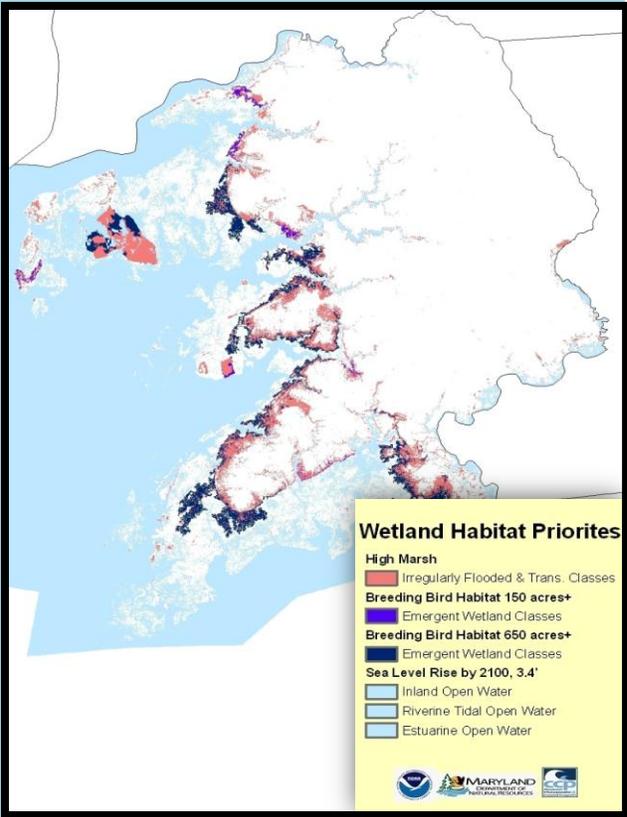
Identify high-priority wetlands based on habitat size and ecological importance

a. Extract emergent wetland classes in 2100 at least 150 acres in size for breeding birds; give priority to those that are 650 acres or more for the northern harrier

b. Extract irregularly flooded and transitional marshes in 2100 for bird species

a. ≥ 150 acres (+10)
 ≥ 650 acres (+10)

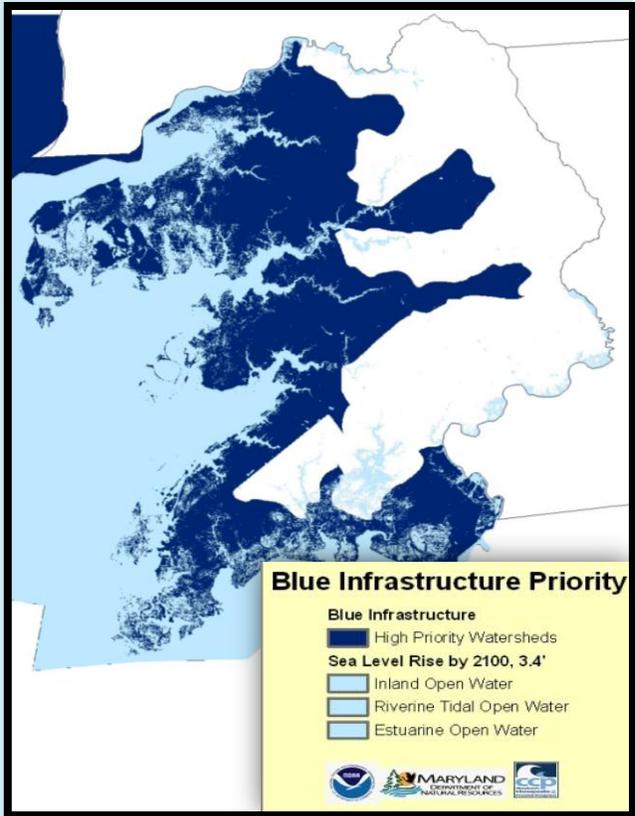
b. Combined high marsh classes (+15)



Identify high-priority nearshore wetlands

Overlay 2100 wetlands with high-priority watersheds identified in the blue infrastructure analysis

Coincident with blue infrastructure watersheds (+10)



Identify high-priority inland wetlands

Overlay 2100 wetlands with hubs and corridors identified in the green infrastructure analysis

Overlay 2100 wetlands with forest interior dweller (FID) habitat

Coincident with green infrastructure network (+10)

Coincident with FIDs (+10)



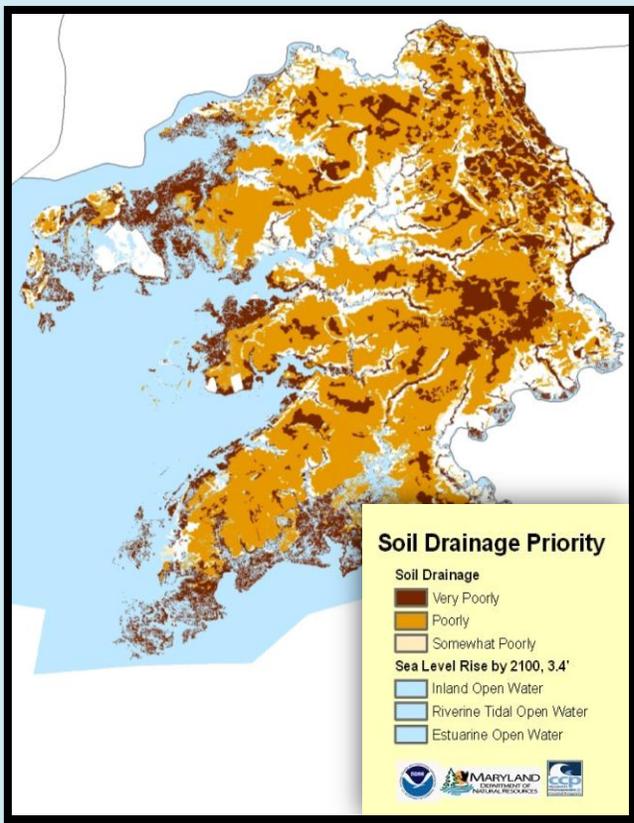
Identify suitable soils for wetland establishment and transition

Overlay 2100 wetlands with suitable hydric soils; soils classed into SPD (somewhat poorly drained), PD (poorly drained), and VPD (very poorly drained)

Hydric Soil Drainage Class 2 SPD (+5)

Class 3 PD (+10)

Class 4 VPD (+15)



Appendix C: Parcel-Level Climate Change Evaluation Form

The following climate change evaluation form is being used in combination with data from Maryland's Coastal Atlas, which includes Maryland's SLAMM analysis results for predicted new wetlands by year 2100, to evaluate and rank parcels for land acquisition.

RECOMMENDED INTERIM CRITERIA FOR COASTAL LAND ACQUISITIONS & EASEMENTS

DRAFT

In Response to Climate Change Impacts of Sea Level Rise

Climate Change Evaluation Criteria

Projected impacts are based on the best available science for the mid-Atlantic region. Relative sea level rise projections for the mid-Atlantic range between 1-1.3 feet by 2050 and 2.7-3.4 feet by 2100. Please refer to the companion guide that identifies the supporting data for this evaluation.

Property Name: _____ County: _____

Scoring: In interpreting the scale it is assumed that the higher the rating, the greater the capacity of the property to provide resiliency to climate change stressors of sea level rise and storm surge through adaptation and/or mitigation.

I. Sea Level Rise Resiliency

Identifying potential sea level rise vulnerability of a site will help establish a long-term management plan to help increase the resiliency of the site.

Overall Rating: slight low moderate high



Sea Level Rise Resiliency Potential

i. Is there potential for inundation on the property by 2050?

Yes No

If yes, roughly how much of the property would be inundated?

- a. 76-100% slight
- b. 51-75%
- c. 26-50%
- d. 25% or less high

ii. Is there potential for inundation on the property by 2100?

Yes No

If yes, roughly how much of the property would be inundated?

- a. 76-100% slight
- b. 51-75%
- c. 26-50%
- d. 25% or less high



II. Wetland Migration

Identifying the potential for future wetland areas can help prioritize sites to maintain coastal wetlands into the future.

Overall Rating: slight low moderate high



Wetland Migration Potential

- i. Percentage of the property wetlands potentially inundated by 2050
 - a. 76-100% of the property within the 0-2' elevation slight
 - b. 51-75% of the property within the 0-2' elevation
 - c. 26-50% of the property within the 0-2' elevation
 - d. 25% or less of the property within the 0-2' elevation high

- ii. Percentage of the property wetlands potentially inundated by 2100
 - a. 76-100% of the property within the 2-5' elevation slight
 - b. 51-75% of the property within the 2-5' elevation
 - c. 26-50% of the property within the 2-5' elevation
 - d. 25% or less of the property within the 2-5' elevation high

- iii. Land Use/Land Cover
 - a. Low to medium residential development slight
 - b. Forested, orchards and open urban land
 - c. Wetlands, scrub shrub, pastures, and cropland high
 - d. Not applicable/no score if property is used by heavy transportation, high residential, and/or commercial development

- iv. Living Shoreline Suitability (Worcester, Somerset and Calvert Counties)
 - a. May not be suitable for living shoreline slight
 - b. May be suitable for hybrid option
 - c. May be suitable for soft stabilization high
 - d. Not applicable/no score



III. Restoration Potential

Identifying restoration potential may help to build the resiliency of the site if forest canopy and wetland areas were improved and/or expanded.

Overall Rating: slight low moderate high



Restoration Potential

- i. Percentage of property currently forested ____%
- ii. Current or future reforestation projects on site yes ____ no ____
 - If yes:
 - a. Reforestation planned for ____ acres
 - 1. If most acreage is *within* 2-5' elevation slight
 - 2. If most acreage is *above* 2-5' elevation high
 - If no:
 - a. There is *no* potential for reforestation *above* 2-5' elevation slight
 - b. There is potential for reforestation *above* 2-5' elevation high
- iii. Percentage of property is wetland ____%
 - a. Wetlands onsite
 - 1. If *Phragmites* (invasive wetland grass) present high
 - 2. If wetlands are ditched or diked high
 - 3. Not applicable/no score

IV. Natural Storm Surge Protection

Identifying the natural capacity of storm surge protection a property may provide surrounding communities, protected lands, and/or adjacent properties may help prioritize the protection of the property.

Overall Rating: slight low moderate high



Natural Storm Surge Potential

i. Storm Surge Buffers

- a. Stabilization Structures present slight
- b. Bare bank
- c. Beach buffer present
- d. Marsh buffer present high

ii. Shoreline Rates of Change

- a. High slight
- b. Moderate
- c. Low
- d. Slight high

iii. Natural storm surge resiliency of the site: select the category that best describes the property

- a. Majority of the property is within Category 1 slight
- b. Majority of the property is within Category 1 & 2
- c. Majority of the property is within Category 2 & or 3
- d. Majority of the property is within Category 4 high
- e. Not applicable/no score

iv. Land Use/Land Cover

- a. Open urban lands slight
- b. Agriculture, row crops, cropland, pasture

- c. Brush, beaches, orchards and vineyards
- d. Wetlands and deciduous/mixed/evergreen forest high
- e. Not applicable/no score if property is bare ground/exposed rock or used by heavy transportation, residential/commercial/industrial development and/or feeding/breeding operations

V. Potential Barriers to Habitat Migration

Identifying the potential barriers to wetland migration under accelerated sea level rise may help inform the long-term restoration potential for the site.

Overall Rating: slight low moderate high



Habitat Migration Potential

i. Stabilization Structures

- a. Yes, majority of shoreline is hardened slight
- b. Yes, some of the shoreline is hardened
- c. No hardened structures but not fully vegetated
- d. Living shoreline or fully vegetated high

*Additional structures present: groins, revetments, and breakwaters
Yes, there is another type of shoreline protection: _____

ii. Bank Cover

- a. Bare Bank Cover slight
- b. Partial Bank Cover (partial vegetated)
- c. Total bank Cover (vegetated) high

iii. Bank Height

- a. 5 - 30 feet high slight
- b. 0 - 5 feet high high
- c. Not applicable/no score



iv. Is the Bank undercut?

- a. Yes slight
- b. No high
- c. Not applicable/no score

v. Shoreline Rates of Change

- a. High slight
- b. Moderate
- c. Low
- d. Slight high

VI. Environmental Hazards

Identifying potential hazards inundation and temporal flooding of septic tanks and drain fields, fuel tanks, and animal feed operations may pose on the property, will help inform an effective management plan to increase the long-term resiliency of the property through the removal of these hazards.

Overall Rating: slight low moderate high



Mitigation Potential

i. Does the property have a septic system?

- a. No slight
- b. Yes, but it is not likely to be inundated
- c. Yes, likely to be inundated by year 2100
- d. Yes, likely to be inundated by year 2050 high

ii. Does the property have an existing or decommissioned underground fuel tank?

- a. No slight
- b. Yes, but not likely to be inundated
- c. Yes, likely to be inundated by year 2100
- d. Yes, likely to be inundated by year 2050 high

RECOMMENDED INTERIM CRITERIA FOR COASTAL LAND ACQUISITIONS & EASEMENTS

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iii. Current or past animal feeding operations present?

- a. No slight
- b. Yes and not likely be inundated by sea level rise
- c. Yes and likely to be inundated by year 2100
- d. Yes and likely to be inundated by year 2050 high

