Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay: Workshop Marsh Geomorphology Profiles

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Sea Grant MARYLAND

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This report summarizes presentations, discussions, and results from the Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay Workshop, held October 6, 2022, in College Park, Maryland. The workshop, sponsored by Maryland Sea Grant, was to discuss and brainstorm solutions to increase human resilience and adaptation to climate change through improved marsh management.

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Profiles Overview and Background

At the "Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay" workshop on October 6, 2022, participants were asked to assess how different marsh geomorphologies may best support varied ecosystem services (Session I) and then how to manage a particular marsh geomorphology into the future (Session II). Their comments and rankings were based on their own expertise and experience. The workshop steering committee designated the ecosystem services and the marsh geomorphologies along with definitions and characteristics for each service/type in the workshop briefing materials (see Briefing Materials for ecosystem service and marsh geomorphology definitions).

In Session I, participants were placed in breakout groups (5-10 people/group) that represented an ecosystem service based on their preferences in the workshop registration/pre-survey (Appendix A). The steering committee designated eight ecosystem services during the registration/pre-survey; because of low interest in the "water purification" ecosystem service in the pre-survey, we did not assign a group to it during the workshop (though several groups mentioned water quality in their discussions) (See Briefing Materials). Based on interest levels in the registration/pre-survey, some ecosystem system services had more than one group assigned to them. The groups were given 45 minutes to evaluate seven geomorphologies (or approximately 6 minutes per geomorphology) and ultimately provide a ranking of whether each geomorphology was a high, medium, or low priority for protection or restoration for their assigned ecosystem service (Table 1). Some groups were not able to evaluate all geomorphologies in the assigned time.

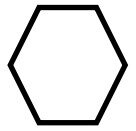
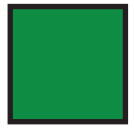
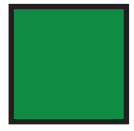
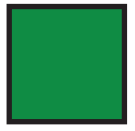
While we asked groups to focus on their specific ecosystem service, participants also considered and discussed the distribution of these geomorphologies in the Chesapeake and coastal bays, the potential longevity of the marsh with or without intervention, and the ease of implementing restoration. While these topics are fully appropriate in considering investment in a marsh's conservation, they may not speak specifically to advantages or weaknesses toward the assigned ecosystem service.

In Session II, groups were asked to consider current vulnerabilities of a specific marsh geomorphology and best management strategies to sustain marsh goals, based on the ecosystem service priorities of the previous breakout session. Some geomorphologies had more than one group assigned to the assessment. To aid in their thinking about how to manage a for a geomorphology we also provided an example of each geomorphology located in the Chesapeake Bay (see Appendix B).

Based on background research for the Briefing Materials and the feedback from participants during Sessions I and II, Maryland Sea Grant has developed a summary for each marsh geomorphology that includes their capacity to provide specific ecosystem services, recommended restoration techniques and associated concerns, and remaining uncertainties regarding the marsh's ecology and/or management. These summaries are based on expert consensus among the workshop participants, acknowledging that participants had limited time to draw conclusions, expertise varied within groups, and summaries were drawn from workshop notes (i.e., points and nuances may not have been fully captured). We hope these brief profiles for marsh geomorphologies may serve as a starting point to describe their assets, challenges to their persistence, and recommended restoration strategies for their on going management. This may aid in evaluating a site for possible conservation in terms of potential co-benefits and management of stressors.

Table 1. Breakout session I participants completed this matrix based on discussions around marsh geomorphology types and marsh ecosystem service interactions. Each shape represents a breakout group (some services had multiple groups across the in-person and virtual spaces). A green square indicates that this marsh type is a high priority to maximize the ecosystem service, a yellow triangle is a medium priority, and an orange circle is a low priority. A white hexagon indicates that no designation was selected.

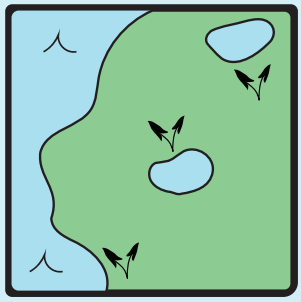
Ecosystem Service–Marsh Geomorphology Matrix

Ecosystem service \ Marsh geomorphology	Island	Back Barrier	Embayed/Pocket	Headland/Point	Mainland Fringe	Tidal Fresh	Urban Cluster
Bird habitat conservation							
Maintenance of fisheries							
Benefits to private agriculture and residential lands							
Benefits to the surrounding communities							
Carbon sequestration							
Coastal protection							
Coastal erosion							

Tidal Fresh Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A marsh that experiences regular lunar tides with oligohaline to fully fresh water.

Marsh Characteristics

Sediment Supply

Deposition from riverine and estuarine sources.

Salinity

Ranges from fresh to low oligohaline.

Stressors

High concern: Changing salinity, high groundwater.
Possible: Relative sea level rise, erosion, storms, sediment supply, invasive species, anthropogenic nutrients, increasing temperature.

Ability to Migrate

Yes, if no topographic or man-made barriers.

Vegetation

High diversity of emergent vegetation that is intolerant of saltwater. Generally, less vegetation zonation, with mixed communities dominated by broad-leaved perennial herbaceous species (*Peltandra spp., Pontedaria spp., Scirpus spp., Cyperus spp.*) May include woody vegetation, trees, and shrubs, especially close to the upland. May be tolerant of temporary exposure to saline water. Potential for invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Need to possibly plan and facilitate migration and a shift in vegetation regime. Manage phragmites (*Phragmites australis*) with tolerant native species.
- Prioritize work based on local community needs.
- Manage interior creek systems via weirs to keep marshes moist and manage for erosion. Also consider bottomless culverts or tide gate alternatives.
- Possibly use containment berms for water management.
- Recommend a program directly responsible for tidal fresh management and restoration (e.g., state program).

Restoration Concerns

- Since sea level rise is shifting tidal fresh marshes more inland and upstream, think less about restoring in its current location and more about creating or facilitating new tidal marsh upstream.
- Some restoration at first may be a carbon source until it becomes a carbon sink (e.g., removing phragmites (*Phragmites australis*) until it is ultimately replaced with different vegetation).
- Identify funding sources related to local community needs.
- Community education and engagement to prepare for possible tidal marsh migration and transition to saltier system.
- Consider elevating the priority level of tidal fresh marshes compared to other salt marshes. Also, increase the associated education and outreach.
- Stressors (e.g., development, nutrient loads) from upland and nontidal areas and tidal areas.

Research Questions

- Overall, more information is needed about tidal fresh marsh restoration.
- What happens when there are salinity changes in the marshes?
- When will sea level rise and associated salt water intrusion cause the tidal fresh marsh to convert to a salt marsh?
- How vulnerable are some tidal fresh marshes to coastal storms?
- What are methane flux dynamics in different fresh marsh settings? Does it cost more to measure methane flux than offset it?
- How do you do fine, thin-layer placement in a tidal freshwater marsh? Needs evaluation before recommending this as a strategy.

Tidal Fresh Marsh

Workshop Ecosystem Services Evaluation

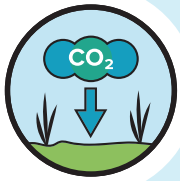
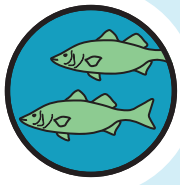
Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Other Beneficial Features

Great partnership potential and larger land area to do large-scale restoration. Large, localized benefits.

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	Larger sites can provide a more natural buffer to surrounding private lands.	■
 **Benefits to the Surrounding Communities**	High water quality benefits, recreation (e.g., waterfowl hunting, wildlife viewing), and fishery spawning habitats. Tribal nations may have strong heritage ties to these systems.	● ▲
 **Bird Habitat Conservation**	Typically used by nontidal, inland bird species more so than salt marsh obligates.	●
 **Carbon Sequestration**	High accretion rates increase carbon stock, but there is a need to understand methane flux to determine total carbon storage.	■ ▲
 **Coastal Erosion**	Tend to have less wave action and good sediment supply (although not always), and are therefore less vulnerable to erosion.	■ ■ ▲
 **Coastal Protection**	High value for buffer/flood protection, potentially near urban, high-density communities.	● ■
 **Maintenance of Fisheries**	Provide spawning and nursery habitat for anadromous fish, although there are high maintenance costs to preserve habitat.	▲

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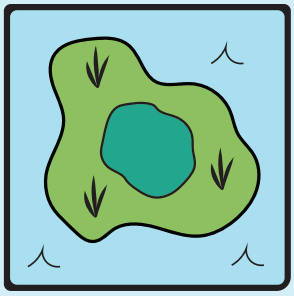
Island Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A marsh or marsh upland complex surrounded by water on all sides. An interior portion of the marsh may have higher elevation with shrubs and trees.

Marsh Characteristics

Sediment Supply

Dependent on the amount of sediment available in floodwater and ambient tidal waters. Sediment can include mineral and organic particles suspended in tidal water. Available sediment related to shoreline hardening.

Salinity

Ranges from polyhaline to oligohaline.

Stressors

High Concern: Relative sea level rise. Erosive forces (depending on exposure to fetch, topographic elevation, size). Some participants have observed high rates of inundation and subsequent interior ponding.
Possible: Erosion, storms, invasive species, anthropogenic nutrients, increasing temperature.

Ability to Migrate

Minimal/none, except migration into interior upland hummocks.

Vegetation

Low and potentially high and upland vegetation types. Potentially invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Thin-layer placement
- Hardening/infrastructure or oyster reefs to control erosion
- Predation control or nest protection for birds and terrapins, depending on distance from mainland

Restoration Concerns

- Beneficial reuse dredge material for thin-layer placement will be available, but it requires great coordination, and it may be hard to transport depending on distance from dredge source.
- Restoration may be expensive, time consuming, and ongoing.
- Consider who is being impacted by projects and which communities need support. If the island is populated, will those communities need protection or relocation?

Research Questions

- Given sea level rise predictions, will there be some marsh islands created as peninsulas flood (i.e., neck disconnected from mainland)?
- What islands have enough interior elevation to withstand sea level rise and allow for marsh migration?
- Where do we select island restoration in the Bay?
- What is the critical size of an island to protect the coast?

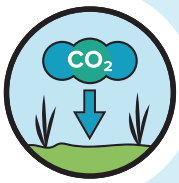
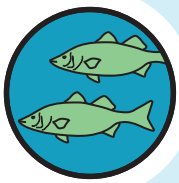
Island Marsh

Workshop Ecosystem Services Evaluation

Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	Tend to be residential rather than agricultural so limited benefit; may protect private lands on the mainland.	●
 **Benefits to the Surrounding Communities**	Islands may provide good tourism revenue including fishing and recreation, but possibly low accessibility.	▲ ▲
 **Bird Habitat Conservation**	Large islands good for marsh-resident birds; potentially low predation.	▲
 **Carbon Sequestration**	May have considerable carbon stocks, but less longevity due to sea level rise.	■ ●
 **Coastal Erosion**	High erosive potential given surface area (eroding from all sides) and varying exposure to fetch; potentially could pair with fringing oyster reefs to help with erosion control.	▲ ● ▲
 **Coastal Protection**	Size and position of island matters; it may provide important wave attenuator and storm barrier for populated islands or nearby communities.	■ ▲
 **Maintenance of Fisheries**	Important habitat for small or juvenile fish, particularly shallow water areas with gentle slope and good fringe oyster habitat.	▲

Other Beneficial Features

Protect and maintain healthy submerged aquatic vegetation (SAV) beds.

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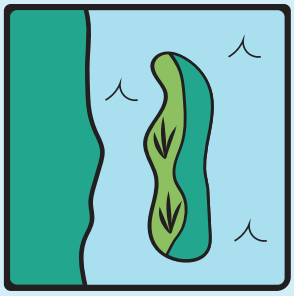
Back Barrier Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A fringe salt marsh located on the landward side of a barrier island.

Marsh Characteristics

Sediment Supply

Sediment (primarily sand) deposited during overwash events.

Salinity

Typically polyhaline.

Stressors

Possible: Relative sea level rise, erosion, storms, invasive species, stormwater runoff, sewage, and nutrient loads on populated barrier islands. Development could possibly change hydrology, add pollutants, reduce habitat, and reduce migration potential. If lower elevation, they are less resilient to storm events.

Ability to Migrate

Marsh extent varies as the island migrates. Marsh may also migrate on the leeward edge into forest (if present). Little to no migration to island upland.

Vegetation

High- and low-marsh species. Potentially invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Build a barrier island system via dredge
- Maintain and/or expand dunes
- Limit development, if possible (e.g., funding buyouts)
- Invasive species management
- Manage habitat for species shift

Restoration Concerns

- Use dredge material that is compatible with the marsh's soil composition.
- Consider limiting island development possibly via permitting, insurances, road design, and/or elevating/relocating public services.

Research Questions

- How do you separate the back barrier marsh from the barrier island upland?
- If the island beaches and upland take the brunt of the impact from storms and erosion, how do you quantify the value of having the upland area? What does the marsh provide behind it?
- What is the connection between back barrier marsh and seaside (beach-side) processes?
- How fast are sand dynamics and rollover rate changing and where? What is the fate of the carbon (i.e., what happens if carbon ends up in the adjacent mud flats or shoals)?

Back Barrier Marsh

Workshop Ecosystem Services Evaluation

Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

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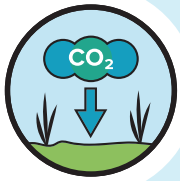
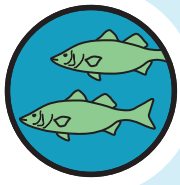
- High
- Medium
- Low
- No Data

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	Depends if island is populated and what the island upland and mainland land uses are.	●
 **Benefits to the Surrounding Communities**	If undeveloped and remote, there is less direct benefit to communities.	● ■
 **Bird Habitat Conservation**	High density of salt marsh sparrow (*Ammodramus caudacutus*). If back barrier island is developed, expect more predation on bird species.	■
 **Carbon Sequestration**	May have big stores of carbon in some areas, but their dynamism and rollover potentially limit their sequestration capacity.	■ ▲
 **Coastal Erosion**	Good renewal of sediment supply (e.g., island rollover) but very site-specific conditions for erosion/sediment.	⬡ ● ▲
 **Coastal Protection**	Barrier island may protect mainland (i.e., wave attenuation), although the island may be providing more coastal protection than the marsh.	▲ ▲
 **Maintenance of Fisheries**	Important nursery area for marine species, especially related to submerged aquatic vegetation (SAV), and overwintering habitat.	■

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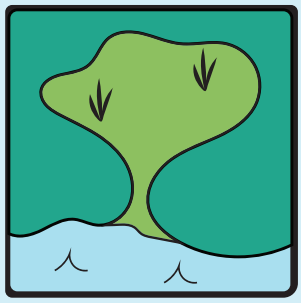
Embayed/ Pocket Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A marsh that forms along the shoreline of a semi-enclosed body of water with a narrow inlet to the estuary. Typically contained within a small, essentially semi-circular area on a shoreline.

Marsh Characteristics

Sediment Supply

Deposition from riverine sources and estuarine sources. Overland flow likely.

Salinity

Ranges from polyhaline to oligohaline.

Stressors

High concern: Relative sea level rise, nutrients, invasive species. Potential to be cut off from the seaward source of water by sand bar building across the inlet, especially if inlet is narrow. Subject to trapping natural and human debris. Possible: Erosion, storms, sediment supply, invasive species, anthropogenic nutrients, shoreline hardening, increasing temperature.

Ability to Migrate

Yes, if no topographic or man-made barriers. Frequently backed by higher elevations, limiting migration potential.

Vegetation

High- and low-marsh species. Potential for invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Prioritize projects based on habitat value and long-term stability.
- Prioritize projects that do not involve infrastructure (i.e., dams or roads).
- Integrated sediment management
- Invasive species removal, especially where migration is encountering development or agricultural lands
- Thin-layer placement
- Maintain riparian buffers

Restoration Concerns

- Restoration is dependent on topographic slope (i.e., steep or gentle). Hard to restore for steep slopes. Gentle slopes provide more opportunity, greater likelihood of success.

Research Questions

- How many exist in the Chesapeake Bay? What is their extent?
- Under what conditions (e.g., salinity) does the marsh emit methane and/or hydrogen sulfide?

Embayed/ Pocket Marsh

Workshop Ecosystem Services Evaluation

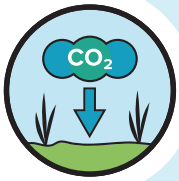
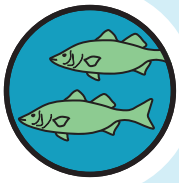
Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Other Beneficial Features

More self-sustaining with natural sediment inputs and a more stable system if protected from wave energy. May have high- and low-marsh species (i.e., more diversity), although often dominated by high-marsh species.

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	If marsh is lost, agricultural land loses its buffer zone, becoming prone to saltwater intrusion. Also sequesters nutrients from agricultural runoff. Potentially, a great area for hunting.	■
 **Benefits to the Surrounding Communities**	Recreational value, but less of a priority than other, bigger marsh types.	● ▲
 **Bird Habitat Conservation**	Dependent on size. If marsh is large, habitat is excellent, but typically marsh is too small to support resident birds and predator access is high.	▲
 **Carbon Sequestration**	Sequestration ability depends on vegetation species (i.e., higher if dominated by high-marsh species) and salinity.	▲ ▲
 **Coastal Erosion**	Typically situated in a more stable, low energy wave environment but more exposed to erosion. Frequently backed by high banks, which are also erosive.	● ● ▲
 **Coastal Protection**	Able to provide good flood storage and sediment capture, but only protects the inlet and does not provide as much storm surge reduction as marshes with greater shoreline length.	⬡ ▲
 **Maintenance of Fisheries**	Provides habitat for nekton and forage habitat for smaller fish.	■

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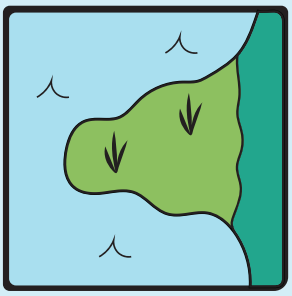
Headland/ Point Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A marsh that projects from the upland into the estuary and is surrounded by water on three sides. Its development is usually influenced by tidal currents that form a sand berm behind which the marsh forms.

Marsh Characteristics

Sediment Supply

Deposition from estuarine sources.
Possible overland flow.

Salinity

Ranges from polyhaline to oligohaline.

Stressors

High concern: Relative sea level rise, increased storm intensity causing high exposure to erosion and flood events. Interior ponding.
Possible: Erosion, storms, sediment supply, invasive species, anthropogenic nutrients, shoreline hardening, increasing temperature. Bifurcation from upland.

Ability to Migrate

Possible, if no topographic or man-made barriers, but unlikely as a peninsula is vulnerable to sea level rise and erosion.

Vegetation

High and low marsh species.
Potentially invasives.

Restoration Considerations

Recommended Restoration Techniques

- Structural protection/edge stabilizations.

Restoration Concerns

- Restoration is challenging due to dynamism and likely expensive due to erosion exposure.
- Marsh system may not be very stable.
- If able to catch sediment, good marsh longevity.

Research Questions

- What is the impact of restoration to downstream shorelines?
- Does this system both catch sediments and contribute sediments?

Headland/ Point Marsh

Workshop Ecosystem Services Evaluation

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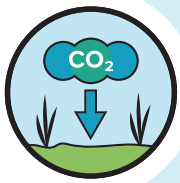
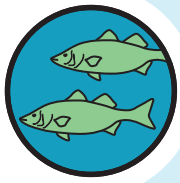
**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Other Beneficial Features

Intercepts fetch-dependent waves from multiple compass directions providing wave energy attenuation. Tend to be larger marsh extents that retain sediment. Protect and maintain healthy SAV beds.

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	May be located on residential lands. It is potentially easier to get landowner buy-in for protection if they see degradation and erosion on their lands.	▲
 **Benefits to the Surrounding Communities**	Possibly allows for water access. Recreational value, particularly fishing. A desirable site for fishing with associated submerged aquatic vegetation (SAV) areas.	● ▲
 **Bird Habitat Conservation**	Dependent on marsh size. Larger units support black rail (*Laterallus jamaicensis jamaicensis*) and salt marsh sparrow (*Ammodramus caudacutus*).	▲
 **Carbon Sequestration**	Good carbon sequestration, but not necessarily high impact compared to other marsh systems.	■ ▲
 **Coastal Erosion**	High erosive potential due to waterline exposure. The marshes have ability to prevent erosion, but sites may not persist.	● ● ▲
 **Coastal Protection**	Dependent on location (high-energy systems will have less coastal protection capacity). Proximal buildings reap benefits of low-energy system.	■ ▲
 **Maintenance of Fisheries**	Preferred edge habitat for fish and crustaceans. Significant concentration of fish and prey.	■

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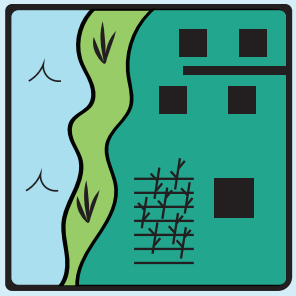
These summaries are based on expert consensus among the workshop participants, acknowledging that participants had limited time to draw conclusions, expertise varied within groups, and summaries were drawn from workshop notes (i.e., points and nuances may not have been fully captured). These brief profiles for marsh geomorphologies may serve as a starting point to describe their assets, challenges to their persistence, and recommended restoration strategies for their ongoing management.

Mainland Fringe Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A fringe marsh is adjacent to the mainland. Land use or landcover includes agriculture, nontidal wetlands, coastal or upland forest, and urban or suburban development. Width of the fringe varies.

Marsh Characteristics

Sediment Supply

Deposition from estuarine and riverine sources.

Salinity

Ranges from polyhaline to oligohaline.

Stressors

Possible: Relative sea level rise, sediment supply, erosion, excess nutrients. Potential for restricted landward mirgration, especially with upstream development.

Ability to Migrate

Yes, if no topographic or man-made barriers.

Vegetation

High and low marsh species. Potentially invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Thin layer placement
- Ditch plug removal
- Living shorelines
- Oyster reef and submerged aquatic vegetation restoration
- Create migration corridors through "Climate-Smart" zoning, acquisition or easements, managing for vegetation shift (i.e., ghost forests, phragmites (*Phragmites australis*)).
- Work with landowners and community engagement (e.g., public awareness, easements, need for other incentives).
- Greater regional sediment management
- Integrate fringe marshes into local economy and quality of life (e.g., ecotourism, recreation).

Restoration Concerns

- Many fringe marshes exist on private property, including agricultural land.
- Many with private property may prefer hardened shorelines and/or may find it is harder to fund or coordinate restoration.
- Strong need for collaboration (e.g., landowners, community leaders, local government, funders). Need more permanent long-term funding.
- If public monies are used, best to ensure there is public access.
- Equity is a concern for which private lands are targeted for conservation opportunities.

Research Questions

- Depending on who owns the marsh, who owns the carbon?
- How does living shoreline design impact downstream areas?
- How does one get multiple owners to agree to long stretches of shoreline restoration?
- How much maintenance (e.g., thin-layer placement) is required?

Mainland Fringe Marsh

Workshop Ecosystem Services Evaluation

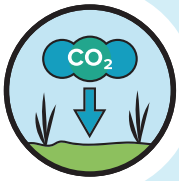
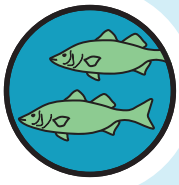
Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Other Beneficial Features

Important ecological corridors and room for retreat (depending on upland topography and development). Potential for sediment and nutrient trapping. Number and extent allow for more regional impact.

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	High local aesthetic benefit, revenue, and property value, may not viewed as a positive. Both an opportunity and challenge to collaborate to protect long stretches of marsh.	■
 **Benefits to the Surrounding Communities**	Offers many services (e.g., storm surge, erosion, nutrient removal, recreation, aesthetics). Education necessary to understand/adapt to marsh migration and not hardened shorelines.	■ ■
 **Bird Habitat Conservation**	Typically have larger marsh areas, which support salt marsh obligate birds but invasives and predation likely present and possibly harder to manage and monitor.	■
 **Carbon Sequestration**	Extent of marshes allows for big opportunity to sequester carbon, although there is a need to develop private landowner incentives (i.e., carbon credits) for conservation.	■ ●
 **Coastal Erosion**	Good erosion control, though long linear edge vulnerable to erosion. Fringing oyster reefs could provide extra protection.	■ ■ ■
 **Coastal Protection**	Good storm surge protection. Tend to be closest to man-made developments. If nearer to people, it is easier to show impact and get stakeholder approval for restoration and conservation.	■ ■
 **Maintenance of Fisheries**	Nursery habitat for recreational fisheries.	■

These summaries are based on expert consensus among the workshop participants, acknowledging that participants had limited time to draw conclusions, expertise varied within groups, and summaries were drawn from workshop notes (i.e., points and nuances may not have been fully captured). These brief profiles for marsh geomorphologies may serve as a starting point to describe their assets, challenges to their persistence, and recommended restoration strategies for their ongoing management.

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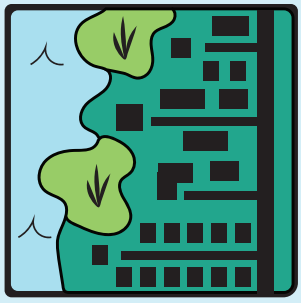
Urban Cluster Marsh

Large-Scale Marsh Persistence and Restoration in the Chesapeake Bay

Workshop Marsh Geomorphology Profile



A group of marshes that exist in an urban setting within a tidal creek, often small and fragmented due to surrounding development.

Marsh Characteristics

Sediment Supply

Deposition from riverine, estuarine, overland flow, and stormwater sources.

Salinity

Ranges from polyhaline to oligohaline.

Stressors

High concern: Anthropogenic nutrients from stormwater runoff, nutrient loads, sewage, and septic systems. High potential for invasive plant and animal establishment, anthropogenic impacts like shoreline hardening, mowing, and debris disposal.
Possible: Relative sea level rise, erosion, sediment supply.

Ability to Migrate

Limited due to man-made barriers in the surrounding development. Sites are often fragmented.

Vegetation

High- and low-marsh species. Potentially invasive species.

Restoration Considerations

Recommended Restoration Techniques

- Potential for tidal reintroduction into previously cutoff areas.
- Use marshes to manage the flow of stormwater and drainage infrastructure.
- Create more wetlands to store stormwater volume. Municipalities might consider purchasing vulnerable properties to restore, while considering environmental justice in their selection process.
- Build more marshes, with upland migration in mind, to reduce flooding vulnerability in communities and give recreational access to water.
- Invasive species control.
- Living shorelines.
- Thin-layer deposition is possible but challenging in small sites.

Restoration Concerns

- Slow stormwater runoff to reduce marsh erosion and enhance marsh nutrient and pollution regulation.
- Limit community displacement.
- Large-scale restoration is challenging, since each marsh is small, fragmented, and, in many cases, on private lands.
- Likely high costs for maintenance and upkeep. Who owns the marsh (e.g., city, county, private) and do they have a management plan?
- Invest in outreach and education to help set expectations and understanding.
- These marshes are often highly polluted/disturbed, which may require additional steps in restoration.
- May be situated in front of high-value infrastructure, increasing realized value.
- Equity is a concern for which private lands are targeted for conservation opportunities.

Research Questions

- Will restoration create new carbon sinks?
- How will increased urbanization and climate change over time impact coastal habitats in urban areas?
- How do you help a property owner and contractors plan or manage expenses for 2050?

Urban Cluster Marsh

Workshop Ecosystem Services Evaluation

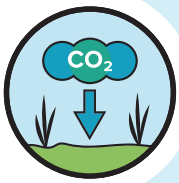
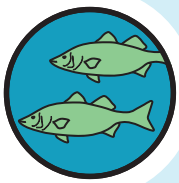
Each ecosystem service has summarized workshop comments that describe the chosen priority level for conserving/ restoring the marsh geomorphology.

**There may be more than one priority level for each service because multiple work groups provided an assessment.*

- High
- Medium
- Low
- No Data

Other Beneficial Features

Projects may have lower costs compared to gray infrastructure. Nutrient removal from water bodies and irrigation sources can provide cleaner water for agriculture.

Ecosystem Service	Workshop Evaluation	Priority Level*
 **Benefits to Private Agriculture & Residential Lands**	Ownership may be public or private; requires education about why to favor marshes over hardened shorelines.	■
 **Benefits to the Surrounding Communities**	Due to their urban location (including underserved communities), have a high value of coastal protection, water quality, education, and connecting people with nature.	■ ▲
 **Bird Habitat Conservation**	Typically too small to support resident bird populations, but may be an oasis for migrants.	●
 **Carbon Sequestration**	Carbon is sequestered over small areas.	● ●
 **Coastal Erosion**	Erosion problems vary by locale. Where marsh shorelines are hardened by bulkheads or seawalls, there is reduced erosion over the short-term.	▲ ▲ ■
 **Coastal Protection**	May provide urban flood protection, good buffer value (e.g., flood mitigation, pollution absorption/ filtration).	▲ ▲
 **Maintenance of Fisheries**	Potentially high diversity of fish species, but limited fisheries value.	⬡

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Appendix A: Workshop Participants

This was a hybrid workshop. Online participants are indicated with a * symbol. Please note participants listed are ones that gave permission to share their information; not all participants are listed.

Mike Allen
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NOAA Digital Coast Fellow
The Nature Conservancy/ Maryland Department of Natural Resources

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Professor - Retired
University of Virginia

Kristen Saacke Blunk
Field Liaison
Headwaters LLC

Bianca Boggs*
Associate
Skeo Solutions

Libby Brieri*
River Steward
Friends of Rappahannock

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University of Maryland Sea Grant Extension

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Underwood & Associates

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DoD Chesapeake Bay Program

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Grants Coordinator
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Lynn Faulkner
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Harford County ACLEC

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Megan Fitzgerald
Life Scientist
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Landowner Assistance Coordinator
ShoreRivers

Zack Greenberg
Officer, Conserving Marine Life in the U.S.
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Eastern Shore Land Conservancy

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Natural Resources Specialist
NOAA

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Virginia Department of Wildlife Resources

David Satterfield
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Eastern Shore Land Conservancy

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Lower Shore Land Trust

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Old Dominion University

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Exec. Director
Maryland Coastal Bays Program

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Stewardship Coordinator
Maryland Department of Natural Resources, Chesapeake Bay National Estuarine Research Reserve

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Chesapeake Research Consortium

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Blackwater NWR

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Scientist
EA Engineering

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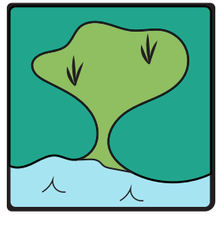
Assistant Professor
Biological Sciences, Old
Dominion University

Appendix B:
Example Marsh Geomorphologies

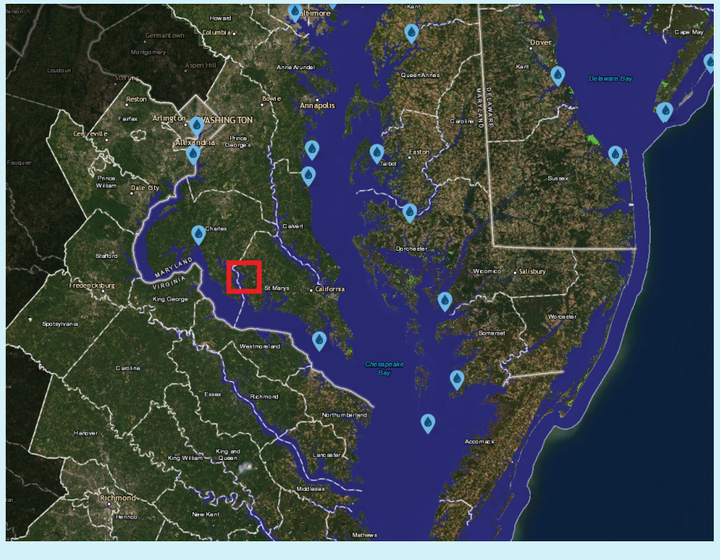
Each group was provided an example of their assigned marsh geomorphology in the Chesapeake Bay. The following maps show current distribution/extent of the marsh and the projected sea level rise impacts in 2030 and 2050. Groups were instructed to use these visualizations as an example only.

Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



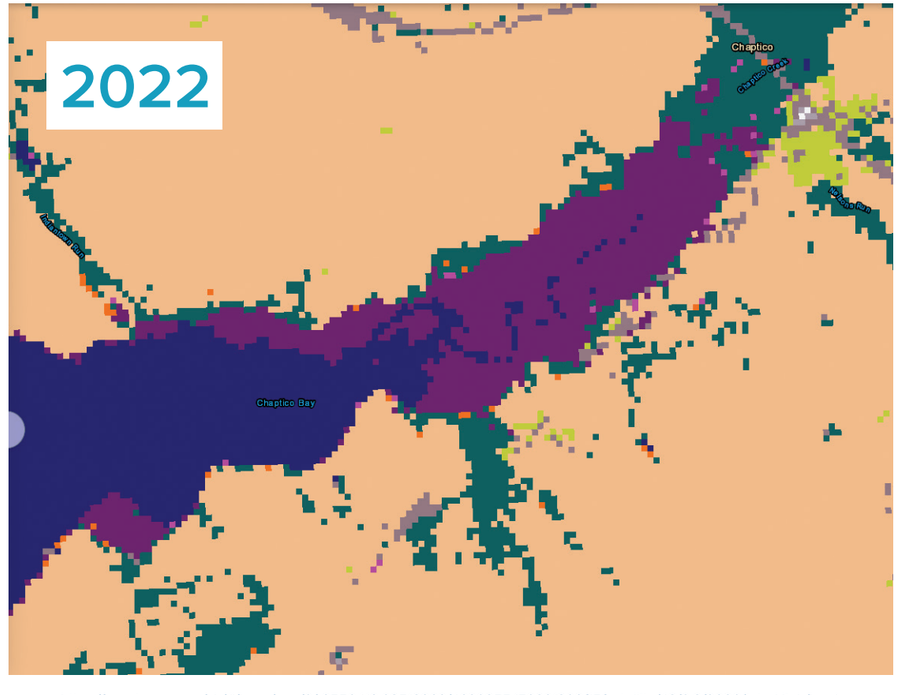
Embayed/Pocket Marsh

Chaptico Bay, MD



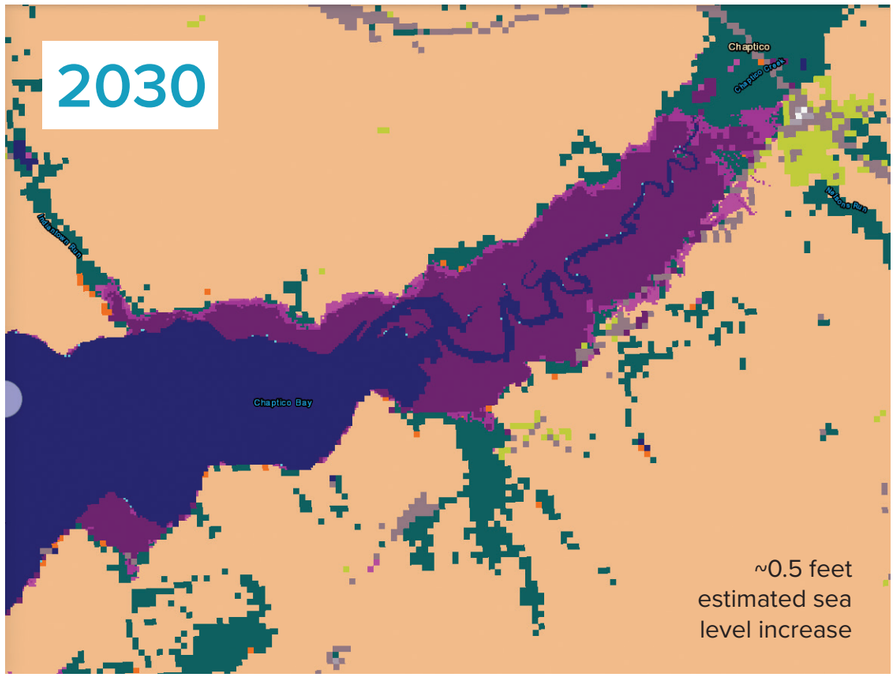
Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



https://coast.noaa.gov/slr/#/layer/mar/0/-8550419.03519369/4630255.176601302/15/satellite/48/0.8/2020/interHigh/lowAccretion

- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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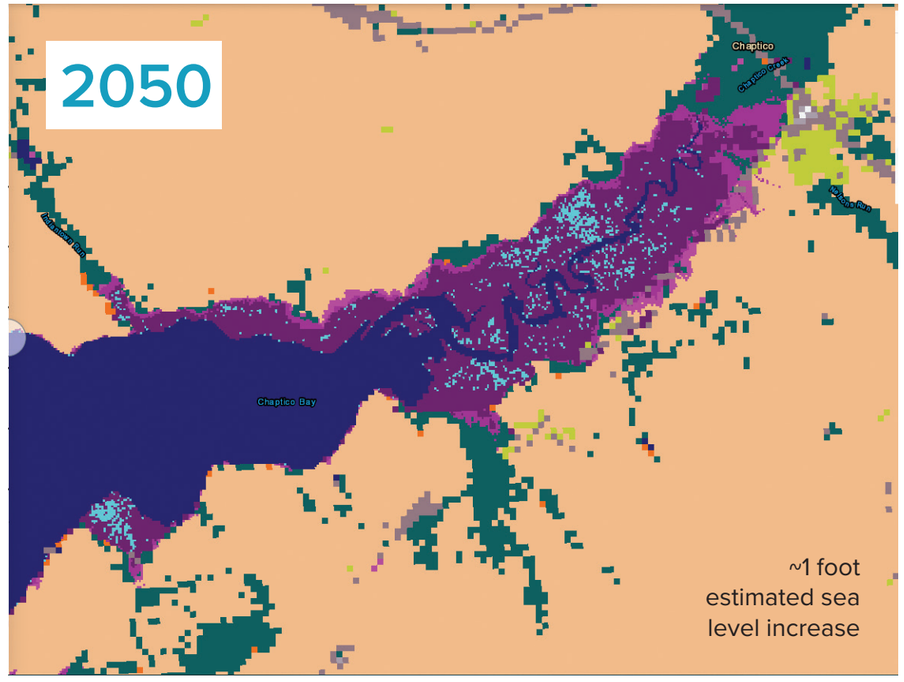
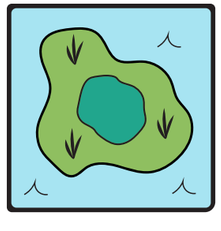


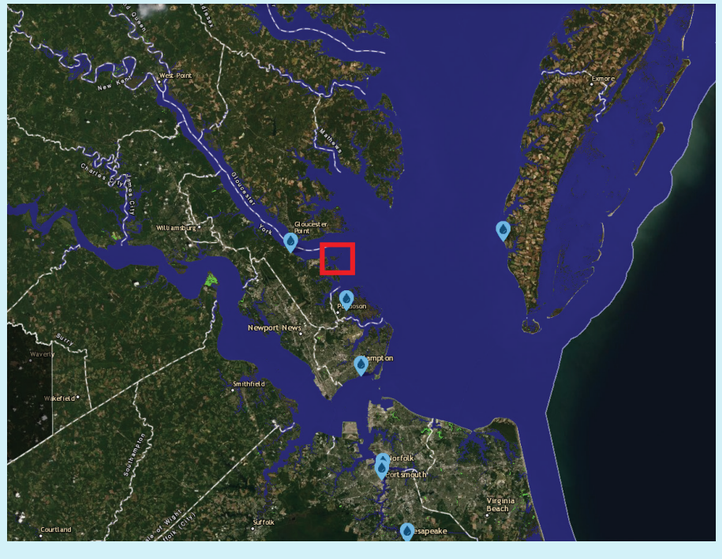
https://coast.noaa.gov/slr/#/layer/mar/1/-8550585.075047294/4630769.344878918/15/satellite/48/0.8/2050/interHigh/lowAccretion

Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



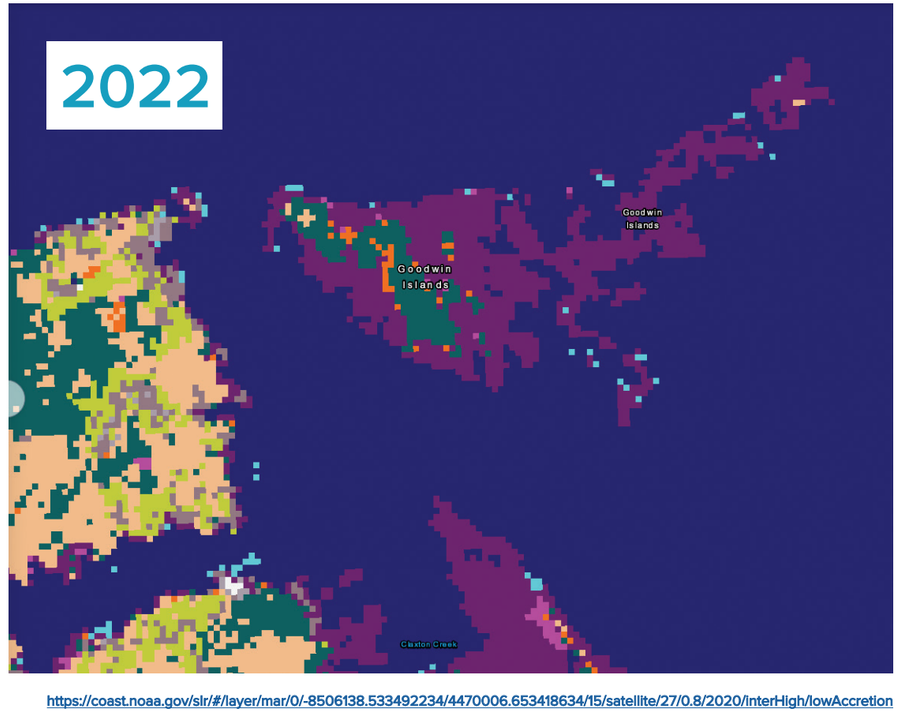
Island Marsh

Goodwin Island, VA



Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



https://coast.noaa.gov/slr/#/layer/mar/0/-8506138.533492234/4470006.653418634/15/satellite/27/0.8/2020/interHigh/lowAccretion

- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
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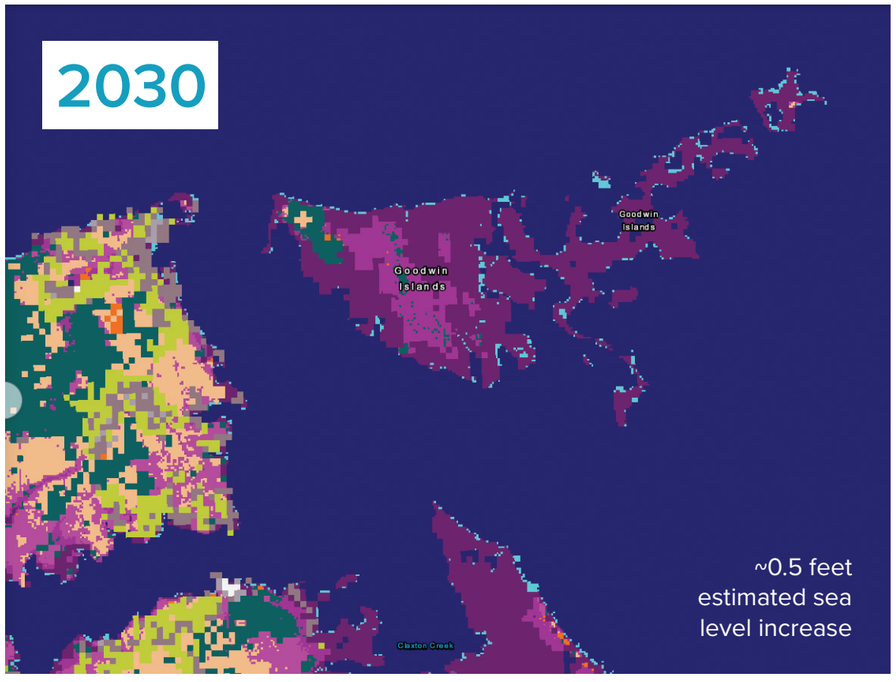
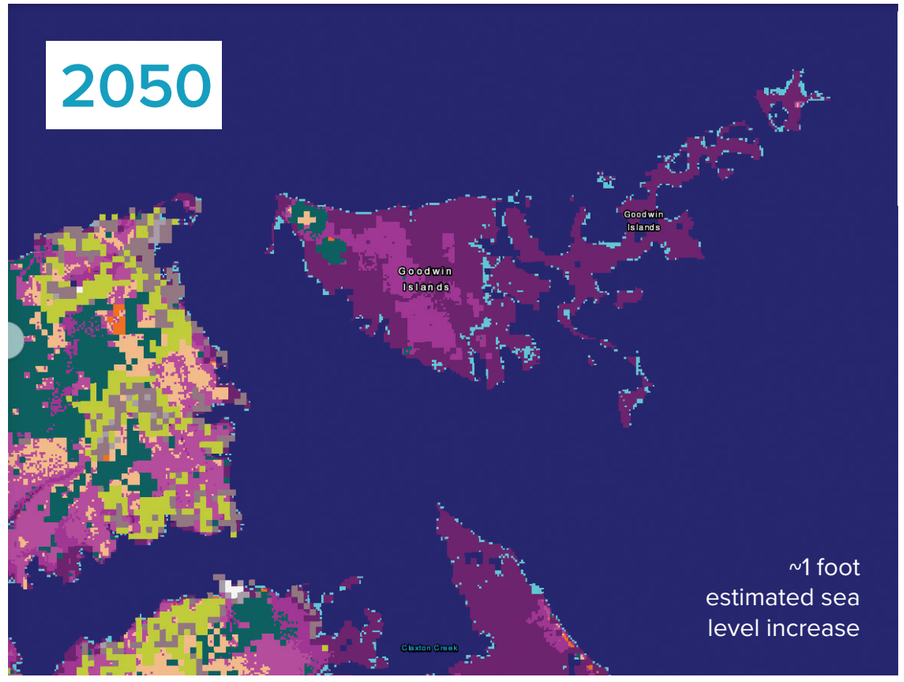
- Water

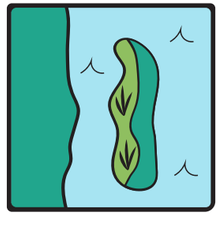


https://coast.noaa.gov/slr/#/layer/mar/0.5/-8506104.726752456/4469309.1212803675/15/satellite/27/0.8/2030/interHigh/lowAccretion



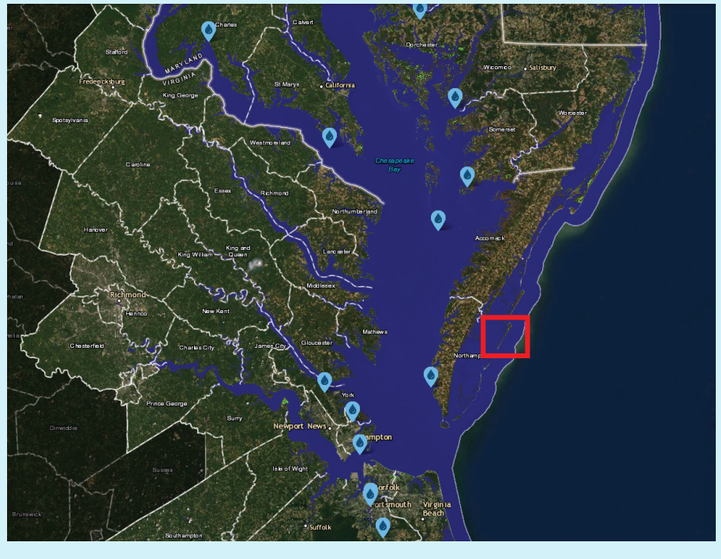
https://coast.noaa.gov/slr/#/layer/mar/1/-8506104.726752456/4469309.1212803675/15/satellite/27/0.8/2050/interHigh/lowAccretion

Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



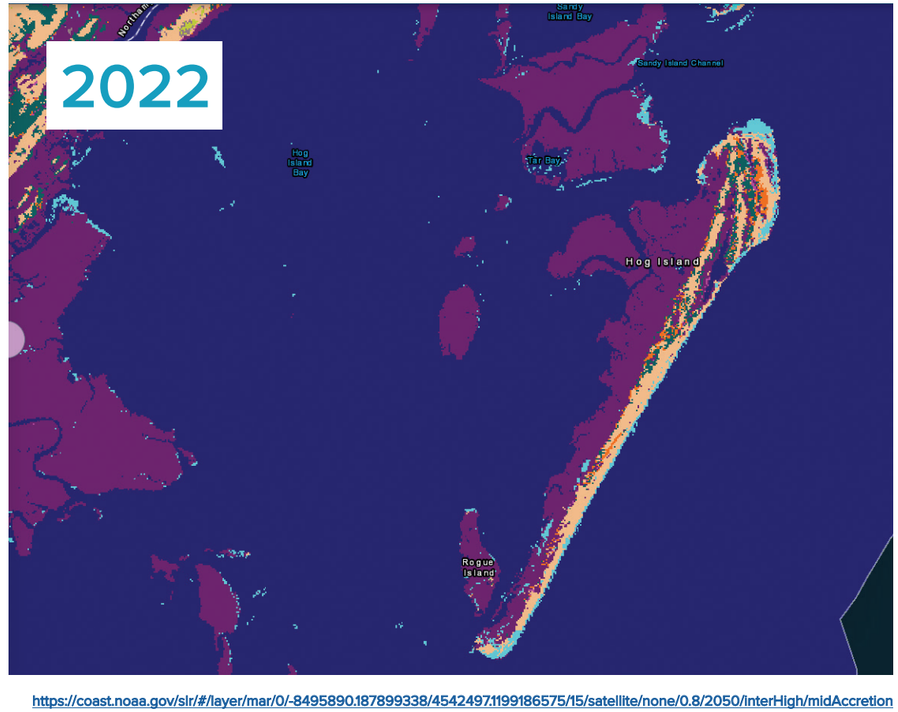
Back Barrier Marsh

Hog Island, VA



Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



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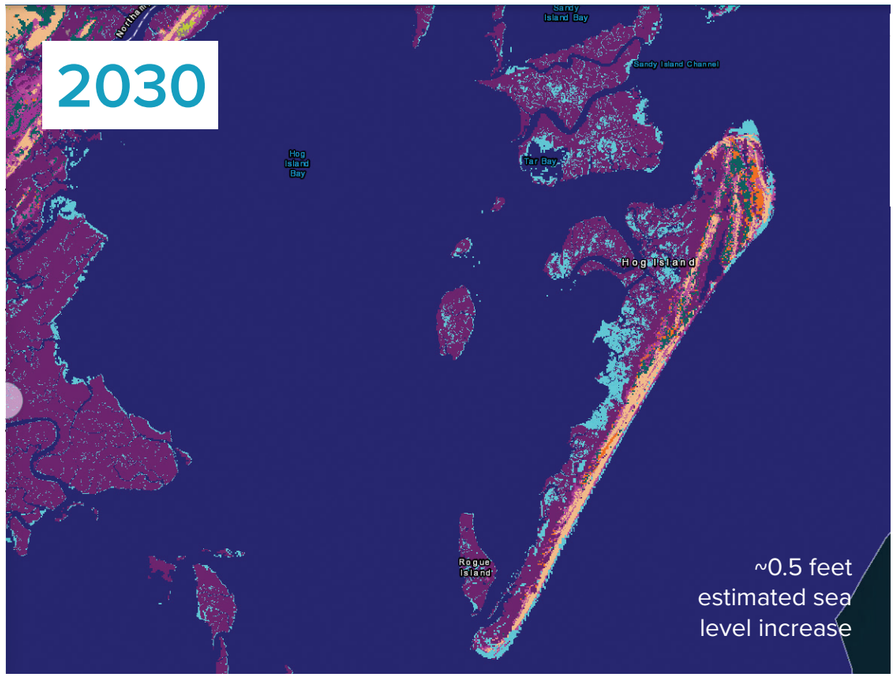
- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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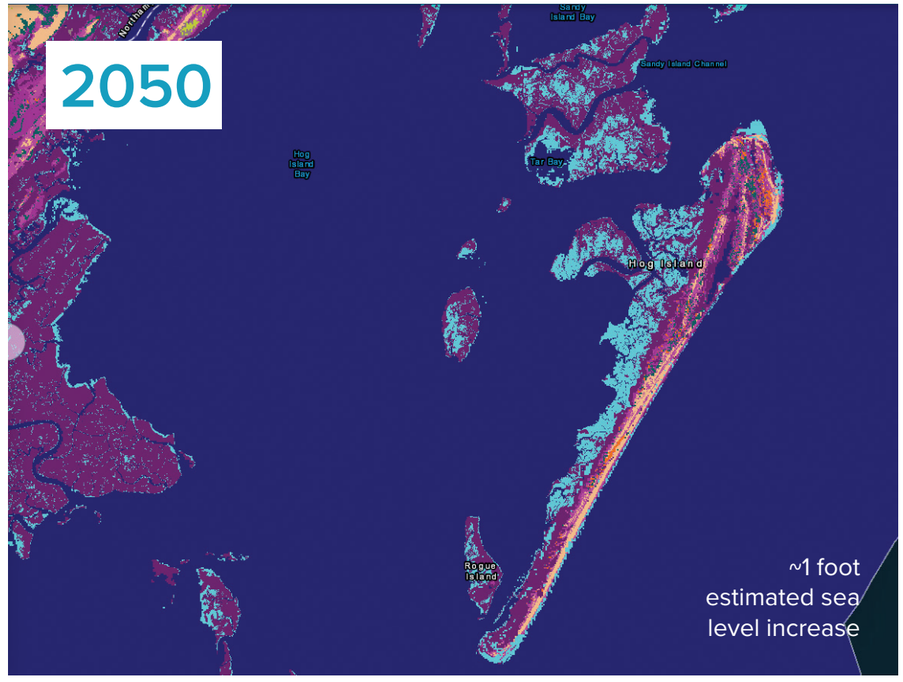

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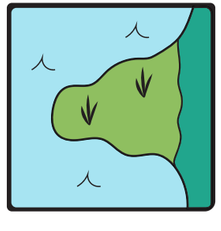
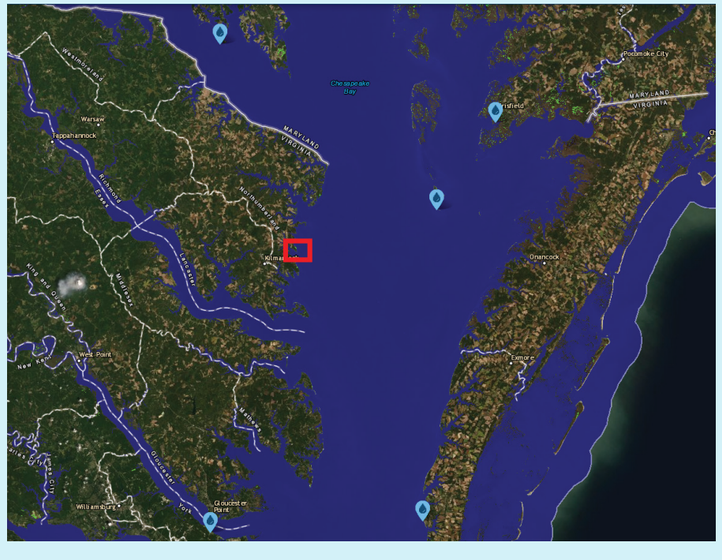
Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



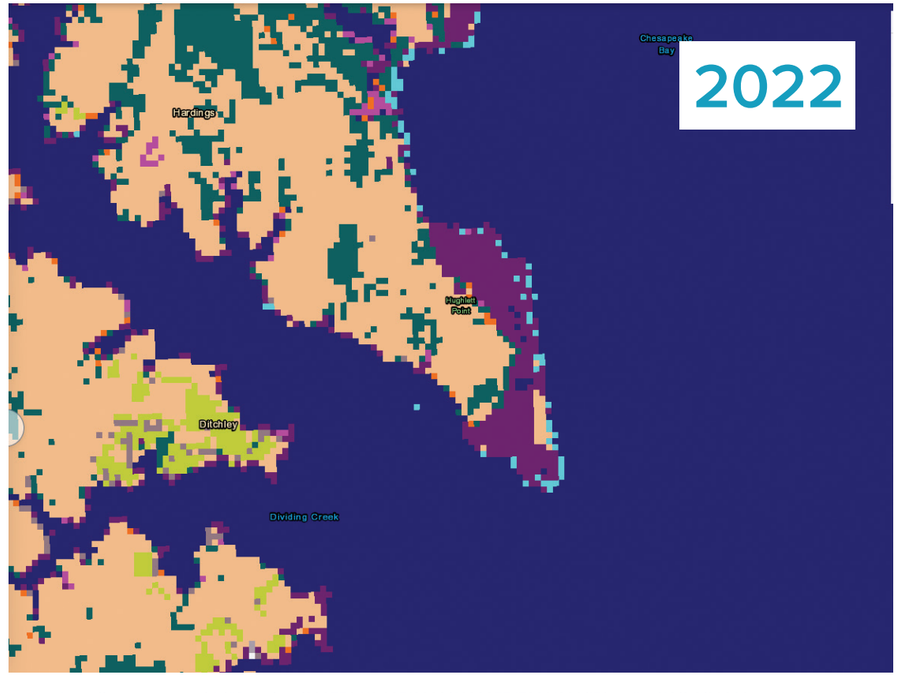
Headland/Point Marsh

Hughlett Point Natural Area Preserve, VA



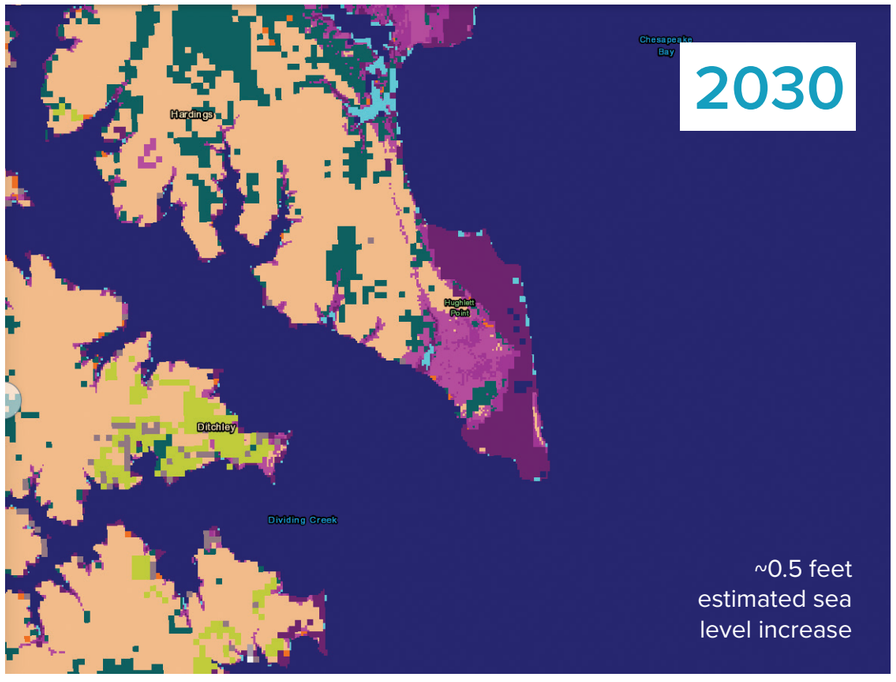
Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



https://coast.noaa.gov/slr/#/layer/mar/0/-8550419.03519369/4630255.176601302/15/satellite/48/0.8/2020/interHigh/lowAccretion

- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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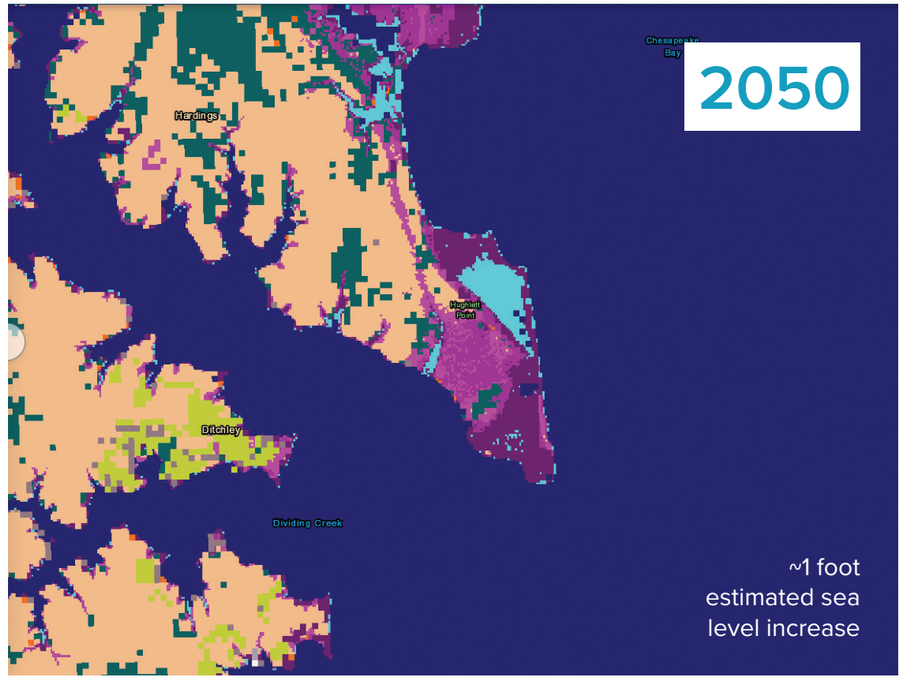

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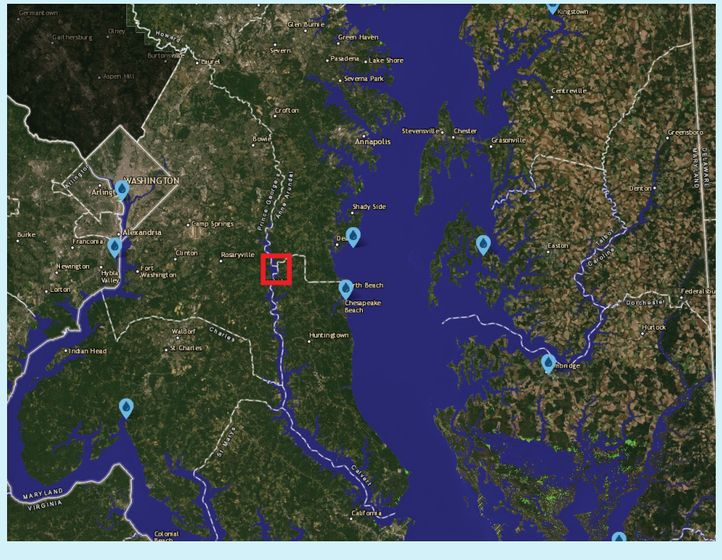
Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections

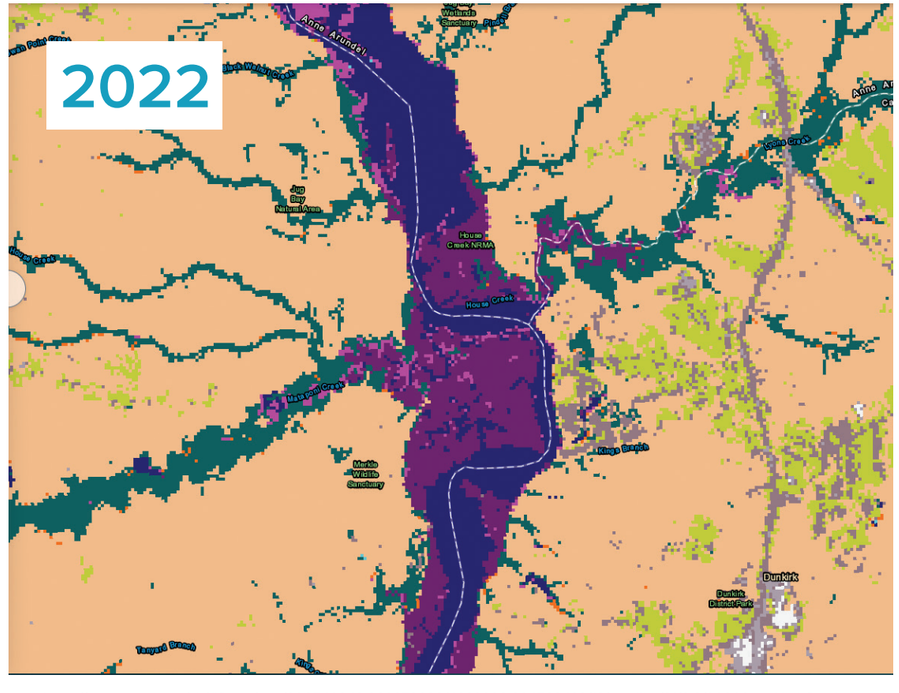
Tidal Fresh Marsh

Jug Bay, MD



Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



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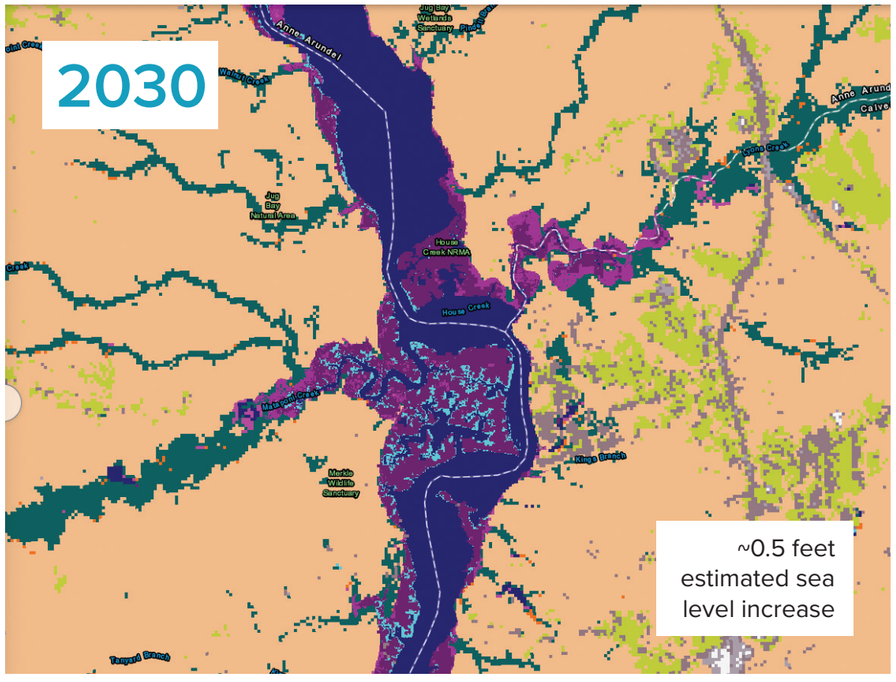
- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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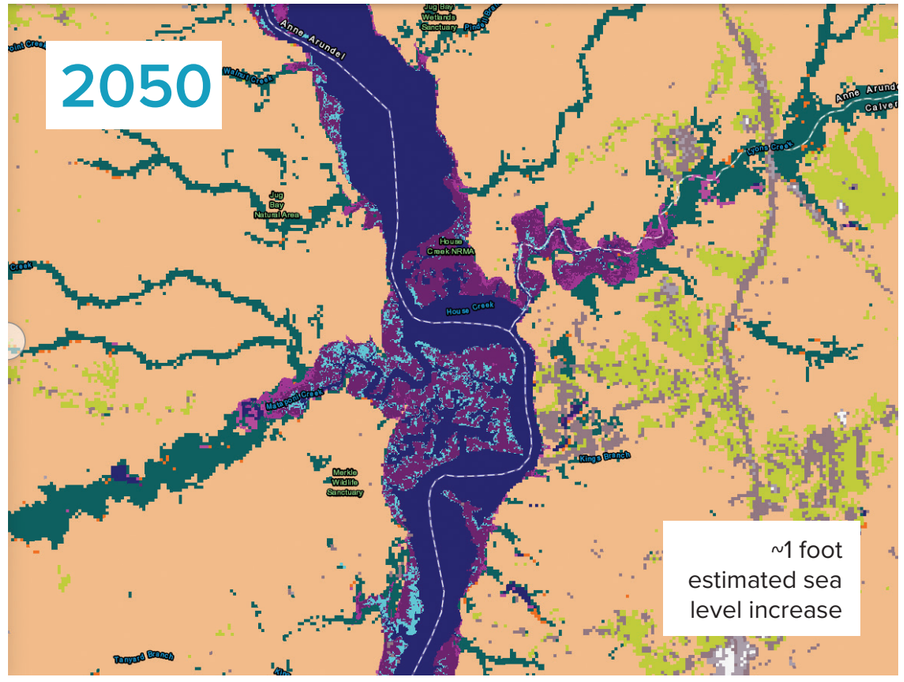

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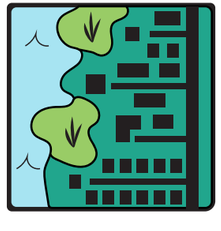
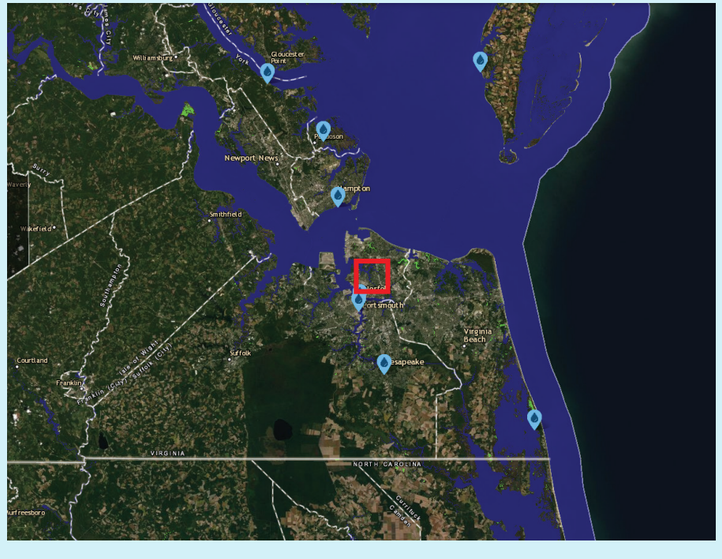
Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



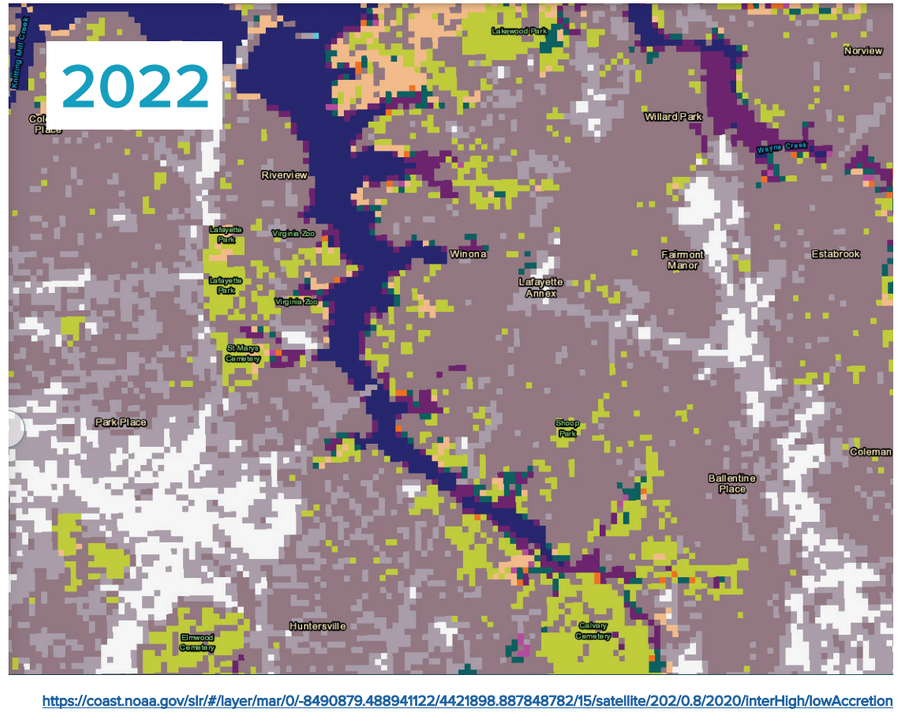
Urban Cluster Marsh

Lafayette River, Newport, VA



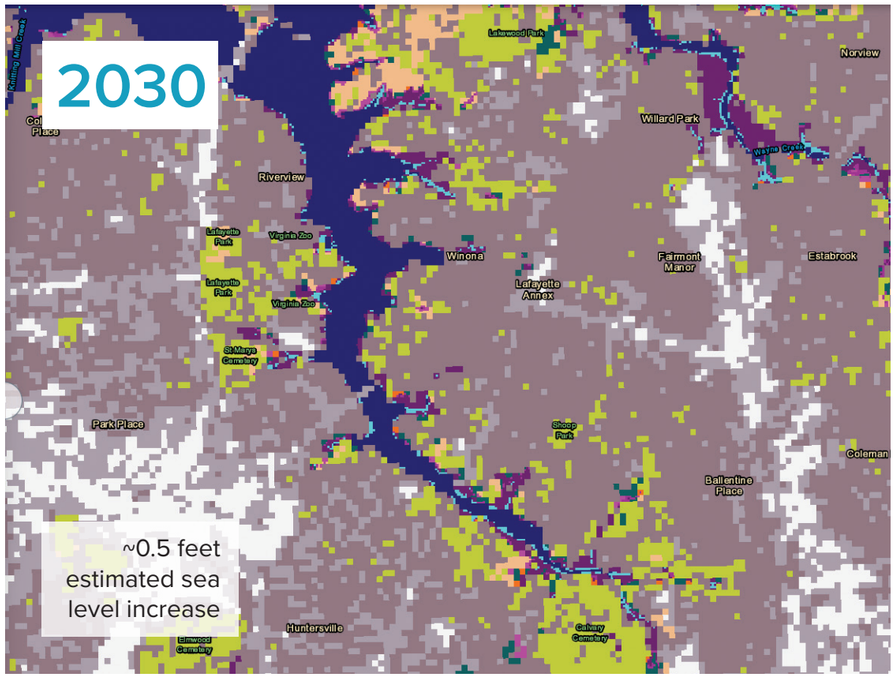
Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



https://coast.noaa.gov/slr/#/layer/mar/0/-8490879.488941122/4421898.887848782/15/satellite/202/0.8/2020/interHigh/lowAccretion

- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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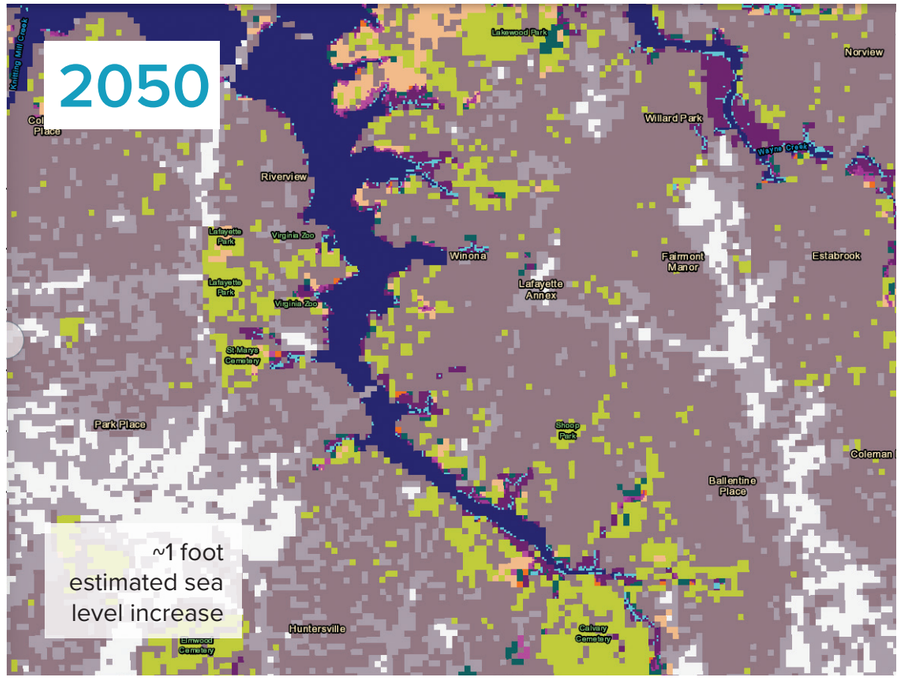
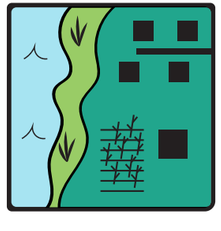


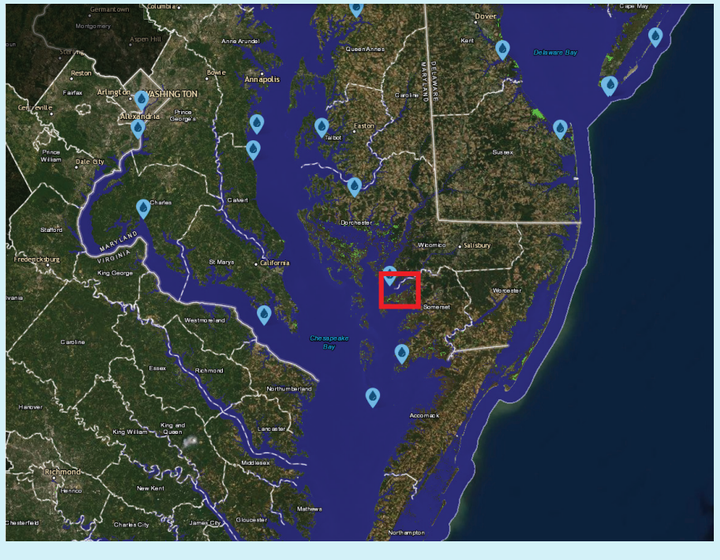
https://coast.noaa.gov/slr/#/layer/mar/1/-8490232.162857838/4421703.017963807/15/satellite/68/0.8/2050/interHigh/lowAccretion

Example marsh geomorphology with 2020, 2030, and 2050 sea level rise projections



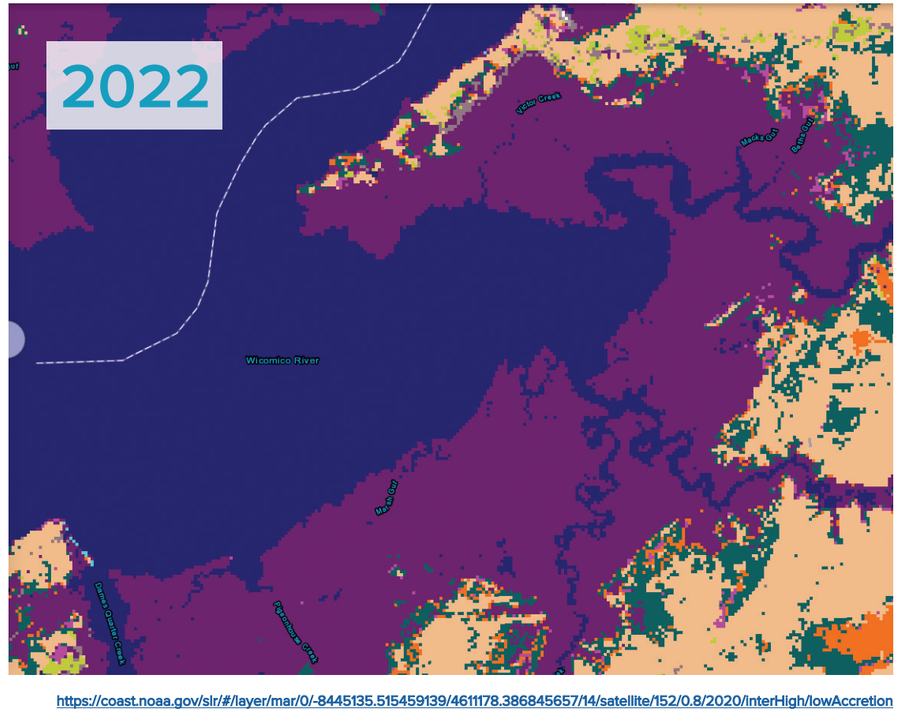
Mainland Fringe Marsh

Monie Bay, MD



Projections acquired from NOAA Sea Level Rise Viewer, Marsh Migration (https://coast.noaa.gov/slr/)

Parameters used: low accretion (2mm/yr), 2022 projections, intermediate scenario



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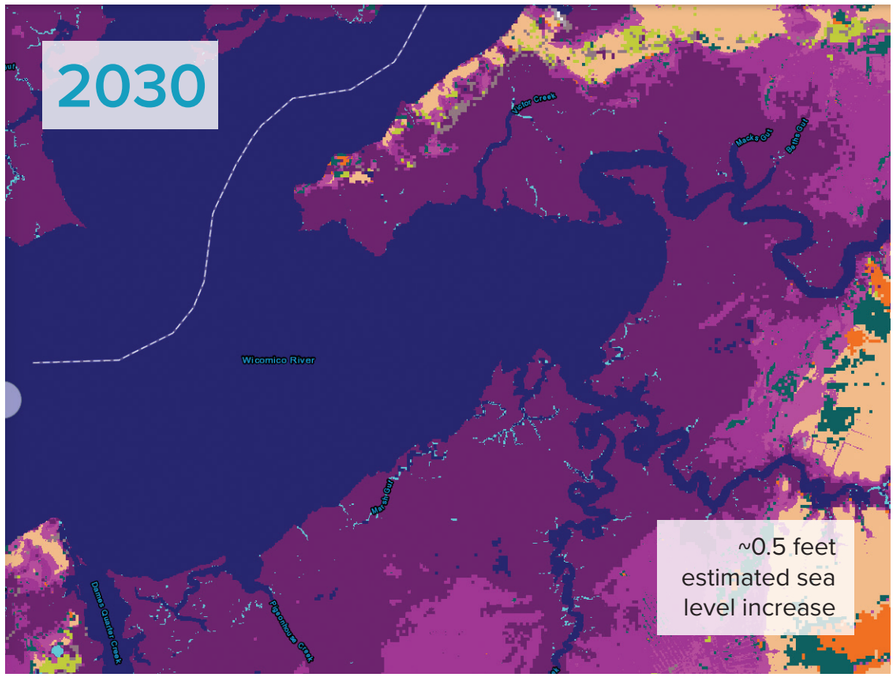
- High intensity developed
- Medium intensity developed
- Low intensity developed
- Developed open space
- Upland
- Freshwater forested wetland
- Freshwater shrub wetland
- Freshwater emergent wetland
- Brackish/transitional marsh
- Saltwater marsh
- Unconsolidated shore
- Water



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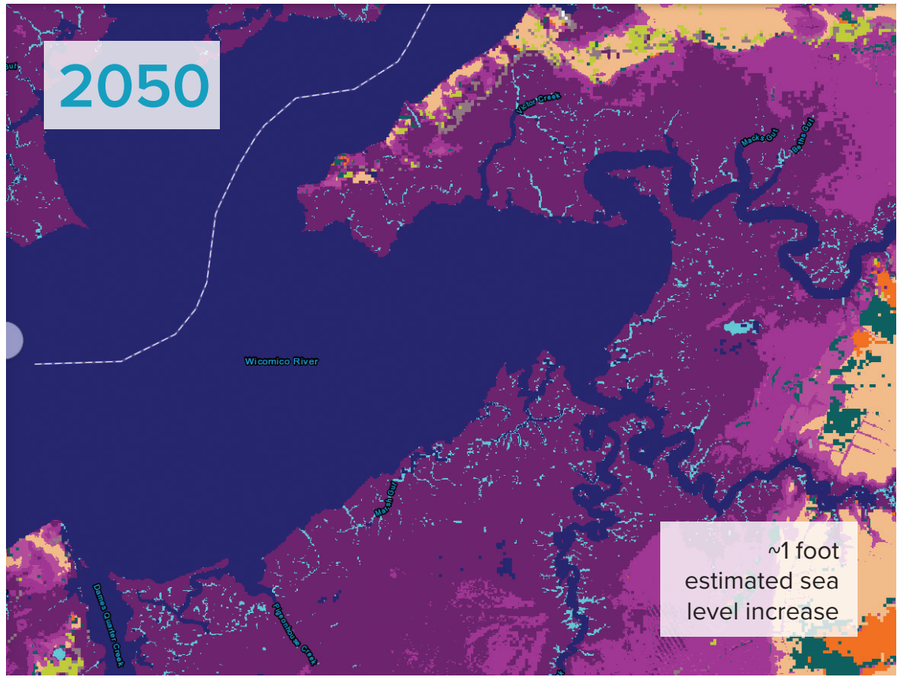

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