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# Conservation Targeting: Models and Policy for Climate Resilience of coastal habitat and heritage resources in Virginia's Coastal Zone

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# Conservation Targeting: Models and Policy for Climate Resilience of coastal habitat and heritage resources in Virginia's Coastal Zone

Final Report for NOAA Coastal Zone Management


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# Introduction

In response to accelerating sea level rise and its anticipated impacts on coastal habitats and species, we proposed to develop spatial models and maps of species distributions in Coastal Virginia. This project is a three-year effort to develop and serve geospatial data to inform land use decision making within the context of projected habitat and current elemental occurrences to promote habitat and species persistence and resilience. The Center for Coastal Resources Management (CCRM) at the Virginia Institute of Marine Science (VIMS), in partnership with the Virginia Department of Conservation and Recreation, Virginia Natural Heritage Program (DCR VNHP) and the former Virginia Coastal Policy Center (VCPC) has completed the third year of this effort, and as a total project effort, is provided in this report.

The report is organized around the tasks and products for each of the project team. The first section is reporting efforts by CCRM, followed by content describing the work done by DCR VNHP. Policy analysis by VCPC follows next with summary and conclusion by CCRM last. The complete report from DCR VNHP is included in Appendix 3.

# CCRM GIS Modeling

## Habitat Modeling

The habitat most likely to be negatively impacted by climate change in coastal Virginia over the next several decades is tidal marsh (Mitchell et al. 2017). Because tidal marsh extent is dictated by the intertidal range, which is rapidly changing as a result of climate change, tidal marshes must also rapidly adapt in order to persist on the landscape (Morris et al. 2002). There are two primary mechanisms for adaptation: accretion and migration. Accretion relies on the combined elevation gain from sediment and organic matter deposition on the surface of the marsh as well as subsurface biogenic contributions (Butzeck et al. 2015). Unfortunately, accretion is unlikely to be a viable option for most marshes throughout the Bay due to the combination of a microtidal environment and relatively low suspended sediment concentrations resulting in deposition rates far below what is necessary to keep apace of current rates of SLR (Kirwan et al. 2010). Without appreciable accretion, migration is the primary mechanism of persistence available to tidal marshes in the Chesapeake Bay (Feagin et al. 2010, Gardner and Johnston 2020). Migration occurs as the upland edge of the marsh moves further inland in response to rising sea level. As formerly upland areas become regularly inundated by spring tides, these areas convert to high marsh due to increasing salt content and saturation. If erosion was minimal and accretion was able to keep the low marsh high enough in the tidal envelop to prevent drowning, marshes would increase their overall areal extent through this process, as has happened repeatedly in geologic history whenever sea levels have risen. However, due to the inadequate sediment supply and rapid resulting erosion of low marsh edges, there is a net inland movement of marshes occurring throughout the Bay. In the short term, some areas are likely going to experience a net increase in areal extent due to the very low slope of immediately upland areas. Once the upper extent of the marsh reaches a steeper slope, however, the upland migration rate will slow dramatically, resulting in net loss as drowning and erosion continue at the front edge of the marsh. This process, termed coastal squeeze, will occur regardless of whether the upland slope is untenable due to natural (e.g., berms) or anthropogenic (e.g., coastal defense structures) features

## Data acquisition

Data were derived from the USGS CoNED Topobathymetric Elevation Model of Chesapeake Bay (https://www.usgs.gov/special-topics/coastal-national-elevation-database-%28coned%29-applications-project/science/hurricane; CBTBDEM) and the CCRM Tidal Marsh Inventory (TMI) database (https://www.vims.edu/ccrm/_forms/vasitmidownloadagreement/index.php). The TMI data were used to inform the current distribution of marshes throughout coastal Virginia, and the CBTBDEM was used to identify the areal extent of future potential marshes.

## Habitat mapping

The vertical extent of tidal marshes in the Chesapeake Bay can be approximated by using mean sea level (MSL) as the lower bound, and (1.5 * Intertidal range) + mean low water elevation as the upper bound. In Virginia, this elevation boundary is codified in the Tidal Wetlands Act in the definition of tidal wetlands as "lands lying between and contiguous to mean low water and an elevation above mean low water equal to the factor one and one-half times the mean tide range (§ 28.2-1300 Code of Virginia). Using the tidal datums from Sewell's Point in Norfolk, VA as the most representative for the majority of coastal Virginia, elevations were transformed to NAVD88 vertical datum, Table 1 details the relative sea level (RSL; mean sea level accounting for SLR), mean low water, and the upper bound for tidal marshes.

| Year | RSL | MLW | Upper |
|---|---|---|---|
| 2020 | 0.051 | -0.323 | 0.787 |
| 2030 | 0.151 | -0.223 | 0.887 |
| 2040 | 0.251 | -0.123 | 0.987 |
| 2050 | 0.361 | -0.013 | 1.097 |
| 2060 | 0.481 | 0.107 | 1.217 |
| 2070 | 0.621 | 0.247 | 1.357 |
| 2080 | 0.781 | 0.407 | 1.517 |
| 2090 | 0.981 | 0.607 | 1.717 |
| 2100 | 1.201 | 0.827 | 1.937 |

*Table 1. Elevations (m; NAVD88) of tidal marsh envelope from 2020 to 2100. RSL = relative sea level; MLW = mean low water; Upper = upper extent of tidal marsh.*

Using these elevations as the boundaries, we extracted the potential areal footprint of tidal wetlands (TW) for each decade from 2030 to 2100 (Figures 1 & 2) from the CBTBDEM in R version 4.1.2 (R Development Core Team 2022) using the "terra" and "foreach" packages (Hijmans 2022, Microsoft and Weston 2022). Upper and lower extents TW in each decade were identified using contours (Figure 3), also executed using the "terra" package in R. For a detailed script of the process, see Appendix 1. The mean low water locations are conservative estimates due to the absence of erosion and drowning as dynamic processes through time.

### Results

Total potential marsh habitat decreased by ~52% from 973 km$^2$ (~ 240,434 acres) in 2030 to 467 km$^2$ ( 115,398 acres) in 2100. Losses were most extreme along the Eastern Shore, where much of the marsh is contained in extensive, low-lying regions along the seaside and bayside (Figures 1 & 2). Much of the remaining area that will be within the correct tidal envelop will likely overlap with residential and agricultural lands throughout coastal Virginia. Even where total areal extent is maintained or at least not entirely lost, the quality of the remaining habitat may be dramatically diminished relative to well-established regions of existing marsh. Anecdotal evidence (Bryan Watts, pers. comm.) suggests that transitional and newly migrated areas of high marsh do not provide the same habitat value for marsh obligate birds as well-established marshes.

## Year 3 – Landcover Conflicts

The primary objective of the project was to assess and refine predictions related to sea level rise (SLR) and its impact on tidal wetlands across various regions in Virginia. This work included refining predictive models, identifying conflict zones between existing land cover and migrating tidal wetlands, and integrating the results into a publicly accessible web tool.

### Key Activities and Achievements

1. **Refinement of Sea Level Rise Predictions**
    - We refined the SLR predictions by smoothing the digital elevation model (DEM) to improve visual appearance and incorporate appropriate levels of uncertainty into the spatial projections. These projections, based on the NOAA Intermediate SLR curve, were conducted at decadal intervals from 2020 to 2100.
    - The improved DEM ensures more accurate and visually coherent representation of the predicted SLR impacts, aiding stakeholders in better understanding potential future scenarios.
2. **Conflict Identification between Land Cover and Migrating Tidal Wetlands**
    - Our team identified specific times and locations where existing land cover would conflict with migrating tidal wetlands. This analysis was conducted for each Virginia locality and Planning District Commission (PDC).
    - Overall, there was a substantial amount of overlap with currently impervious surface over time. In 2020, there were approximately 1,800 acres of impervious surface that overlapped with potential wetland habitat. By 2100, that value increased to > 9,700 acres. Concurrently, coastal forests will need to convert nearly 40,000 acres to wetlands by 2100 to accommodate migrating tidal wetlands. Conflicts with residential and public areas (land cover classes "Tree" and "Turf/Grass") will increase from approximately 6,800 acres currently to 35,000 acres by 2100.
    - If all land cover types were able to convert to wetland, there would still be a net loss of > 90,000 acres of tidal wetlands by 2100. More realistically, excluding impervious surfaces and optimistically assuming that migration won't be

otherwise prevented onto private property, the loss is likely to be nearly 100,000 acres of tidal wetlands by 2100.
   - By pinpointing these conflict zones, we provide critical information for land-use planning and conservation efforts, enabling proactive measures to mitigate adverse effects on both developed and natural areas.
3. **Summary of Results into Maps and Tables**
   - The results of our analyses were summarized into comprehensive maps and tables. These visual aids encapsulate the extent of potential tidal wetland changes and conflicts at the state, PDC, and locality levels.
   - The summary tables detail the projected changes in tidal wetland areas across Virginia from 2020 to 2100, providing a clear and concise reference for stakeholders.
4. **Integration into AdaptVA Web Tool**
   - We incorporated the resulting spatial layers into the AdaptVA web tool enhancing its utility for users seeking information on SLR impacts and adaptive strategies.
   - This integration allows for interactive exploration of the data, facilitating better decision-making and public awareness regarding the implications of SLR.

## Detailed Findings

The detailed findings of our analyses are encapsulated in the summary tables, which are summarized below and included in full in the Management Implications Section, which outline the projected changes in tidal wetland extents across Virginia at different geographic scales.

**Table 2: Virginia Potential Tidal Wetland Total by Decade 2020-2100**

- The total acreage of potential tidal wetlands in Virginia is projected to decrease significantly over the next century, with a total loss of 160,604 acres by 2100.

**Table 3: Potential Tidal Wetland Area per Planning District Commission by Decade 2020-2100**

- This table breaks down the projected changes in tidal wetland areas for each PDC, revealing varying degrees of impact across regions. For example, the Hampton Roads PDC is expected to lose 44% of its existing tidal wetlands by 2100, while the PlanRVA PDC faces a more severe loss of 73.46%.

**Table 5: Potential Tidal Wetland Area per Locality by Decade 2020-2100 (Appendix 1)**

- At the locality level, detailed projections show significant variability. For instance, Accomack County is projected to experience an increase in tidal wetlands initially but then face a steep decline towards the end of the century, resulting in a 54.36% loss by 2100.

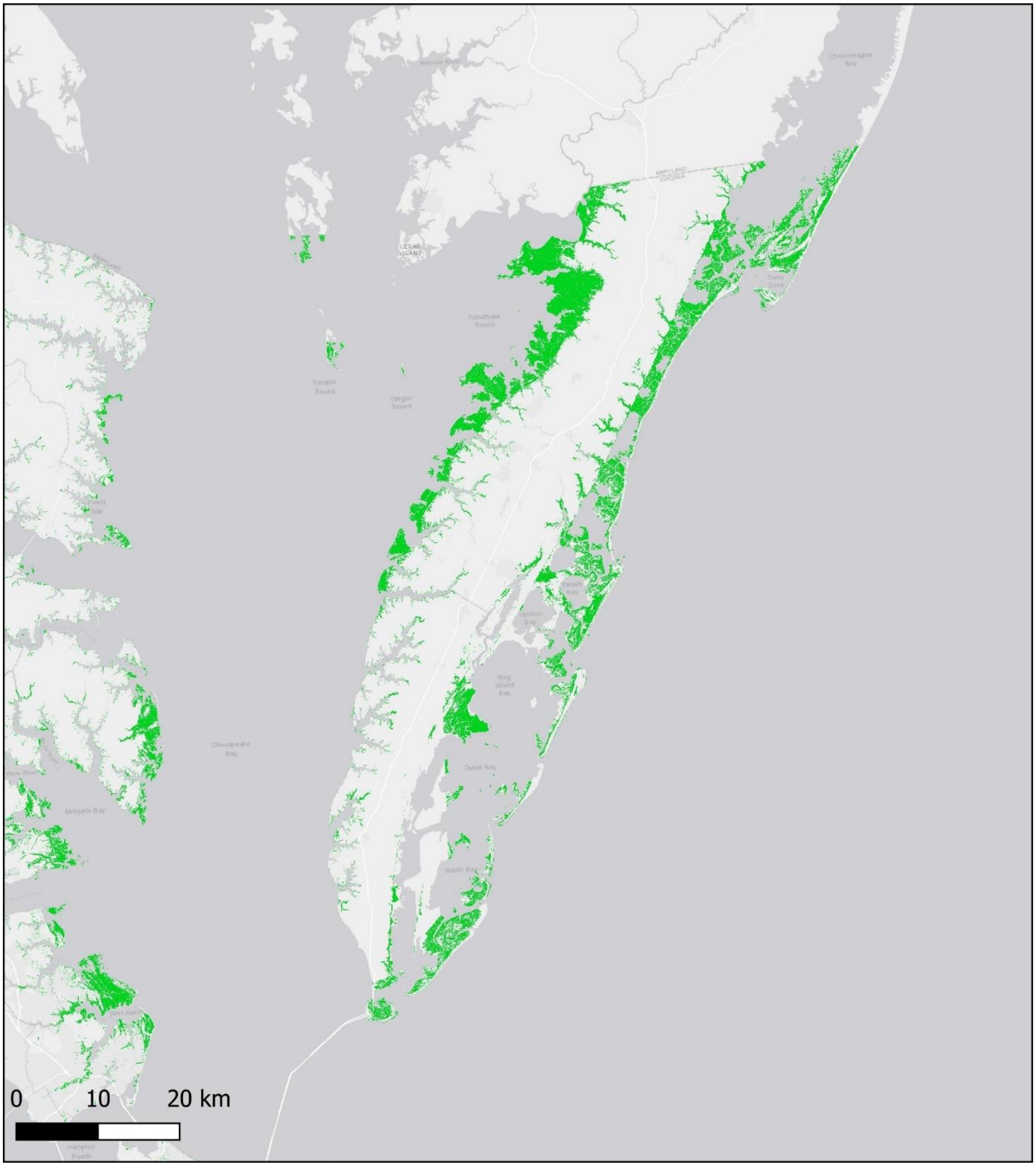


*Figure 1. Potential tidal marsh in 2030. This image shows the potential tidal marsh in 2030 shaded in green for the Eastern Shore of Virginia and select portions of the Western Shore.*

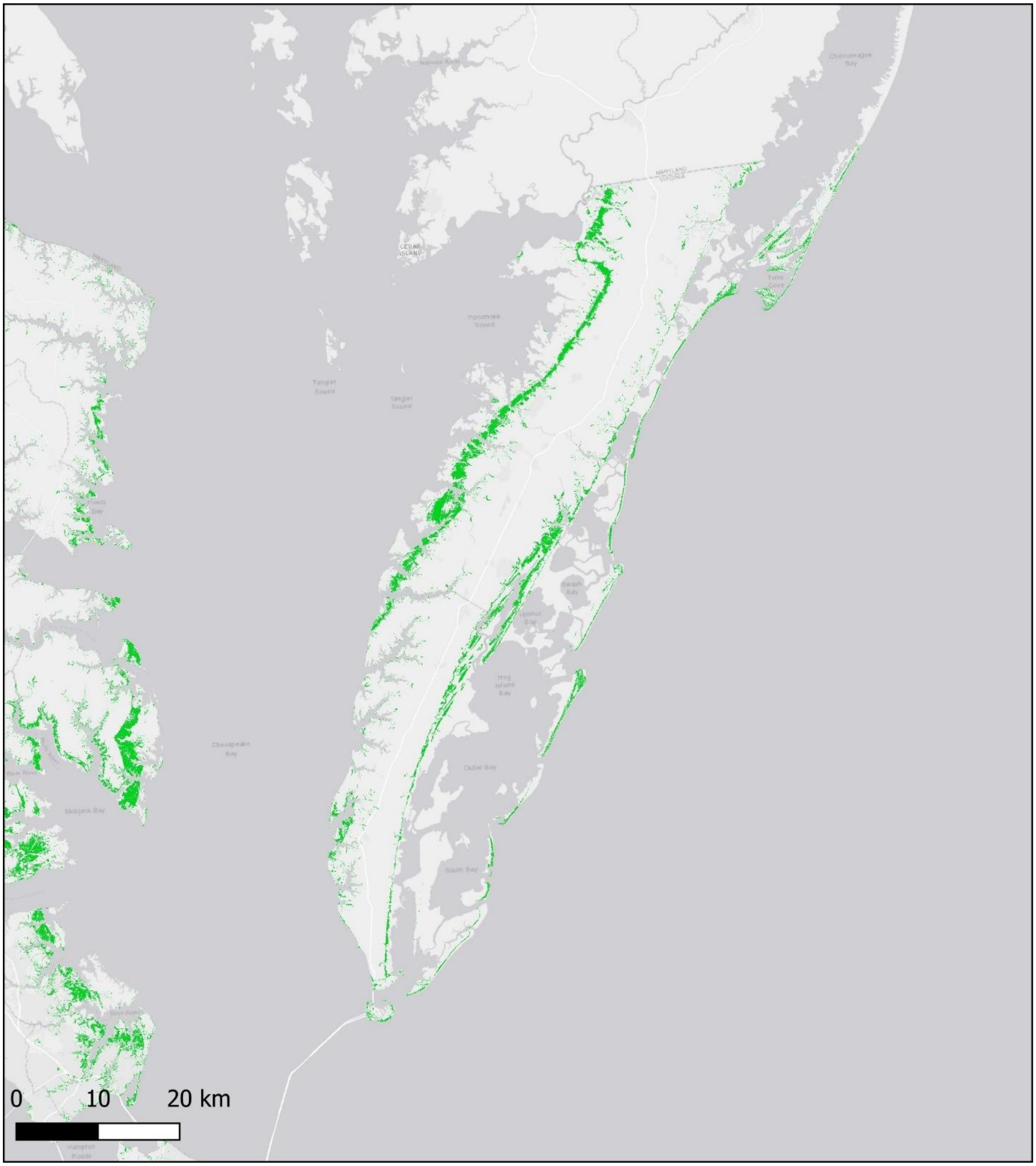


*Figure 2. Potential tidal marsh in 2100. This image shows the potential tidal marsh in 2030 shaded in green for the Eastern Shore of Virginia and select portions of the Western Shore. Potential marsh distribution is dramatically shifted from present, and substantially overlaps with residential areas throughout the region.*

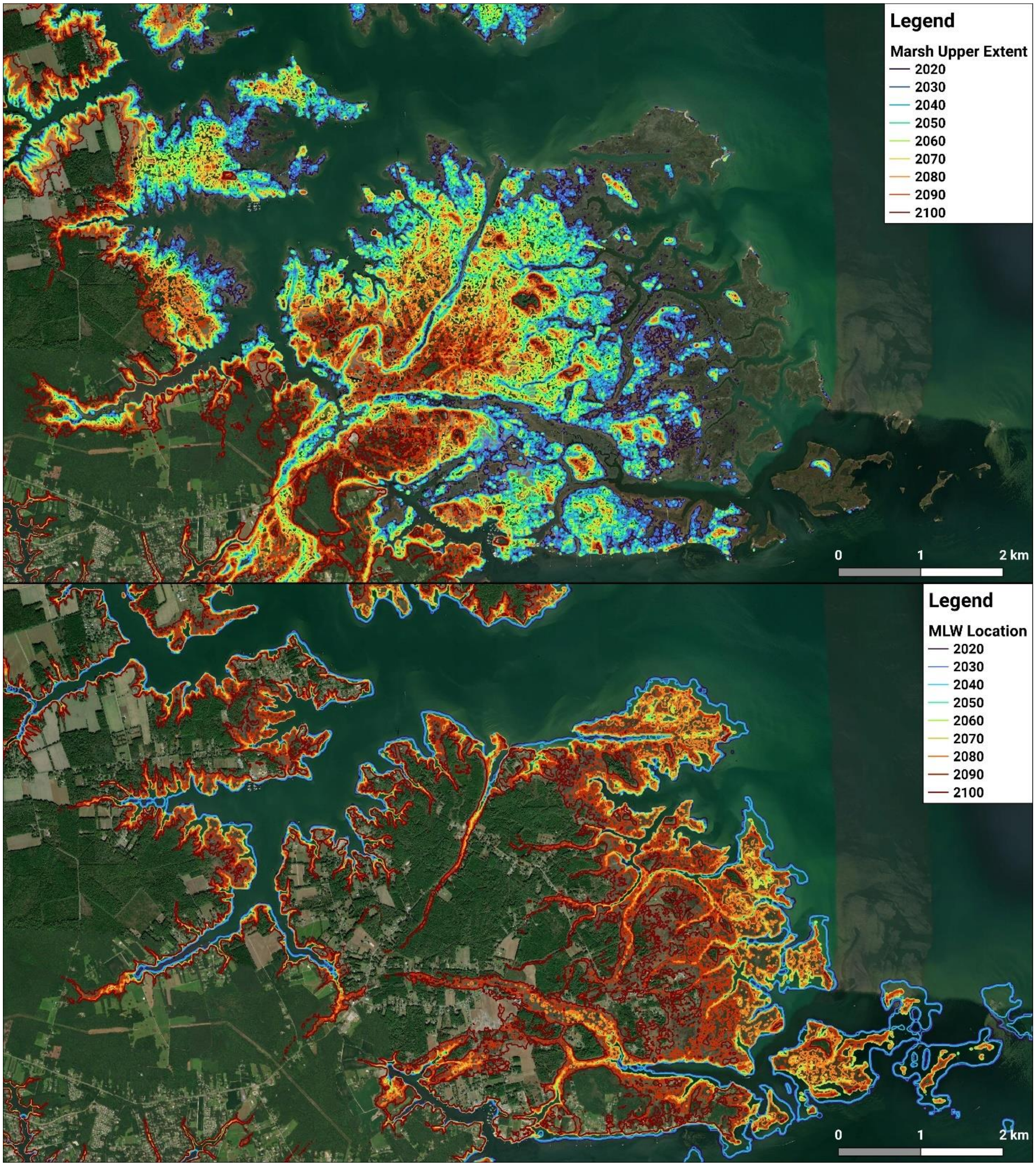


*Figure 3. Upper tidal wetland extent and mean low water (MLW) locations for 2020 through 2100. The upper extents show that much of the nearby upland forested areas around the Guinea Marshes will be steadily converted to marsh over time. MLW locations are conservative estimates that do not account for erosion or drowning.*

## Data Service

The data outputs from the model analyses are served in Adaptva in the Interactive Map https://www.adaptva.org/info/tools.html. The data is under the Natural Resources heading in the table of contents and labeled Potential Tidal Wetlands. Figures 4 and 5 provide a visualization of data location in the viewer and data display by decade time step.


Location of Tidal Wetland Area in the AdaptVa viewer. Data is in the Natural Resources Heading. Labeled Potential Tidal Wetlands. This image shows Wetland Potential 2060, Existing Tidal Marsh Inventory and 2060 sea level projection.

*Figure 4. Location of Potential Tidal Wetland Area as displayed within the Adaptva Interactive Viewer. Data is under the Natural Resources Heading. The image shows current tidal wetland inventory and sea level for 2060.*

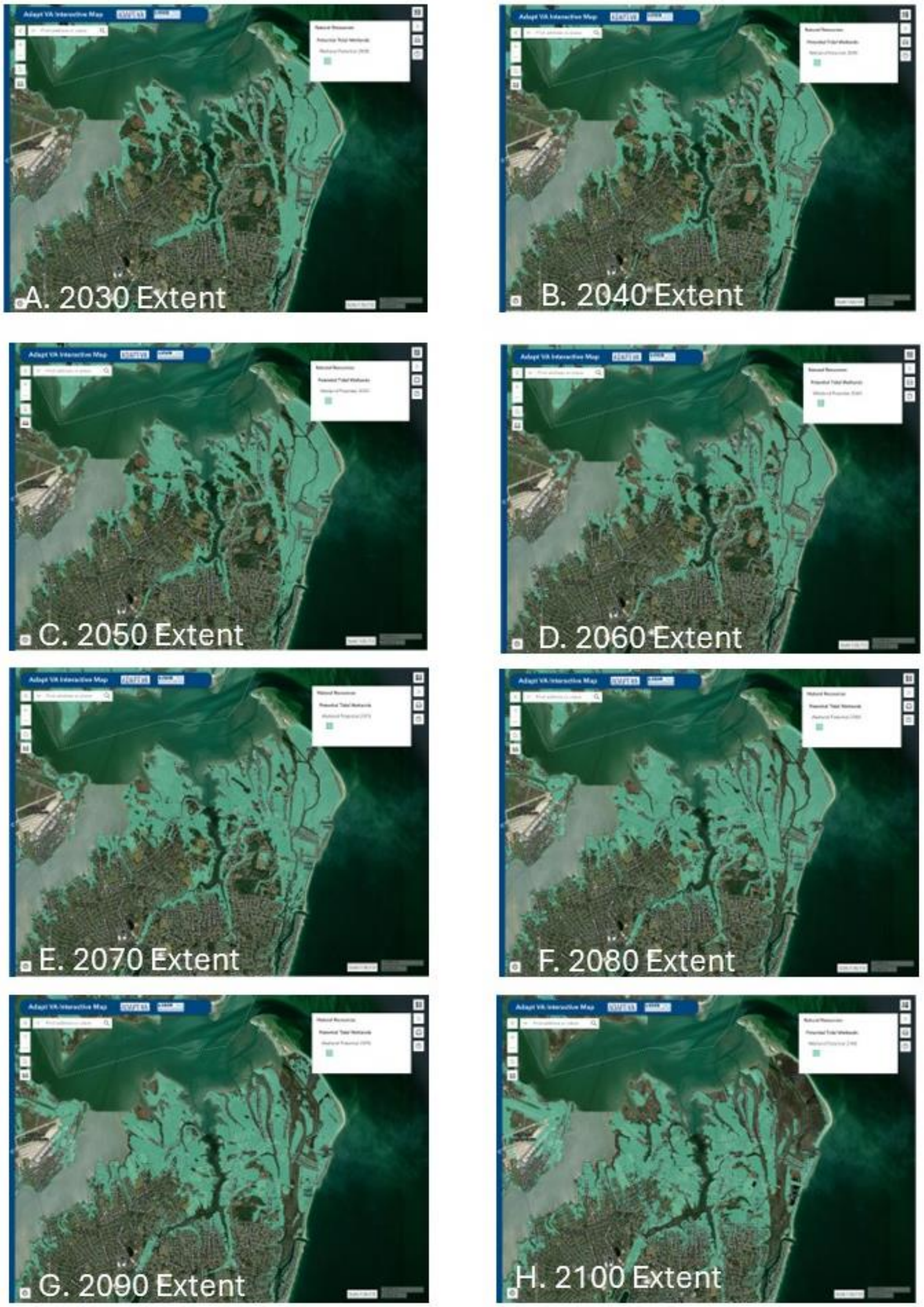


*Figure 5. Extent and location of potential tidal wetlands by decade 2030-2100. Each extent is shown as a separate image to allow visual comparison. Shows a portion of Hampton Va.*

# Virginia Natural Heritage Program Elemental Occurrences and Priority Parcels

## Biological Survey Updates

In the Coastal Zone of Virginia, biodiversity is experiencing multiple stressors related to climate change and development. The Virginia Coastal Zone (VCZ) is home to about one-quarter of Virginia's rarest biodiversity and is under multiple threats, including sea-level rise and urbanization. The region also includes several "endemic" biodiversity elements, not found outside this region in VA. Examples of these endemics include natural communities such as Maritime Live Oak Forest and Sea-level Fen as well species such as Kentucky Lady's-slipper (*Cypripedium kentuckiense*), Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*), Glossy Swamp Snake (*Liodytes rigida*), Oak Toad (*Anaxyrus quercicus*), and Sea-Beach Knotweed (*Polygonum glaucum*).

Given the rates of change from threats and pressures, any conservation planning must include up-to-date data on the location and condition of Natural Heritage Resources (NHR). The data workflows developed for and used in this report, based on best available biodiversity data, show that there are lands within the coastal zone that are both resilient to climate change and contain NHR to be protected. Prioritizing the purchasing of these tracks or improving the protections on already owned lands would be prudent steps for VCZ partners to consider. To be successful, more funding for inventory, Biotics management, model development, and protection projects is needed.

As the Virginia Natural Heritage Program (VNHP) is tasked with the identification, protection, and stewardship of Virginia's biodiversity, it is important that VNHP maintain up-to-date biodiversity information for sites resilient to climate change, especially those threatened by development. Central to the mission of the VNHP is the maintenance of a statewide database (Biotics) of locations of rare plants and animals, and exemplary natural communities (NHR). Each location of an NHR is mapped as an Element Occurrence (EO), which includes the area of land and/or water where the element of biodiversity was observed. These locations have practical value for conservation partners seeking to protect biodiversity, as many of them are unlikely to be incidentally protected due to their geographic rarity. Keeping Biotics information current is essential, as EOs form the building blocks for many of the conservation tools developed by VNHP that have been widely incorporated into local, regional, and statewide planning tools, including the Coastal VEVA (Coastal Virginia Ecological Value Assessment), Coastal GEMS (Geospatial & Educational Mapping System), Virginia NHDE (Natural Heritage Data Explorer), ConserveVirgina, ConservationVision, and the Virginia Wildlife Corridor Action Plan.

Phase 1 of a multi-year project began in 2021 with VNHP completing spatial analyses to identify significant biodiversity occurrences on climate change resilient sites. The most important of these occurrences were identified, and many had not been observed in over 25 years. Using information from spatial analyses and imagery review, a prioritization was completed to highlight occurrences on resilient sites which are most in need of biological inventory review.

In 2022, using the prioritization from Phase I, VNHP botanists, vegetation ecologists, and zoologists began conducting field surveys to update biodiversity information for prioritized sites. Over the course of 42 days, the field biologists surveyed for and/or discovered 166 element occurrences (EO) of plants, natural communities, and animals. Eighty-seven EOs were relocated and 15 new EOs were found. Of the surveyed EOs, 61 had been identified as High or Very High inventory priorities and 23 were relocated. Compared to the EO data from the start of this project in November 2021, information for 58 new EO (from 40 unique NHR) were entered into the Biotics database. A further 164 EO (from 108 unique NHR) were updated to include new source features ($n$ = 135) and/or more recent observation dates ($n$ = 160; *mean change* = 9.6 years, *maximum change* = 36.4 years). A summary of EO updates by element group is provided in Table 4. The number of Terrestrial Conservation Sites in the VCZ increased over the course of the project, from 531 to 545. A total of 35 sites were newly created, while 21 sites no longer contained site-worthy Procedural Features and were excluded from further use.

In Year 3, the updated and new EO information from the Year 2 field surveys was entered into Biotics, resulting in a more accurate and credible EO database for the VCZ. The updated Biotics data were then used to develop custom Essential Conservation Sites (ECS) of which results were scored relative to the VCZ instead of the entire state. A total of 1,589 site-worthy EOs and 545 Conservation Sites were utilized for the custom ECS analysis. From these, 734 EOs (from 374 unique elements) and 285 Conservation Sites were identified as essential relative to other coastal zone conservation sites.

The ECS and Essential EO (EEO) results were analyzed and compared with parcel data and conserved lands and reviewed by the Site Conservation Assessment Team (SCAT), to develop a strategy to target conservation of the highest priority EOs on resilient sites in the VCZ. SCAT is a multidisciplinary team from the VNHP, including staff from the Protection, Inventory, Information Management, and Stewardship units, that collaboratively makes determinations about land conservation efforts to protect NHR. A spatial dataset comprising all the resilient ECS was developed, within which the individual tax parcels supporting EEOs were identified. These parcels contain all or portions of EEOs that are within resilient ECS. Furthermore, parcels thought to contribute to the long-term viability of the NHR, though not encompassing essential EOs, were also identified. The SCAT review further ranked parcels using factors relevant to land acquisition (such as feasibility of successful stewardship, extent of needed restoration, landscape context, etc.) as well as other characteristics such as expert opinion and institutional knowledge of those parcels. Of the 38,211 parcels identified, 80 received Protection Priority Summary scores of >0.75, and thus were categorized as Very High Priority parcels.

The plan identifies parcels harboring EOs in need of urgent conservation action in the VCZ. The plan will be used internally by VNHP to target additions to existing State Natural Area Preserves or protection/dedication of new State Natural Area Preserves. Additionally, VNHP will share these data, under license agreements, with partners in other conservation agencies and land trusts to inform partners of the most critical parcels for conservation action within the VCZ. The full detailed report from VNHP is in Appendix 3.

## Conservation Policy

The proposed effort for year 3 of the 3-year study was a focus on the analysis of potential conflicts, opportunities and policy approaches to manage coastal habitat shifts associated with climate change, and sea level rise specifically. The plan was for the Virginia Coastal Policy Center to use the modeled output from CCRM/ VIMS and DCR Natural Heritage to engage the project team and steering committee in production and co-production of possible policy changes and perhaps even new enforceable CZM policies. However, the plan was confounded by the elimination of the VCPC at William & Mary. VCPC did participate in the first years of the effort and absent the final modeled data to work with, produced a policy analysis around the concept of shifting habitats, associated species shifts and some of the policy that might to relevant.

## VCPC Policy Memorandum

### Introduction

As climate change impacts animal and plant populations throughout Virginia, conservation strategies may need to shift, adopting a responsive approach to accommodate expanded or adjusted ranges for species reacting to new environments. This memorandum reviews current conservation strategies and their policy implications, with particular consideration given to a new approach by the United States Fish and Wildlife Service to update regulatory language for species introduction[1]. The analysis and recommendations reflect this review as well as information gathered by project partners for specific habitats and key species in Virginia. In summary, the project team recommends redirecting current conflict-based approaches in situations where the desired outcome may be preservation of multiple vulnerable species, including both native and climate-displaced species.

The project proposed to enhance current conservation targeting by developing future projections of likely migratory patterns and abilities of natural habitat and species guilds to shift under climate change and sea level rise. The period of future projections was determined by the project team based upon conservation program needs and availability of robust data. The approach focuses on species guilds linked to coastal wetlands, beaches and riparian forests. The project team collaborated with the Virginia Department of Conservation and Recreation Natural Heritage Program to identify habitat thresholds, metrics and access to data, and with the Virginia Coastal Policy Center to determine the overall scope of conservation strategies and their policy implications. Project partners also conferred with the Department of Wildlife Resources to identify habitats and species of import for DWR conservation programs.

[1] Proposed Rule, 87 FR 34625. United States Fish and Wildlife Service, https://www.federalregister.gov/d/2022-12061

As a baseline premise, the project team began with the understanding that climate change and sea level rise represent the potential for substantial changes among Virginia's living resources. Changes in temperature, precipitation patterns, and accelerating sea level rise are expected to impact species distributions throughout the Commonwealth.[2] This is generally perceived as threatening, since natural communities and native species of coastal Virginia provide numerous ecological, cultural, and commercial functions and services to the Commonwealth, the Chesapeake Bay, and beyond.[3] Species distributions are predominately determined by the physiological tolerances of the species (e.g., temperature and salinity ranges), the availability of suitable habitat, and predatory restraints (e.g., both natural and anthropogenic).[4] The largest driver of species distribution shifts in coastal Virginia is expected to be through changes in habitat as a result of sea level rise.[5] In Virginia, the rate of sea level rise is among the highest in the nation, and is accelerating.[6] This rapid sea level rise is resulting in major redistribution and loss of coastal marshes, a critical habitat for many coastal inhabitants.

The project team worked in collaboration with the Virginia Departments of Wildlife Resources (DWR) and Conservation and Recreation (DCR) Natural Heritage Program and the Virginia Marine Resources Commission (VMRC) to develop spatially explicit projections of shifts in coastal habitats and their cascading impacts on natural communities and native species throughout the Tidewater region. Faunal guilds provide a useful mechanism for examining the impacts of climate change on species distributions by aggregating species into guilds based on shared functional (e.g., filter feeders), taxonomic (e.g., shorebirds), managerial (e.g., gamefish), and/or habitat (e.g., salt marsh) characteristics.[7] These guilds increase the data density and

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[2] *See, e.g.* Jonathan L. Goodall, *et al*, "The Impact of Climate Change on Virginia's Coastal Areas" (2021). William & Mary, Faculty Publications. 2042. https://scholarship.law.wm.edu/facpubs/2042 at 17: "The longer growing season, particularly the later onset of fall, has posed problems for some migratory species in the bay. Warmer temperatures encourage them to delay migration, leaving them vulnerable to cold snaps. In 2014, warmer water temperatures enticed speckled trout to overwinter in the Rappahannock River and tributaries of Mobjack Bay. Thousands were killed during a February cold snap. Similar circumstances in 2011 led to the death of 2 million juvenile spot."

[3] *Id.* at 35: "The effects of climate change will place [Virginia] fisheries in jeopardy, but the complex ecology of the Chesapeake Bay watershed and Virginia's offshore waters makes the exact extent and sequence of events difficult to predict. [As an example], plankton respond quickly to changes in their habitat — on time scales of days to weeks — and are often the first to feel the impact of changes in their environment. Fluctuations in such variables as nutrient levels, temperature, salinity, and carbon dioxide concentrations associated with climate change can alter the abundance and growth rates of plankton species and shift the type of species present. These changes, in turn, can affect the economically important species that feed on them."

[4] *See, e.g.* Louis R. Iverson, *et al*. "Analysis of Climate Change Impacts on Tree Species of the Eastern US: Results of DISTRIB-II Modeling" FORESTS 10, no. 4: 302 (2019). https://doi.org/10.3390/f10040302 (modeling impacts to common tree populations based on environmental and anthropogenic factors).

[5] *See, e.g.* Zehao Wu and David Schulte, "Predictions of the Climate Change-Driven Exodus of the Town of Tangier, the Last Offshore Island Fishing Community in Virginia's Chesapeake Bay", FRONTIERS IN CLIMATE. Vol. 3 (2021), https://www.frontiersin.org/articles/10.3389/fclim.2021.779774 : "Human influence [is] cited as the unequivocal main driver of [Sea Level Rise] increases since at least 1971. Locally, the RSLR (relative sea-level rise) has been higher than the global mean, due to a SLR "hotspot" that exists on the East coast of North America."

[6] *Ibid.*

[7] *See generally* Roy Haines-Young and Marion Potschin "Categorisation systems: the classification challenge," in Mapping Ecosystem Services, ed. B. Burkhard, and J. Maes (Nottingham; Sofia: Pensoft Publishers), 42–45 (2019).

facilitate the clear translation to defined ecological, cultural, and commercial impacts.[8] Quantifying the impacts of the shifts in distributions of species and natural communities as a result of climate change can provide scientists and managers with the necessary information to plan for and guide conservation and restoration activities in the coming years.

## Updated Federal Guidance

In 2022, the United States Fish and Wildlife Service published a proposed rule removing language that "generally restricting the introduction of experimental populations to only the species' "historical range" to allow for the introduction of populations into habitat outside of their historical range for conservation purposes".[9] The purpose of this change is to "help improve the conservation and recovery of imperiled ESA-listed species in the coming decades, as growing impacts from climate change and invasive species cause habitats within their historical ranges to shift and become unsuitable".[10]

Historically, conservationists have sought to re-introduce species back into areas where they had been driven out or eradicated due to human actions[11]; examples of successes in Virginia could include bald eagles, elk, or peregrine falcons.[12] Climate change and migration pressures have increased pressure on historical ranges, pushing native species into new areas or causing conflicts as species increasingly encounter human dwellings and infrastructure.[13] Formerly native species are also often becoming invasive species as they crowd out native populations in new areas, a dynamic which may be exacerbated by efforts to relocate and protect valued species vulnerable to the effects of climate change.[14]

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[8] *Id.*

[9] USFWS, *supra* note 1.

[10] Press Release, "Department of the Interior Proposes Expanding Conservation Technique as Climate Change Threatens Greater Species Extinction", USFWS, https://www.fws.gov/press-release/2022-06/department-interior-proposes-expanding-conservation-technique-climate-change (Jun. 6, 2022)

[11] *Id.*

[12] *See, e.g.*: Virginia Department of Wildlife Resources, "Elk in Virginia: Return of a Native Species", https://dwr.virginia.gov/wildlife/elk/

[13] *See, e.g.* Stinchcomb, T. R., Z. Ma, and Z. Nyssa. "Complex human-deer interactions challenge conventional management approaches: the need to consider power, trust, and emotion." ECOLOGY AND SOCIETY 27(1):13 (2022). https://doi.org/10.5751/ES-12899-270113: "Expanding human communities have created ideal "edge" habitat for deer populations to thrive... At the same time, expanding deer populations impact forest ecosystem dynamics, browse on economically important crops, and increase risks of vehicle collisions and disease spread…"

[14] *See, e.g.* Sonia Shah, "Native Species or Invasive? The Distinction Blurs as the World Warms", Yale Environment 360 (Jan. 14, 2020), https://e360.yale.edu/features/native-species-or-invasive-the-distinction-blurs-as-the-world-warms : "The movements of iconic species such as palm trees in Florida, threatened by disease-spreading treehopper bugs that likely blew in on a hurricane, and moose in Minnesota, which may be forced northward by the state's booming tick populations, will cause both economic and cultural losses if they collapse or shift beyond state borders. Under traditional management approaches, the movements of such species could generate counterproductive efforts to protect them as natives in places they're leaving, or worse, repel them as aliens in places they enter."

The proposed rule limits its scope to experimental populations of endangered species, a heavily-regulated designation that involves the intentional and targeted release of a population into suitable habitat outside the species' current natural range.[15] Previous regulatory guidance limited release of experimental populations to areas within their probable historical range[16], a backward-looking approach that does not account for the future needs of the species necessitated by climate change. The proposed changes "will more clearly establish the authority of the Service to introduce experimental populations into areas of habitat outside of the historical range of the affected listed species", citing climate change and the proliferation of invasive species as specific challenges.[17]

This approach is a bellwether for states and other jurisdictions considering the impacts of climate change on local wildlife. Intentional introduction of species into areas where they will, by many definitions, be invaders, even to save the species, may create conflicts with far-reaching consequences.

Most programs addressing species migration have focused on eradicating or reducing new populations, as in the 2015 effort to preserve spotted owl populations in the American Pacific Northwest by killing thousands of barred owls that leapfrogged over the Great Plains from their native habitat in the East via trees planted by 19th century settlers.[18] Many conservationists and members of the public view such culls, at least among charismatic fauna[19], with distaste and there is rising support for a more tolerant, coexistence paradigm.[20] Other strategies have involved exclusion, such as strict prohibitions on biological imports or simple fencing.[21]

Approaches to managing climate-displaced species can be roughly divided into two categories: facilitation and conflict. Arguably, efforts involving culling or exclusion can be understood to constitute a human-wildlife conflict, as does the absence of effort as wildlife and humans share spaces in new ways. Facilitative approaches seek to identify and direct migration so as to minimize conflict. Importantly, neither methodology eliminates conflict; rather, it is a question of degree and intent.

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[15] USFWS, *supra* note 1.
[16] *Id. See also*, Endangered Species Act, 16 U.S.C. 1531(c)(1) *et seq.*, and accompanying regulations, [50 CFR 17.81](#).
[17] *Id.*
[18] Shah, *supra*, note 14.
[19] There is less compassion for, say, the common reed, *Phragmites australis*, a plant of complex origins that has at least a related native American cousin. Populations of *Phragmites* spread quickly, crowd out other species, particularly in vulnerable wetlands, and can grow to heights of 20 feet.
[20] Stinchcomb, *et al., supra* note 13: "Recent scholarship, however, has documented a public shift toward coexistence, including increasing non-consumptive, existence, and mutualist values for wildlife…"
[21] *See, e.g.* Bode, *et al*. "Interior fences can reduce cost and uncertainty when eradicating invasive species from large islands", METHODS IN ECOLOGY AND EVOLUTION, 4 ,819–827 (2013), https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/2041-210X.12072 : "The conservation of many threatened species can be advanced by the eradication of alien invasive animals from islands. However, island eradications are an expensive, difficult and uncertain undertaking. An increasingly common eradication strategy is the construction of 'interior fences' to partition islands into smaller, independent eradication regions that can be treated sequentially or concurrently."

One facilitative approach that is the focus of this project is identifying areas of high natural biodiversity that may be vulnerable to displaced-species migration. There are two significant goals of this work; first to understand the areas of highest biodiversity and resilience that are most necessary to provide "retreat" areas for displaced native species, and second, to prioritize areas for conservation that can help limit and avoid human conflicts, particularly those associated with increased development.

## Project Description and Methodology

Phase 1 of the multi-year project began in 2021 with completing spatial analyses to identify significant biodiversity occurrences on climate change resilient sites. The most important of these occurrences were identified, and many had not been observed in over twenty-five years. Using information from spatial analyses and imagery review, a method prioritization was completed to highlight occurrences on resilient sites which are most in need of biological inventory review.[22]

In 2022, using the prioritization from Phase I, botanists, vegetation ecologists, and zoologists from the Virginia Natural Heritage Program began conducting field surveys to update biodiversity information for prioritized sites. In the third year of the project, the updated biodiversity information was entered into a spatial database and used to update conservation planning tools. These tools will be used to develop a parcel-based strategy to identify high-priority biodiversity occurrences that occur on un-conserved resilient sites that are in urgent need of conservation. The strategy will identify parcels that may qualify for expansion of the State Natural Area Preserves system and will be shared with partners in state and federal conservation agencies, conservation NGOs, and land trusts, with the intention of pointing them to the most critical parcels for conservation action in the Coastal Zone of Virginia.[23]

## Policy and Law Opportunities

Many jurisdictions have traditionally prioritized conflict-based approaches to species migration and management, utilizing such methods as culls[24] (including hunting and fishing

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[22] *See* Bucklin, *et al.* "Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 1 - Priorities for Biological Inventory". Natural Heritage Technical Report 22-08. Richmond, Virginia: Department of Conservation and Recreation, Division of Natural Heritage. (2022)

[23] For more complete project descriptions and data analysis, *see* Anne Chazal, *et al*. "Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 2 – Element Occurrences Field Surveys" at ii. Natural Heritage Technical Report 23-03. Richmond, Virginia: Department of Conservation and Recreation, Division of Natural Heritage (2023).

[24] *See, e.g.* "Menace of the Marsh" [Nutria], Virginia Department of Wildlife Resources, https://dwr.virginia.gov/blog/menace-of-the-marsh/: "[DWR biologist} Englemeyer and [tracking dog Finn] work

incentives) and removals[25], fencing[26], and high-intervention repopulation to boost species' ability to combat incursions[27]. These approaches tend to identify an opponent and a desired proponent species that are pitted against each other in a zero-sum construct, a categorization that may not fully capture the range of social and emotional perceptions of wildlife management techniques.[28]

As climate displacement creates inherent friction between management of native species and climate-displaced species, traditional approaches that are based on eliminating members of the 'opponent' species may not be appropriate given the desired outcome may be supporting both vulnerable species. At the same time, species in similar ecological niches may not be able to coexist.[29]

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in coordination with other partner agencies, both state and federal. When they find evidence of a nutria, the location is promptly uploaded to a nationwide database. Then traps are set to kill the invasive animal."

[25] *See, e.g.* "Marsh Invader" [Phragmites], Virginia Department of Conservation and Recreation, https://www.dcr.virginia.gov/natural-heritage/document/phragmitescontrolbooklet-final2008.pdf : "At the first indication of a Phragmites invasion, control actions should be taken."

[26] *See, e.g.* "Virginia Deer Management Plan 2015-2024", Virginia Department of Game and Inland Fisheries (DWR), https://dwr.virginia.gov/wp-content/uploads/virginia-deer-management-plan.pdf at 62: "Use fencing and repellents to manage conflicts with deer populations".

[27] *See, e.g.* "Coldwater Fish Production and Stocking", Virginia Department of Wildlife Resources, https://dwr.virginia.gov/fishing/fish-stocking/coldwater/ : "Fish stocking is a management tool used to: (1) establish sportfish in new, reclaimed, or renovated waters open to public fishing; (2) supplement natural stocks where reproduction is inadequate; (3) introduce new species as predators and/or to provide a trophy fishery; (4) and provide immediate fishing by introducing catchable size fish."

[28] *See, e.g.* Stinchcomb, *et al., supra* note 13: "The interviewee's livelihood or land management activities were seen to be the most influential factor shaping their feelings toward deer. When deer interfere with crop and timber yields or hardwood forest regeneration, they elicit frustration and blame. As one woodland owner explained, it "take[s] a lot of work and expensive money" to "replace the walnuts ... in our woods" and the deer "come up every night ... and they browse around, biting [the walnut seedlings] off" (WLO08). Conversely, when deer minimally affect livelihoods or land management practices, landowner emotions remain largely positive or tolerant… "I can shoot them if they're eating my beans, but I can't kill them if they're not doing anything wrong. (FARM08)…".

[29] *See infra*, discussion of barred owls vs. spotted owls, p. 3. *See also*, John Hadidian, "Wildlife in U.S. Cities: Managing Unwanted Animals (Basel). 5(4):1092-113 (2015), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4693205/ [includes a case study in which the decision was made to destroy "resident" Canada geese, whereas "migratory" populations are protected by treaty]: "In compliance with the National Environmental Policy Act (NEPA) the U.S. National Park Service published a final environmental impact statement in 2014 for the Anacostia Watershed in Washington, DC, USA, addressing the management of a restored 100 acres of wetlands along one of the nation's more degraded waterways… The preferred alternative calls for a combination of wetland management (most of which would be deferred because of expense) together with the annual culling of 40 to 60 percent of the "resident" [Canada] geese found within the vegetation restoration areas. This would be preceded by some amount of destruction of eggs and nests as these could be located. The process is to be open-ended and is deemed necessary because "resident" geese remain year-long in the area and subject the wetlands to more grazing pressure than would a migratory population. Such "resident" geese are subject to permissive depredation permitting authorized by the U.S. Fish and Wildlife Service which views them essentially as a non-native component of the biotic community [though migratory populations of the same bird are typically protected by various treaties]. Critics have argued that the Park Service's plan is neither reasonable nor humane, since the effective designation of some geese as "non-native" is arbitrary and the effort to protect only a tiny fraction of a much larger and highly degraded waterway is ecologically unrealistic."

Law and policy solutions may necessarily involve varied strategies depending on such factors as location, environment, and desired outcome[30], but it may be beneficial to consider an approach that establishes climate migration and species displacement as an anticipated and inevitable conclusion. From this position, balancing the desired species conservation goals may be considered using three overarching types of primarily facilitative, rather than conflict, methodologies: observation, niche exclusion, and migration.

Observation approaches recognize the potential for new interactions related to climate change and rely on passive study of changing environments, ecosystems, and behavior to inform potential actions on behalf of one or more identified vulnerable species.[31] The majority of environments in Virginia will be observation areas, since it is beyond the resources and remit of state and local authorities to manage the entirety.[32]

Niche exclusion involves the selective management of high-priority natural areas important to the survival and reproduction of desirable species and unique ecosystems. Niche exclusion can involve traditional conflict-based schemes such as fencing and culling, but for defined areas that are understood to have high value and are resilient to climate change so that beneficial effects of conflict actions are not quickly lost due to broader influences.[33] Niche approaches are limited in scale and scope, potentially managing costs and improving public perceptions.[34] Virginia's Natural Area Preserve program is one type of niche exclusion effort, albeit a relatively passive one, that works to preserve sensitive locations by limiting access and strictly regulating activity within the exclusion area.[35]

Migration areas represent another opportunity to limit conflict and facilitate species migration to achieve outcomes that may have wider beneficial effects. A migration approach

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[30] *See, e.g.* Goodall, *supra*, note 2 at 55: "Planning for climate change in rural coastal Virginia necessarily differs from the approaches favored in more densely developed and populated areas like Hampton Roads or Northern Virginia. With more land to protect and few resources to do so, communities in rural areas are turning primarily to green initiatives like strategic land conservation, wetland restoration, and living shorelines."

[31] *See, e.g.* Goodall, *supra*, note 2.

[32] *See, e.g.* Spotted Lanternfly Management Guide, PennState Extension, https://extension.psu.edu/spotted-lanternfly-management-guide advocating "slow the spread" of these invasive insects, rather than eradication.

[33] *See, e.g.* Bode, *supra* note 21 at 820: "An 'interior fence' strategy proved effective during the successful eradication of feral pigs *Sus scrofa* from California's Santa Catalina and Santa Cruz Islands, which were divided into four and five regions, respectively, before eradication was undertaken … Interior fences were also constructed during the eradication of cattle *Bos taurus* from Amsterdam Island… and sheep *Ovis aries* from Campbell Island … They are currently being planned as part of a multispecies eradication on Stewart Island, New Zealand… and as part of the world's largest feral cat *Felis catus* eradication programme on Dirk Hartog Island, Western Australia..."

[34] *See, e.g.,* Stinchcomb, *supra* note 28.

[35] VIRGINIA CODE § 10.1-209 *et seq.* Virginia Natural Area Preserves Act. *See also*, Virginia Department of Conservation and Recreation, Division of Natural Heritage, Natural Area Preserves, https://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/: "Except for certain specific situations, camping, fires, unleashed pets, hunting, off-road vehicles and removal or destruction of plants, animals, minerals or historic artifacts are prohibited on all Virginia Natural Area Preserves… Each natural area preserve is managed primarily for the benefit of the rare plants, animals and natural communities found there. Many preserves feature low-intensity public access facilities such as trails and parking."

intentionally prioritizes corridors and movement areas for existing native species to relocate populations and for climate-displaced species to move around, not across niche exclusion areas or human-dominated potential conflict zones. Some Virginia localities are experimenting with migration solutions, such as wildlife corridors under highways,[36] and a Wildlife Corridor Action Plan was commissioned by the Virginia legislature in 2021.[37]

Together, these three types of approaches can form an integrated strategy that minimizes conflict and proactively accounts for the environmental pressures associated with climate change.

## Conclusion

In consideration of recent federal actions to acknowledge the impacts of climate change on historically native species and the potential for displacement, as well as data from this project's observation of Virginia natural areas, it may be beneficial to consider a novel structure for species management that moves away from traditional, conflict-based approaches in situations where the desired outcome is preservation of multiple vulnerable, but potentially incompatible, species in favor of a targeted approach that attempts to direct, rather than eliminate, climate migration.

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[36] *See, e.g.* Karen Firehock, "Green Planning in Albemarle and Charlottesville", Presentation to League of Women Voters February 10, 2019, Green Infrastructure Center.

[37] VIRGINIA CODE § 29.1-579. Wildlife Corridor Action Plan: § 29.1-579. Wildlife Corridor Action Plan; adoption: "The Plan shall: (1) Identify wildlife corridors, existing or planned barriers to movement along such corridors, and areas with a high risk of wildlife-vehicle collisions. The Plan shall list habitat that is identified as of high quality for priority species and ecosystem health; migration routes of native, game, and migratory species using the best available science and Department surveys…"

## Stakeholder Process

CCRM, with assistance and review by CZM, identified stakeholders to help guide the information output from the habitat modeling and the service of the model output data. Three stakeholder meetings were held: a kick-off meeting in October 2022, a meeting to review modeled data in May 2023, and a meeting to consider output format and data service in February 2024. The stakeholder workgroup had broad representation from state and localities, PDCs and non-profits. The stakeholder meetings were planned and supported by CCRM with participation of the project team. See Appendix 4 for a list of stakeholders, meeting agendas, and meeting notes.

## Management Implications

This project was completed working in collaboration with the Department of Conservation and Recreation (DCR) Natural Heritage Program and the Virginia Marine Resources Commission (VMRC), the Virginia Department of Wildlife Resources (DWR) and others via the stakeholder process to assess spatially explicit projections of shifts in coastal habitats and their likely cascading impacts on natural communities and native species throughout the Tidewater region. The acreage and distribution of potential tidal wetlands provides critical information for decision-making around tidal wetlands and the ecosystem services they provide. From habitat to several rare, threatened and endangered endemic species, to foodweb support for aquatic and terrestrial fauna, to water quality maintenance, erosion protection, flood benefits, recreation, open space provision, tidal wetlands are a fundamental landscape for coastal communities.

| Year | Acres |
|---|---|
| 2020 | 336,896 |
| 2030 | 336,339 |
| 2040 | 335,574 |
| 2050 | 315,053 |
| 2060 | 310,576 |
| 2070 | 293,173 |
| 2080 | 249,132 |
| 2090 | 192,657 |
| 2100 | 176,292 |
| Total Loss: | 160,604 |

*Table 2. Total Area of Potential Tidal Wetlands by Decade 2020-2100*

Faunal guilds provide a useful mechanism for examining the impacts of climate change on species distributions by aggregating species into guilds based on shared functional (e.g., filter feeders), taxonomic (e.g., shorebirds), managerial (e.g., gamefish), and/or habitat (e.g., salt marsh) characteristics. These guilds increase the data density and facilitate the clear translation to defined ecological, cultural, and commercial impacts

Quantifying the impacts of the shifts in distributions of species and natural communities because of climate change can provide scientists and managers with the necessary information to plan for and guide conservation and restoration activities in the coming years.

The projected potential loss of tidal wetlands by the year 2100 as a percentage of the 2020 extent is 47.7%

(336,896 acres 2020; 176,292 acres 2100) (Table 1). The areal extent change, and rate of loss, are not uniform across the coastal zone.

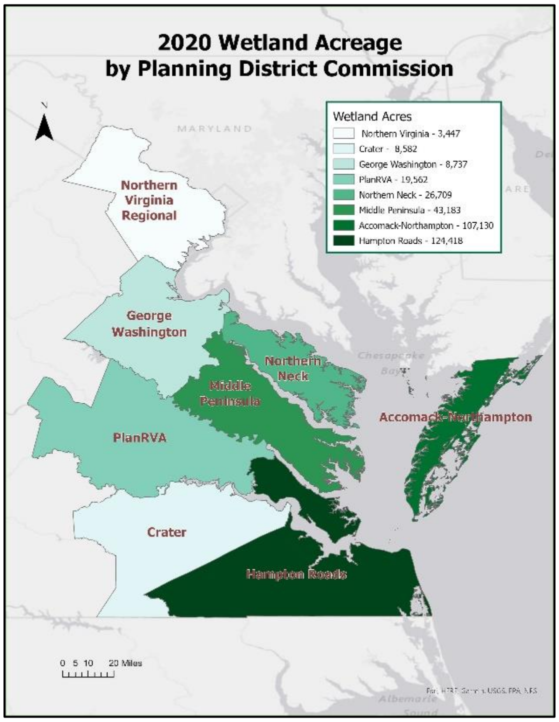
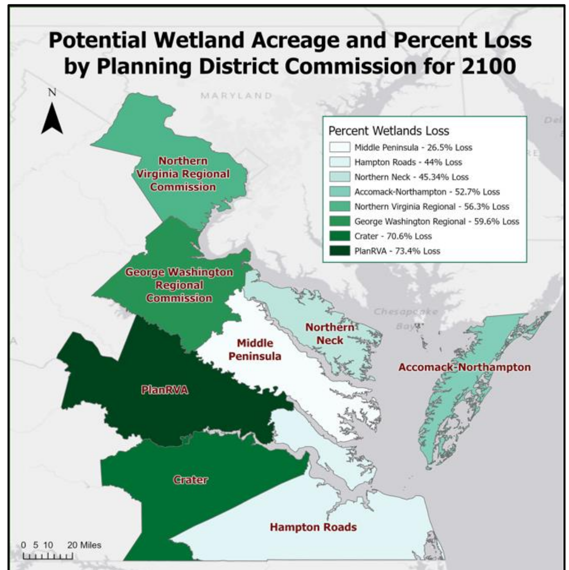



*Figure 6. Wetland Acres totaled by Planning District Commission 2020.*




| PDC | Wetland Acres | Percent Wetland Loss since 2020 |
|---|---|---|
| Accomack-Northampton | 50676 | 52.7 |
| Crater | 2526 | 70.6 |
| George Washington Regional Commission | 3531 | 59.6 |
| Hampton Roads | 69655 | 44 |
| Middle Peninsula | 31720 | 26.5 |
| Northern Neck | 14598 | 45.34 |
| Northern Virginia Regional Commission | 1506 | 56.3 |
| PlanRVA | 5192 | 73.46 |

*Figure 7. Potential wetland acres and losses in 2100 calculated by Planning District Commission.*

Figures 6 and 7 show the current and projected acreage of tidal wetlands by Planning District Commission (PDC). Figure 6 shows the 2020 tidal wetlands acreage totals by coastal PDC. Figure 7 shows the projected potential tidal wetlands area for the year 2100, the difference from 2020 and percentage change by PDC.

| PDC | Year | Acres |
|---|---|---|
| Accomack-Northampton | 2020 | 107130 |
| Accomack-Northampton | 2030 | 108063 |
| Accomack-Northampton | 2040 | 109421 |
| Accomack-Northampton | 2050 | 109186 |
| Accomack-Northampton | 2060 | 105738 |
| Accomack-Northampton | 2070 | 97737 |
| Accomack-Northampton | 2080 | 81867 |
| Accomack-Northampton | 2090 | 59974 |
| Accomack-Northampton | 2100 | 50676 |

| PDC | Year | Acres |
|---|---|---|
| Loss 52.7% | | |
| Crater | 2020 | 8582 |
| Crater | 2030 | 8291 |
| Crater | 2040 | 8017 |
| Crater | 2050 | 7735 |
| Crater | 2060 | 7628 |
| Crater | 2070 | 7251 |
| Crater | 2080 | 6180 |
| Crater | 2090 | 3395 |
| Crater | 2100 | 2526 |
| Loss 70.6% | | |
| George Washington Regional Commission | 2020 | 8737 |
| George Washington Regional Commission | 2030 | 8521 |
| George Washington Regional Commission | 2040 | 8296 |
| George Washington Regional Commission | 2050 | 7714 |
| George Washington Regional Commission | 2060 | 7499 |
| George Washington Regional Commission | 2070 | 6883 |
| George Washington Regional Commission | 2080 | 5604 |
| George Washington Regional Commission | 2090 | 3945 |
| George Washington Regional Commission | 2100 | 3531 |
| Loss 59.6% | | |
| Hampton Roads | 2020 | 124418 |
| Hampton Roads | 2030 | 125559 |
| Hampton Roads | 2040 | 125587 |
| Hampton Roads | 2050 | 116784 |
| Hampton Roads | 2060 | 116495 |
| Hampton Roads | 2070 | 110298 |
| Hampton Roads | 2080 | 91880 |
| Hampton Roads | 2090 | 71912 |
| Hampton Roads | 2100 | 69655 |
| Loss 44.0% | | |
| Middle Peninsula | 2020 | 43183 |
| Middle Peninsula | 2030 | 43386 |
| Middle Peninsula | 2040 | 43094 |
| Middle Peninsula | 2050 | 38145 |
| Middle Peninsula | 2060 | 39413 |
| Middle Peninsula | 2070 | 39812 |
| Middle Peninsula | 2080 | 37285 |
| Middle Peninsula | 2090 | 32886 |

| PDC | Year | Acres |
|---|---|---|
| Middle Peninsula | 2100 | 31720 |
| Loss 26.6% | | |
| Northern Neck | 2020 | 26709 |
| Northern Neck | 2030 | 24478 |
| Northern Neck | 2040 | 23643 |
| Northern Neck | 2050 | 19908 |
| Northern Neck | 2060 | 19856 |
| Northern Neck | 2070 | 19443 |
| Northern Neck | 2080 | 17684 |
| Northern Neck | 2090 | 15350 |
| Northern Neck | 2100 | 14598 |
| Loss 45.34% | | |
| Northern Virginia Regional Commission | 2020 | 3447 |
| Northern Virginia Regional Commission | 2030 | 3531 |
| Northern Virginia Regional Commission | 2040 | 3144 |
| Northern Virginia Regional Commission | 2050 | 3123 |
| Northern Virginia Regional Commission | 2060 | 3027 |
| Northern Virginia Regional Commission | 2070 | 2679 |
| Northern Virginia Regional Commission | 2080 | 2427 |
| Northern Virginia Regional Commission | 2090 | 1825 |
| Northern Virginia Regional Commission | 2100 | 1506 |
| Loss 56.3% | | |
| PlanRVA | 2020 | 19562 |
| PlanRVA | 2030 | 19337 |
| PlanRVA | 2040 | 19353 |
| PlanRVA | 2050 | 17593 |
| PlanRVA | 2060 | 16209 |
| PlanRVA | 2070 | 13651 |
| PlanRVA | 2080 | 9566 |
| PlanRVA | 2090 | 6299 |
| PlanRVA | 2100 | 5192 |
| Loss 73.46% | | |

*Table 3. Potential Tidal Wetland area per Planning District Commission by decade 2020-2100*

Tidal wetland persistence is placed-based dependent on many factors acting at multiple scales, some local and others at systems, shoreline reach, watershed scale. These factors include elevation, sediment supply, sediment accumulation, organic material production (above and belowground), erosion conditions, landward elevations enabling migration, lack or minimal development limitations, and more). Many of these factors have impacts at a systems scale, such as wave climate, relative sea level rise rate, sediment supply, and others. The projected wetlands change shows the highest loss rates are in the PDC regions that are in the western part of the coastal plain, farther from the Bay shore and contingent to the Piedmont physiographic province sometimes referred to as the inner coastal plain (Table 2). The Coastal Plain is a terraced landscape that stair-steps down towards the coast and to the major rivers. The ‘steps’ are topographic scarps that formed as ancient shorelines, and the ‘treads’ are emergent bay and river bottoms. The higher, older plains in the western part of the Coastal Plain are more dissected by stream erosion than the lower, younger terrace surfaces to the east (http://geology.blogs.wm.edu/coastal-plain/). All the potential wetlands areas by decade per locality are shown in Appendix 1.

The information from the modeled projections in concert with the priorities set by the DCR/ Heritage surveys and analyses, support conservation decisions within a sea level rise, climate resilience lens. Many local, regional, state and national decision-makers and decision processes influence conservation decisions regarding coastal landscapes and tidal wetlands. Efforts around tidal wetlands include an existing Chesapeake Bay Program (CBP) Outcome for all wetlands (tidal included) that is determined to be well off-course for achievement by 2025. The CBP is currently working through the process for establishment of outcomes for beyond 2025. The primary lead for this effort is the Wetlands Workgroup within the Habitat Goal Implementation Team (HGIT). The process has already led to a decision that the CBP wetland outcome needs to include goals for tidal and non-tidal wetlands separately. And most specific to tidal wetlands, the outcomes are likely to also be time bound.

Existing tidal wetland efforts at the CBP include a grant with the Chesapeake Bay Trust to add capacity for tidal wetlands efforts. Specifically, the Trust is leading the development of a Bay tidal wetlands strategy which will include recommendations for, and implementation of tidal wetlands projects. The CBP HGIT also led the development of Wetland Action Plans. The Plans are for all wetlands (tidal and nontidal), but for jurisdictions (Maryland and Virginia) with tidal wetlands, the plans specifically speak to tidal wetland implementation issues, concerns and actions. The plans have been in place for almost two years, with updates provided by the jurisdiction leads in December 2023. The CBP Climate Resiliency Workgroup (CRWG) is also engaged in promotion of tidal wetlands projects, decision-support and outreach. The CRWG is completing a project that has specifically highlighted the Virginia Middle Peninsula as a target for wetlands resiliency projects. The target is based on the designation by NOAA as a Critical Habitat Area and the designation was a collaborative process with the Virginia Marine Resources Commission (VMRC), Virginia Department of Wildlife Resources (DWR), Virginia Institute of Marine Science and other wetlands scientists and decision-makers.

VRMC, DWR, DCR, other state agencies and nonprofits are actively engaged in efforts for tidal wetlands resiliency. These efforts include protection (fee simple and easement acquisition), restoration, erosion protection, sediment management, living shorelines and many other actions to management persistence of existing tidal wetlands and enable the migration of tidal wetlands to support persistence into the future. Efforts in Virginia to develop a state-wide wetlands team are in process and expectations are that an improved collaboration process will be instated. Given this thinking, the outputs from this project will be very useful for a collaborative effort to a more coordinated effort to address tidal wetlands climate-driven change in Virginia.

## Management Recommendations

**(Note: As VCPC was not part of the year 3 effort, where policy and management recommendations were to be developed, this section reflects input from CCRM and stakeholders, but is not a detailed as originally proposed)**

The application of the data from this project will enhance the ability of conservation decision-makers to incorporate climate resilience considerations into projects. Two primary datasets were generated: 1) tidal wetlands potential area by decade from 2020 to 2100, and 2) prioritized parcels for protection of natural heritage elemental occurrences based on resilience.

Conservation is a broad term and can mean many differing types of actions or activities. When it comes to wetlands, the following generally applies. Protection is the fee simple or easement acquisition of lands. While considered protected via permit requirements in state law, recognition of the need for additional protections is commonly accepted. Restoration is to recreate a wetland where one existed formally. Creation is a new wetland preferably out of fastland or uplands. Creation can also be new wetland built on subaqueous lands (sometime also referred to as restoration if a marsh shoreline has receded from the area). Management actions involve manipulation of sediment, hydrology and/or vegetation. Management actions that enable existing marsh persistence include hydrology controls like runnels, weirs and tide gates to de-water and control tidal flooding, sediment placement to increase elevation relative to sea levels, and erosion control on the leading edge of a wetland.

Management actions that enable marsh migration can support both marsh persistence and marsh creation (where areas without wetlands now can become wetlands due to sea level rise). These actions might be protection of future marsh locations, grading to establish appropriate elevations for wetlands, or removal of migration barriers. There is also a need for new policies to support these management actions as existing policies focus on the existing footprint of the wetland resources. In the regulatory program, consideration is given to the landward wetland buffer as a control for stressors that impact or diminish wetland function. Research and policies supporting wetland mitigation requirements in the regulatory program might serve as a possible framework for policy development for wetland migration buffers.

| Category | Action | Wetland Benefit |
|---|---|---|
| Protection | Wetland Fee Simple Acquisition | Persistence |
| | Wetland Easement | Persistence |
| | Buffer Fee Simple/ Easement | Persistence, Migration |
| | Agricultural Conservation Easement/Wetland Reserve Easement Program | Persistence, Migration |
| | Floodplain Easement | Migration |
| | Coastal Resilience Easement (or other resilience instrument) | Migration |
| Restoration | Re-establish | New wetland and/or Expansion (in historical boundary) |
| Creation | Build New | New wetland |
| Management | Runnels | Persistence, Expansion |
| | Weirs | Persistence |
| | Tide gates | Persistence |
| | Sediment additions (i.e., TLP) | Persistence, New wetland |
| | Elevation control/grading | Persistence, Expansion, New Wetland |
| | Erosion Control | Persistence |
| | Remove physical barriers (i.e., berms, impervious surface) | Persistence, Expansion |
| | Vegetation: planting and/or stabilization controls | Persistence |

*Table 4. Wetland Conservation Actions for Wetland Outcomes*

Considering the relative projected wetlands losses by PDC, there is a need to include a range of conservation actions to support tidal wetlands existence in Virginia into the future. Individual wetlands, and wetland complexes in the outer coastal plain are more likely to persist over time. In order to support persistence, conservation actions should focus on management of hydrology, sediment and actions to enable marsh migration. For the inner coastal plain, the conservation actions would need to focus on restoration and creation. In these areas, topography limits the availability of lowlands for tidal wetlands restoration and creation. As such, creation may necessitate the need to convert shallow water to tidal wetlands. This approach, if pursued, would need development of new policies to address the jurisdictional trade-offs.

Where the EO in the DCR data represents a wetland endemic, or wetland denizen, and the geography co-occurs with projected wetland location, we suggest this increase the relative priority for conservation actions in those areas. Where the EO is wetland dependent, and the wetland is not projected to co-occur, we suggest efforts for restoration or creation to support the EO.

## Acknowledgements

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# Appendix 1: Potential Tidal Wetland Acres per Locality by Decade

| Locality | Year | Acres |
|---|---|---|
| Accomack County | 2020 | 83762 |
| Accomack County | 2030 | 84735 |
| Accomack County | 2040 | 86072 |
| Accomack County | 2050 | 86152 |
| Accomack County | 2060 | 83973 |
| Accomack County | 2070 | 78291 |
| Accomack County | 2080 | 65019 |
| Accomack County | 2090 | 46259 |
| Accomack County | 2100 | 38229 |
| Alexandria City | 2020 | 94 |
| Alexandria City | 2030 | 97 |
| Alexandria City | 2040 | 103 |
| Alexandria City | 2050 | 112 |
| Alexandria City | 2060 | 116 |
| Alexandria City | 2070 | 118 |
| Alexandria City | 2080 | 131 |
| Alexandria City | 2090 | 153 |
| Alexandria City | 2100 | 170 |
| Arlington County | 2020 | 77 |
| Arlington County | 2030 | 24 |
| Arlington County | 2040 | 25 |
| Arlington County | 2050 | 27 |
| Arlington County | 2060 | 28 |
| Arlington County | 2070 | 31 |
| Arlington County | 2080 | 37 |
| Arlington County | 2090 | 45 |
| Arlington County | 2100 | 56 |
| Caroline County | 2020 | 1935 |
| Caroline County | 2030 | 1824 |
| Caroline County | 2040 | 1790 |
| Caroline County | 2050 | 1650 |
| Caroline County | 2060 | 1658 |
| Caroline County | 2070 | 1614 |
| Caroline County | 2080 | 1266 |
| Caroline County | 2090 | 829 |
| Caroline County | 2100 | 712 |

| Locality | Year | Acres |
|---|---|---|
| Charles City County | 2020 | 7682 |
| Charles City County | 2030 | 7514 |
| Charles City County | 2040 | 7416 |
| Charles City County | 2050 | 6696 |
| Charles City County | 2060 | 6138 |
| Charles City County | 2070 | 5237 |
| Charles City County | 2080 | 3997 |
| Charles City County | 2090 | 2753 |
| Charles City County | 2100 | 2275 |
| Chesapeake City | 2020 | 17867 |
| Chesapeake City | 2030 | 18537 |
| Chesapeake City | 2040 | 18935 |
| Chesapeake City | 2050 | 18651 |
| Chesapeake City | 2060 | 18009 |
| Chesapeake City | 2070 | 16334 |
| Chesapeake City | 2080 | 14350 |
| Chesapeake City | 2090 | 12039 |
| Chesapeake City | 2100 | 12910 |
| Chesterfield County | 2020 | 3684 |
| Chesterfield County | 2030 | 3649 |
| Chesterfield County | 2040 | 3574 |
| Chesterfield County | 2050 | 3493 |
| Chesterfield County | 2060 | 3455 |
| Chesterfield County | 2070 | 3375 |
| Chesterfield County | 2080 | 3093 |
| Chesterfield County | 2090 | 1537 |
| Chesterfield County | 2100 | 1010 |
| Colonial Heights City | 2020 | 417 |
| Colonial Heights City | 2030 | 421 |
| Colonial Heights City | 2040 | 414 |
| Colonial Heights City | 2050 | 403 |
| Colonial Heights City | 2060 | 386 |
| Colonial Heights City | 2070 | 363 |
| Colonial Heights City | 2080 | 327 |
| Colonial Heights City | 2090 | 222 |
| Colonial Heights City | 2100 | 202 |
| Essex County | 2020 | 10102 |
| Essex County | 2030 | 9272 |
| Essex County | 2040 | 8420 |

| Locality | Year | Acres |
|---|---|---|
| Essex County | 2050 | 7154 |
| Essex County | 2060 | 7060 |
| Essex County | 2070 | 6468 |
| Essex County | 2080 | 4569 |
| Essex County | 2090 | 3096 |
| Essex County | 2100 | 2807 |
| Fairfax County | 2020 | 1484 |
| Fairfax County | 2030 | 1540 |
| Fairfax County | 2040 | 1525 |
| Fairfax County | 2050 | 1521 |
| Fairfax County | 2060 | 1487 |
| Fairfax County | 2070 | 1422 |
| Fairfax County | 2080 | 1308 |
| Fairfax County | 2090 | 1075 |
| Fairfax County | 2100 | 915 |
| Fredericksburg City | 2020 | 0 |
| Fredericksburg City | 2030 | 0 |
| Fredericksburg City | 2040 | 0 |
| Fredericksburg City | 2050 | 0 |
| Fredericksburg City | 2060 | 0 |
| Fredericksburg City | 2070 | 0 |
| Fredericksburg City | 2080 | 0 |
| Fredericksburg City | 2090 | 16 |
| Fredericksburg City | 2100 | 18 |
| Gloucester County | 2020 | 12332 |
| Gloucester County | 2030 | 13001 |
| Gloucester County | 2040 | 13481 |
| Gloucester County | 2050 | 12333 |
| Gloucester County | 2060 | 13032 |
| Gloucester County | 2070 | 13564 |
| Gloucester County | 2080 | 13670 |
| Gloucester County | 2090 | 12674 |
| Gloucester County | 2100 | 11751 |
| Hampton City | 2020 | 4142 |
| Hampton City | 2030 | 4196 |
| Hampton City | 2040 | 4205 |
| Hampton City | 2050 | 3916 |
| Hampton City | 2060 | 4225 |
| Hampton City | 2070 | 4568 |

| Locality | Year | Acres |
|---|---|---|
| Hampton City | 2080 | 4887 |
| Hampton City | 2090 | 5079 |
| Hampton City | 2100 | 5514 |
| Hanover County | 2020 | 429 |
| Hanover County | 2030 | 436 |
| Hanover County | 2040 | 443 |
| Hanover County | 2050 | 446 |
| Hanover County | 2060 | 449 |
| Hanover County | 2070 | 450 |
| Hanover County | 2080 | 405 |
| Hanover County | 2090 | 239 |
| Hanover County | 2100 | 247 |
| Henrico County | 2020 | 1598 |
| Henrico County | 2030 | 1628 |
| Henrico County | 2040 | 1617 |
| Henrico County | 2050 | 1366 |
| Henrico County | 2060 | 1122 |
| Henrico County | 2070 | 924 |
| Henrico County | 2080 | 904 |
| Henrico County | 2090 | 831 |
| Henrico County | 2100 | 716 |
| Hopewell City | 2020 | 220 |
| Hopewell City | 2030 | 212 |
| Hopewell City | 2040 | 205 |
| Hopewell City | 2050 | 203 |
| Hopewell City | 2060 | 204 |
| Hopewell City | 2070 | 204 |
| Hopewell City | 2080 | 199 |
| Hopewell City | 2090 | 124 |
| Hopewell City | 2100 | 100 |
| Isle of Wight County | 2020 | 7618 |
| Isle of Wight County | 2030 | 7747 |
| Isle of Wight County | 2040 | 7802 |
| Isle of Wight County | 2050 | 6777 |
| Isle of Wight County | 2060 | 6461 |
| Isle of Wight County | 2070 | 5985 |
| Isle of Wight County | 2080 | 5018 |
| Isle of Wight County | 2090 | 3291 |
| Isle of Wight County | 2100 | 2321 |

| Locality | Year | Acres |
|---|---|---|
| James City County | 2020 | 9445 |
| James City County | 2030 | 9453 |
| James City County | 2040 | 9377 |
| James City County | 2050 | 8136 |
| James City County | 2060 | 7804 |
| James City County | 2070 | 7036 |
| James City County | 2080 | 5395 |
| James City County | 2090 | 3220 |
| James City County | 2100 | 2806 |
| King George County | 2020 | 4273 |
| King George County | 2030 | 4240 |
| King George County | 2040 | 4115 |
| King George County | 2050 | 3835 |
| King George County | 2060 | 3686 |
| King George County | 2070 | 3345 |
| King George County | 2080 | 2670 |
| King George County | 2090 | 1821 |
| King George County | 2100 | 1589 |
| King William County | 2020 | 9592 |
| King William County | 2030 | 9687 |
| King William County | 2040 | 9711 |
| King William County | 2050 | 9670 |
| King William County | 2060 | 9653 |
| King William County | 2070 | 8770 |
| King William County | 2080 | 6917 |
| King William County | 2090 | 3907 |
| King William County | 2100 | 2934 |
| King and Queen County | 2020 | 5695 |
| King and Queen County | 2030 | 5866 |
| King and Queen County | 2040 | 5999 |
| King and Queen County | 2050 | 5776 |
| King and Queen County | 2060 | 5782 |
| King and Queen County | 2070 | 5692 |
| King and Queen County | 2080 | 4881 |
| King and Queen County | 2090 | 2950 |
| King and Queen County | 2100 | 2503 |
| Lancaster County | 2020 | 5515 |
| Lancaster County | 2030 | 5367 |
| Lancaster County | 2040 | 5192 |

| Locality | Year | Acres |
|---|---|---|
| Lancaster County | 2050 | 4185 |
| Lancaster County | 2060 | 4245 |
| Lancaster County | 2070 | 4302 |
| Lancaster County | 2080 | 4252 |
| Lancaster County | 2090 | 4022 |
| Lancaster County | 2100 | 3759 |
| Mathews County | 2020 | 9605 |
| Mathews County | 2030 | 10043 |
| Mathews County | 2040 | 10249 |
| Mathews County | 2050 | 9953 |
| Mathews County | 2060 | 10685 |
| Mathews County | 2070 | 11364 |
| Mathews County | 2080 | 11749 |
| Mathews County | 2090 | 11928 |
| Mathews County | 2100 | 12468 |
| Middlesex County | 2020 | 5450 |
| Middlesex County | 2030 | 5205 |
| Middlesex County | 2040 | 4944 |
| Middlesex County | 2050 | 2929 |
| Middlesex County | 2060 | 2855 |
| Middlesex County | 2070 | 2724 |
| Middlesex County | 2080 | 2415 |
| Middlesex County | 2090 | 2239 |
| Middlesex County | 2100 | 2192 |
| New Kent County | 2020 | 9853 |
| New Kent County | 2030 | 9759 |
| New Kent County | 2040 | 9877 |
| New Kent County | 2050 | 9084 |
| New Kent County | 2060 | 8499 |
| New Kent County | 2070 | 7040 |
| New Kent County | 2080 | 4259 |
| New Kent County | 2090 | 2476 |
| New Kent County | 2100 | 1954 |
| Newport News City | 2020 | 4040 |
| Newport News City | 2030 | 4053 |
| Newport News City | 2040 | 3909 |
| Newport News City | 2050 | 3615 |
| Newport News City | 2060 | 3580 |
| Newport News City | 2070 | 3421 |

| Locality | Year | Acres |
| --- | --- | --- |
| Newport News City | 2080 | 3052 |
| Newport News City | 2090 | 2663 |
| Newport News City | 2100 | 2498 |
| Norfolk City | 2020 | 1899 |
| Norfolk City | 2030 | 1813 |
| Norfolk City | 2040 | 1683 |
| Norfolk City | 2050 | 1623 |
| Norfolk City | 2060 | 1746 |
| Norfolk City | 2070 | 1926 |
| Norfolk City | 2080 | 2141 |
| Norfolk City | 2090 | 2478 |
| Norfolk City | 2100 | 3088 |
| Northampton County | 2020 | 23368 |
| Northampton County | 2030 | 23329 |
| Northampton County | 2040 | 23348 |
| Northampton County | 2050 | 23034 |
| Northampton County | 2060 | 21764 |
| Northampton County | 2070 | 19446 |
| Northampton County | 2080 | 16848 |
| Northampton County | 2090 | 13715 |
| Northampton County | 2100 | 12447 |
| Northumberland County | 2020 | 8191 |
| Northumberland County | 2030 | 7990 |
| Northumberland County | 2040 | 7693 |
| Northumberland County | 2050 | 5353 |
| Northumberland County | 2060 | 5299 |
| Northumberland County | 2070 | 5276 |
| Northumberland County | 2080 | 5168 |
| Northumberland County | 2090 | 5068 |
| Northumberland County | 2100 | 5109 |
| Petersburg City | 2020 | 33 |
| Petersburg City | 2030 | 35 |
| Petersburg City | 2040 | 37 |

| Locality | Year | Acres |
|---|---|---|
| Petersburg City | 2050 | 39 |
| Petersburg City | 2060 | 40 |
| Petersburg City | 2070 | 38 |
| Petersburg City | 2080 | 34 |
| Petersburg City | 2090 | 31 |
| Petersburg City | 2100 | 26 |
| Poquoson City | 2020 | 6443 |
| Poquoson City | 2030 | 6361 |
| Poquoson City | 2040 | 6085 |
| Poquoson City | 2050 | 5787 |
| Poquoson City | 2060 | 5809 |
| Poquoson City | 2070 | 5710 |
| Poquoson City | 2080 | 5163 |
| Poquoson City | 2090 | 3685 |
| Poquoson City | 2100 | 2738 |
| Portsmouth City | 2020 | 1393 |
| Portsmouth City | 2030 | 1237 |
| Portsmouth City | 2040 | 1064 |
| Portsmouth City | 2050 | 891 |
| Portsmouth City | 2060 | 914 |
| Portsmouth City | 2070 | 951 |
| Portsmouth City | 2080 | 1019 |
| Portsmouth City | 2090 | 1190 |
| Portsmouth City | 2100 | 1550 |
| Prince George County | 2020 | 3849 |
| Prince George County | 2030 | 3587 |
| Prince George County | 2040 | 3390 |
| Prince George County | 2050 | 3191 |
| Prince George County | 2060 | 3139 |
| Prince George County | 2070 | 2961 |
| Prince George County | 2080 | 2396 |
| Prince George County | 2090 | 1376 |
| Prince George County | 2100 | 1081 |
| Prince William County | 2020 | 1962 |
| Prince William County | 2030 | 1992 |
| Prince William County | 2040 | 1619 |
| Prince William County | 2050 | 1602 |
| Prince William County | 2060 | 1540 |
| Prince William County | 2070 | 1257 |

| Locality | Year | Acres |
|---|---|---|
| Prince William County | 2080 | 1119 |
| Prince William County | 2090 | 750 |
| Prince William County | 2100 | 590 |
| Richmond City | 2020 | 378 |
| Richmond City | 2030 | 386 |
| Richmond City | 2040 | 396 |
| Richmond City | 2050 | 407 |
| Richmond City | 2060 | 405 |
| Richmond City | 2070 | 309 |
| Richmond City | 2080 | 131 |
| Richmond City | 2090 | 105 |
| Richmond City | 2100 | 105 |
| Richmond County | 2020 | 8249 |
| Richmond County | 2030 | 6653 |
| Richmond County | 2040 | 6367 |
| Richmond County | 2050 | 6063 |
| Richmond County | 2060 | 6047 |
| Richmond County | 2070 | 5791 |
| Richmond County | 2080 | 4600 |
| Richmond County | 2090 | 3059 |
| Richmond County | 2100 | 2594 |
| Spotsylvania County | 2020 | 51 |
| Spotsylvania County | 2030 | 43 |
| Spotsylvania County | 2040 | 42 |
| Spotsylvania County | 2050 | 51 |
| Spotsylvania County | 2060 | 53 |
| Spotsylvania County | 2070 | 55 |
| Spotsylvania County | 2080 | 57 |
| Spotsylvania County | 2090 | 60 |
| Spotsylvania County | 2100 | 64 |
| Stafford County | 2020 | 2308 |
| Stafford County | 2030 | 2291 |
| Stafford County | 2040 | 2222 |
| Stafford County | 2050 | 2039 |
| Stafford County | 2060 | 1958 |
| Stafford County | 2070 | 1718 |
| Stafford County | 2080 | 1442 |
| Stafford County | 2090 | 1019 |
| Stafford County | 2100 | 922 |

| Locality | Year | Acres |
|---|---|---|
| Suffolk City | 2020 | 8023 |
| Suffolk City | 2030 | 7989 |
| Suffolk City | 2040 | 7994 |
| Suffolk City | 2050 | 6784 |
| Suffolk City | 2060 | 6681 |
| Suffolk City | 2070 | 6339 |
| Suffolk City | 2080 | 5439 |
| Suffolk City | 2090 | 3614 |
| Suffolk City | 2100 | 2299 |
| Surry County | 2020 | 3742 |
| Surry County | 2030 | 3712 |
| Surry County | 2040 | 3679 |
| Surry County | 2050 | 3172 |
| Surry County | 2060 | 2951 |
| Surry County | 2070 | 2705 |
| Surry County | 2080 | 2154 |
| Surry County | 2090 | 1495 |
| Surry County | 2100 | 1253 |
| Virginia Beach City | 2020 | 40442 |
| Virginia Beach City | 2030 | 41330 |
| Virginia Beach City | 2040 | 41912 |
| Virginia Beach City | 2050 | 38559 |
| Virginia Beach City | 2060 | 39240 |
| Virginia Beach City | 2070 | 37797 |
| Virginia Beach City | 2080 | 28885 |
| Virginia Beach City | 2090 | 22857 |
| Virginia Beach City | 2100 | 23498 |
| Westmoreland County | 2020 | 4754 |
| Westmoreland County | 2030 | 4467 |
| Westmoreland County | 2040 | 4392 |
| Westmoreland County | 2050 | 4307 |
| Westmoreland County | 2060 | 4264 |
| Westmoreland County | 2070 | 4074 |
| Westmoreland County | 2080 | 3664 |
| Westmoreland County | 2090 | 3201 |
| Westmoreland County | 2100 | 3135 |
| Williamsburg City | 2020 | 110 |
| Williamsburg City | 2030 | 113 |
| Williamsburg City | 2040 | 117 |

| Locality | Year | Acres |
|---|---|---|
| Williamsburg City | 2050 | 92 |
| Williamsburg City | 2060 | 88 |
| Williamsburg City | 2070 | 82 |
| Williamsburg City | 2080 | 75 |
| Williamsburg City | 2090 | 54 |
| Williamsburg City | 2100 | 50 |
| York County | 2020 | 4790 |
| York County | 2030 | 4501 |
| York County | 2040 | 4135 |
| York County | 2050 | 3978 |
| York County | 2060 | 4047 |
| York County | 2070 | 4095 |
| York County | 2080 | 4024 |
| York County | 2090 | 3411 |
| York County | 2100 | 3384 |

*Table 5 Wetland area per locality by decade 2020-2100*

# Appendix 2

## R script for elevation reclassification

The following script documents how to calculate and extract relevant tidal elevations for potential marsh habitat.

```
library(terra)
library(foreach)
library(doParallel)
library(parallel)
library(sf)

# Data from NOAA 2022 Technical Report
# https://oceanservice.noaa.gov/hazards/sealevelrise/Sea_Level_Rise_Datasets_2022.zip
# Sewell's Point Intermediate Median values
int <- data.frame(
  year = seq(2020, 2100, by = 10),
  RSL = c(13, 23, 33, 44, 56, 70, 86, 106, 128)
)

# Tidal range
#
https://tidesandcurrents.noaa.gov/datums.html?datum=MLLW&units=1&epoch=0&id=8638610&na
me=Sewells+Point&state=VA
# Accessed 2022-04-27
MN <- 0.740
MLW <- 0.038
MHHW <- 0.840
MSL <- 0.412
ITR <- MHHW-MSL

MLW_NAVD88 <- -0.453
MSL_NAVD88 <- -0.079

# Convert RSL to m
int$MLW <- MLW_NAVD88 + int$RSL/100
int$RSL <- MSL_NAVD88 + int$RSL/100
int$upper <- int$MLW + 1.5*MN

# Read in the CBTBDEM raster
dem <- rast("//ccrmspace/vdot/RTE/GIS/VA_CBTBDEM_v2_1m.tif")

rmats <- list()
for(i in 1:nrow(int)){
  rmats[[i]] <- matrix(
    data = c(  -999, int$MLW[i], 0,
               int$MLW[i], int$upper[i], 1,
               int$upper[i], 999, 0),
    ncol = 3,
    byrow = TRUE
  )
}

cl <- parallel::makeCluster(4)
doParallel::registerDoParallel(cl)
foreach::foreach(i = seq_len(length(rmats)), .packages = c("terra")) %dopar% {
  dem <- terra::rast("V:/RTE/GIS/VA_CBTBDEM_v2_1m.tif")
  outname <- paste0("T:/watershed/PROJECTS/NOAACZMConservationTargeting/GIS/
                    DEMs/Reclass1m/WetPotential",
                    int$year[i],".tif")
  terra::classify(
```

```
    x = dem,
    rcl = rmats[[i]],
    filename = outname,
    datatype = "INT2S",
    gdal = c("COMPRESS=LZW")
  )
}
parallel::stopCluster(cl)

# Contours by year
uppers <- terra::as.contour(dem, levels = int$upper, maxcells = 1E11)
writeVector(uppers, filename =
"T:/watershed/PROJECTS/NOAACZMConservationTargeting/GIS/DEMs/UpperExtents20230203.shp"
, overwrite = TRUE)
mlws <- terra::as.contour(dem, levels = int$MLW, maxcells = 1E11)
writeVector(mlws, filename =
"T:/watershed/PROJECTS/NOAACZMConservationTargeting/GIS/DEMs/MLWExtents20230203.shp",
overwrite = TRUE)
```

# Appendix 3: Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 3 – Conservation Targeting for Resilience

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# COMMONWEALTH of VIRGINIA

## Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 3 - Conservation Targeting for Resilience

*Photo credit: Rob Evans*

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Virginia Department of Conservation and Recreation
Division of Natural Heritage
Natural Heritage Technical Report 24-04
March 2024

Virginia Department of Conservation & Recreation

# Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 3 – Conservation Targeting for Resilience

Final Report

**Submitted to:**
The Virginia Institute of Marine Science
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March 2024

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Cover photo: Savage Neck Dunes Natural Area Preserve

# Contents

## Executive Summary

Conservation practitioners have long worked to abate threats to biodiversity, including rare plants and animals, and exemplary natural communities. Land protection is a classic and effective strategy to do so, especially when the threats are well understood. However, climate change presents novel challenges to classic paradigms of conservation. Understanding and planning for the ongoing impacts of climate change is, arguably, most critical in the coastal zone portion of Virginia. Here, infrastructure, development, and converted lands consume much of the landscape and continue to expand, while sea-level rise is actively degrading documented biodiversity elements and previously established conservation areas. The coastal zone is also likely to experience some of the worst effects of climate change because of warmer temperatures, abnormal precipitation rates, sea level rise, and more violent storms. As the Virginia Natural Heritage Program (VNHP) and conservation partners in the region seek to proactively and strategically conserve biodiversity, it is imperative to consider resilience in light of these climate change stressors and impacts, so that conservation efforts can best fulfill their long-term goals.

Central to the mission of the VNHP is the maintenance of a statewide database (Biotics) of locations of rare plants and animals, and exemplary natural communities, collectively known as Natural Heritage Resources (NHR). Each location of an NHR is mapped as an Element Occurrence (EO), which includes the area of land and/or water where the element of biodiversity was observed. These locations have practical value for conservation partners seeking to protect biodiversity, as many of them are unlikely to be incidentally protected due to their geographic rarity. EOs are classified as “historic” if they have not been observed or otherwise verified within 30 years, at which point they are no longer used for conservation decisions. Keeping Biotics information current is essential, as EOs form the building blocks for many of the conservation tools developed by VNHP that have been widely incorporated into local, regional, and statewide planning tools, including the Coastal VEVA (Coastal Virginia Ecological Value Assessment), Coastal GEMS (Geospatial & Educational Mapping System), Virginia NHDE (Natural Heritage Data Explorer), ConserveVirgina, ConservationVision, and the Virginia Wildlife Corridor Action Plan.

This report is the culmination of a three-year focal project that prioritized EOs on resilient sites, surveyed those sites to update EOs and augment the Biotics database, and developed a strategy to conserve the highest priority EOs on resilient sites. In this final phase, the updated and new EO information from the field surveys was entered into Biotics, resulting in a more accurate and credible EO database for the Virginia Coastal Zone (VCZ). The updated Biotics data were then used to develop custom Essential Conservation Site (ECS) and Essential EO (EEO) datasets, for which results were scored relative to the VCZ instead of the entire state. ECS and EEO identify the best examples of each NHR and the Conservation Sites needed to preserve them. The ECS and EEO results were analyzed and compared with parcel data and conserved lands, and reviewed by the Site Conservation Assessment Team (SCAT), to develop a strategy to target conservation of the highest priority EOs on resilient sites in the VCZ. A spatial dataset comprising all the resilient ECS was developed, within which the individual tax parcels

supporting EEOs were identified. These parcels contain all or portions of EEOs that are within resilient ECS, while other parcels contribute to the long-term viability of the NHR. The SCAT review further ranked parcels using factors relevant to land acquisition (such as feasibility of successful stewardship, extent of needed restoration, landscape context, etc.) as well as other characteristics such as expert opinion and institutional knowledge of those parcels. The plan identifies parcels harboring EOs in need of urgent conservation action in the VCZ. The plan will be used internally by VNHP to target additions to existing State Natural Area Preserves or protection/dedication of new State Natural Area Preserves. Additionally, VNHP will share these data, under license agreements, with partners in other conservation agencies and land trusts to inform partners of the most critical parcels for conservation action within the VCZ. Finally, the updated Biotics database will provide more accurate data to guide ongoing field inventory and protection efforts, and inform conservation planning tools and resources like the Coastal VEVA.

The VCZ is home to about one-quarter of Virginia's rarest biodiversity and is under multiple threats, including sea-level rise and urbanization. Given the rates of change from these threats and pressures, any conservation planning must include up-to-date data on the location and condition of NHR. The data workflows developed for and used in this report, based on best available biodiversity data, show that there are lands within the coastal zone that are both resilient to climate change and contain NHR to be protected. Prioritizing the purchasing of these tracks or improving the protections on already owned lands would be prudent steps for VCZ partners to consider. To be successful, more funding for inventory, Biotics management, model development, and protection projects is needed.

## Introduction

Conservation practitioners have long worked to abate threats to biodiversity, including rare plants and animals, and exemplary natural communities. Land protection is a classic and effective strategy to do so, especially when the threats are well understood. However, climate change presents novel challenges to classic paradigms of conservation. Understanding and planning for the ongoing impacts of climate change is, arguably, most critical in the coastal zone portion of Virginia (Figure 1). Here, infrastructure, development, and converted lands consume much of the landscape and continue to expand, while sea-level rise is actively degrading documented biodiversity elements and previously established conservation areas. The coastal zone is also likely to experience some of the worst effects of climate change because of warmer temperatures, abnormal precipitation rates, sea level rise, and more violent storms. As the Virginia Natural Heritage Program (VNHP) and conservation partners in the region seek to proactively and strategically conserve biodiversity, it is imperative to consider resilience in light of these climate change stressors and impacts, so that conservation efforts can best fulfill their long-term goals.

Central to the mission of the VNHP is the maintenance of a statewide database (Biotics) of locations of rare plants and animals, and exemplary natural communities, collectively known as Natural Heritage Resources (NHR). Each location of an NHR is mapped as an Element Occurrence (EO), which includes the area of land and/or water where the element of biodiversity was observed. These locations have practical value for conservation partners seeking to protect biodiversity, as many of these them are unlikely to be incidentally protected due to their geographic rarity.  Keeping Biotics information current is essential, as EOs form the building blocks for many of the conservation tools developed by VNHP that have been widely incorporated into local, regional, and statewide planning tools, including the Coastal VEVA (Coastal Virginia Ecological Value Assessment), Coastal GEMS (Geospatial & Educational Mapping System), Virginia NHDE (Natural Heritage Data Explorer), ConserveVirgina, ConservationVision, and the Virginia Wildlife Corridor Action Plan.

The main conservation tool developed from EOs is a spatial layer of Conservation Sites, which are non-regulatory planning boundaries that surround one or more significant examples of NHRs, along with habitat and buffer to support their persistence.  With few exceptions, EOs that have not been observed in 30 years are automatically classified as "historic" and are no longer used to delineate Conservation Sites and are not taken into consideration during environmental review processes.  A more stringent cutoff of 25 years ("near-historic") is used to exclude features from VNHP's "Essential Conservation Sites" (ECS) prioritization process, which identifies the best examples of each NHR and the Conservation Sites needed to preserve them. Unfortunately, the designation of an EO as historic or near-historic can lead to undesirable conservation outcomes, by excluding from consideration areas that may still be worthy of protection.  In many cases, an EO may be designated "historic" simply because no recent surveys have been done in the area, even though the NHR may still be present and thriving at that location. To ensure that conservation efforts are targeted appropriately, it is important to prioritize the survey of resilient sites with suitable habitat where historic and near-historic NHR occurrences were found in the past.

This report is the culmination of a three-year focal project that prioritized EOs on resilient sites, surveyed those sites to update EOs and augment the Biotics database, and developed a strategy to conserve the highest priority EOs on resilient sites.  The following paragraphs will briefly describe the activities and results of the previous years of this focal project.

In Year 1, VNHP Information Management staff extracted from the Biotics database, the set of Procedural Features (PF, the individual polygons of NHR observations that comprise an EO) in the Virginia Coastal Zone (VCZ), added attributes that could be used for prioritization, and reviewed many of the features over imagery.  No spatial edits were made at this time, but relevant attribute fields were populated during the imagery review.  The purpose was to provide VNHP Inventory staff with a spatial dataset prioritized for targeting biological surveys during Year 2, which included the 2022 field season. To be considered a survey priority for this project, PF were required to be on "resilient" lands, i.e., intersecting at least one of the following:

- The Nature Conservancy's (TNC) Coastal Resilience (Resilient Tidal Complexes and Marsh Migration space) (Anderson and Barnett, 2017)
- TNC's Resilient and Connected Landscapes (Anderson et al., 2016)
- Virginia Natural Landscape Assessment's Natural Land Network Core Interiors
- Virginia Institute of Marine Science's Marsh Migration Priorities

Higher priorities were given to historic and near-historic EOs and in areas with greater numbers of species represented in the Potential Suitable Habitat Summary layer, which is a summary of species habitat models developed for all Virginia species listed under federal and/or state endangered or threatened species acts, as well as many globally rare species without government protections. The resulting spatial dataset of PFs contained attributes from the spatial analyses and imagery review assessments, with priority classes assigned to highlight PFs on resilient sites that were most in need of biological inventory and assessment. This dataset formed the basis of the biological inventory performed during Year 2 of the focal project.

In Year 2, VNHP botanists, ecologists, and zoologists used the prioritization developed in Year 1 to target field surveys of priority EOs on resilient sites. New surveys for priority EOs are warranted for at least two reasons. First, the status of EOs change over time as populations expand and contract, and as habitats are altered through natural and anthropogenic disturbance. Threats to EOs include invasive species competition, non-native pathogens, climate change/sea level rise, and more. Second, VNHP's understanding of the biological status and condition of Virginia's NHR has expanded over time. The natural heritage resource lists of rare plants (Townsend, 2022) and animals (Roble, 2022) have changed dramatically over the past 30 years, with over 100 rare plants and animals being recognized in Virginia and with other species being dropped from the list as they were recognized as being more common than previously thought. New groups of organisms, such as lesser-known invertebrates and non-vascular plants, are added to these lists as new information about them becomes available. Perhaps the greatest advances to our understanding of Virginia's biodiversity have been made in our understanding of natural communities. As a result of this, VNHP ecologists have revised the system of classification and naming of natural communities, while keeping it aligned with the federally mandated National Vegetation Classification System (Fleming et al., 2021).

This report highlights the final phase. In Year 3, the updated and new EO information from the Year 2 field surveys was entered into Biotics, resulting in a more accurate and credible EO database for the VCZ. The updated Biotics data were then used to develop a custom ECS of which results were scored relative to the VCZ instead of the entire state. The ECS and Essential EO (EEO) results were analyzed and compared with parcel data and conserved lands, and reviewed by the Site Conservation Assessment Team (SCAT), to develop a strategy to target conservation of the highest priority EOs on resilient sites in the VCZ. SCAT is a multidisciplinary team from the VNHP, including staff from the Protection, Inventory, Information Management, and Stewardship units, that collaboratively makes determinations about land conservation efforts to protect NHR. A spatial dataset comprising all the resilient ECS was developed, within which the individual tax parcels supporting EEOs were identified. These parcels contain all or portions of EEOs that are within resilient ECS. Furthermore, parcels thought to contribute to the long-term viability of the NHR, though not encompassing essential EOs, were also identified. The SCAT review further ranked parcels using factors relevant to land acquisition (such as feasibility of successful stewardship, extent of needed restoration, landscape context, etc.) as well as other characteristics such as expert opinion and institutional knowledge of those parcels. The plan identifies parcels harboring EOs in need of urgent conservation action in the VCZ. The plan will be used internally by VNHP to target additions to existing State Natural Area Preserves or protection/dedication of new State Natural Area Preserves. Additionally, VNHP will share these data, under license agreements, with partners in other conservation agencies and land trusts to inform partners of the most critical parcels for conservation action within the VCZ.

Finally, the updated Biotics database will provide more accurate data to guide ongoing field inventory and protection efforts, and inform conservation planning tools and resources like the Coastal VEVA (Coastal Virginia Ecological Value Assessment).

## Methods

### Updated EO and Conservation Site dataset for VA Coastal Zone

Following biological inventory work from the second year of this project (Chazal et al., 2023), we incorporated new or updated EOs into Biotics. EOs are geographically delineated areas comprised of one or more Source Features. Source Features are converted to "Procedural Features" (PFs) by adding a procedural buffer to point and line features (4.5 meters), to ensure that all PFs (and EOs) are polygons.

For new and/or expanded EOs, we created or updated their respective Conservation Sites, which are planning boundaries encompassing one or mapped locations of NHR, along with surrounding lands supporting the persistence of the resources present. VNHP delineates Conservation Sites for "site-worthy" PFs only. Site-worthiness is determined from attributes of both the PF and the EO it belongs to, including the occurrence's viability, origin status, spatial certainty, as well as the NHR's conservation status. A complete description of site-worthiness is included in the VNHP "ConSite Guide" technical report (VNHP Staff, 2023).

Once all EO and Conservation Site updates were completed, we extracted from Biotics all site-worthy PFs and Conservation Sites in the VCZ and compared them to the respective PF and Conservation Site layers used in the initial year of this project (extracted from Biotics in November 2021).

## Conservation Prioritization Analyses

### Essential Conservation Sites and Element Occurrences in the Coastal Zone

The ECS analysis is a prioritization process developed by VNHP to create a "portfolio" of EOs and Conservation Sites where protection is most needed to ensure the long-term persistence of each NHR. The full details of the ECS process are described in the ConSite Guide, and a general overview is provided below. The ECS methods have evolved gradually over time, and the process described is somewhat different than methods used in the first year of this project (Bucklin et al., 2022).

The ECS prioritization began with site-worthy EOs (i.e., those created using only site-worthy PFs) in the region of analysis. Some tracked elements are preemptively excluded from the prioritization due to data quality issues, and all EOs for those elements are ineligible for prioritization. In addition, EOs are ineligible if they are considered non-viable, or have last observations ≥25 years ago. Each included NHR is assigned a target number of EOs to include in the portfolio, depending on the NHR's global conservation status rank (G-rank). For the rarest NHR (G1), we seek to include 10 EOs. For G2 NHR, the goal is to include 5 EOs, and for the more common NHR (G3-G5), we seek to include 2 EOs. In practice, the target number of EOs for an element cannot always be achieved because there are not enough eligible EOs to fill the allotted portfolio slots.

Once portfolio targets are assigned, the ECS process assigns eligible EOs to one of five tiers as follows:

- **Irreplaceable**: the only eligible EO of the NHR, regardless of G-Rank
- **Critical**: one of only 2 eligible EOs of the NHR, regardless of G-Rank
- **Vital**: the highest-ranked eligible EO of the NHR (for NHR having 3 or more eligible EOs)
- **High Priority**: one of the remaining *N* highest-ranked eligible EOs, where *N* is the number of portfolio slots allotted for the NHR, depending on G-rank
- **General**: eligible EO(s) of lower rank which were not needed to meet the minimum number of portfolio slots allotted for the NHR

As described above, EOs are assigned to the Irreplaceable or Critical tiers due to rarity in the region of analysis. All other EOs are ranked using one or more criteria, such as estimated viability and last observation date, as needed to determine which of the NHR's EOs to include in the conservation portfolio, and their tier assignments.

Conservation Sites associated with one or more portfolio EOs are added to the portfolio, and assigned the tier of the highest-ranking EO with which they are associated. The EOs and Conservation Sites in the top four tiers (Irreplaceable Critical, Vital, or High Priority) are part of the final conservation portfolio and collectively designated as "Essential". All else equal, EEOs and ECS would be the highest priority for acquisition and stewardship by DCR and/or its partners, if not already protected.

The ECS methodology is applied statewide by VNHP for Terrestrial Conservation Sites, Stream Conservation Sites (SCS), and associated EOs, and updated every three months. For this project, a custom ECS was run for the subset of Terrestrial Conservation Sites and associated EOs in the VCZ. Note that SCS were not implemented by VNHP until September 2023, thus, they were not available for the custom ECS. The custom ECS coincided with a statewide ECS run from June 2023, allowing for a comparison of prioritization outcomes for the two different extents.

### Essential Conservation Sites Prioritization

From the custom ECS developed for the VCZ, we extracted the set of EEOs and ECS for the prioritization. To facilitate analysis, we converted EEOs represented by multiple polygons to single-part polygons (PFs) so that metrics could be calculated for each individual polygon. Metrics described in this section were calculated for each of the three spatial layers (PF, EEO, and ECS), so that conservation assessments could be tailored for any of the spatial scales. We initially calculated metrics for PFs and ECS, since these layers include single-part polygons only. Key scores and attributes were then calculated for EEOs using the mean metric value across the EEO's component PFs. In this report we refer to these three layers collectively as "Essential Features" or EF.

From the Virginia Tax Parcels dataset (Virginia Geographic Information Network, 2023), we extracted tax parcels within 100-m of any ECS, as potential candidates for further conservation assessments.

### *Climate change resilience*

We estimated the climate change resilience of ECS based on their overlap with "potentially resilient lands" (PRL) and models of projected sea level rise.

#### Potentially Resilient lands

For this project, PRL are defined as undeveloped lands that are identified in any of the 4 models listed below. Conceptually, these resilient lands should provide NHRs the best opportunity to survive, adapt and/or migrate as a response to climate change effects.

- Resilient Coastal Sites for Conservation in the Northeast and Mid-Atlantic US (Anderson and Barnett, 2017)
- Resilient and Connected Landscapes for Terrestrial Conservation (Anderson et al., 2016)
- VIMS Marsh Migration Conservation Priorities (M. Mitchell, personal communication, 2021)
- Ecological Cores from the Virginia Natural Landscape Assessment, Natural Land Network (VNHP, 2017)

Details on the selection of PRL from each dataset is included in the report for the first year of this project (Bucklin et al., 2022). PRL from all four datasets were extracted, merged, and dissolved into a single "resilient lands" polygon layer for the Coastal Zone. We then intersected the resilient lands layer with EF, identifying the proportion of each polygon covered by resilient land (attribute: *allresil_pc*).

#### Sea Level Rise

While sea level rise is expected to be a major impact of climate change, it had not been explicitly incorporated into any of the component resilience datasets used by this project. To quantify the impacts of sea level rise to EF in the VCZ, we used Coastal Flood Hazard feature layers from the Virginia DCR Coastal Resilience Master Plan Phase I (VDCR, 2021). The flood hazard layers were developed for one current (2020) and five future time periods (2040, 2060, 2080, and 2100). Each period includes water coverage extent for nine different stages, including mean low water (MLW), mean high water (MHW), and seven potential flood scenarios, ranging from 0.2% to 50% annual exceedance probability. Since we are primarily concerned with areas likely to experience permanent inundation, we selected the MLW and MHW projections from the 2080 period for use in this project. We then calculated the proportion of EF inundated under the MHW and MLW projections. We then calculated a sea level rise exposure metric as the mean of the two proportion values (attribute: *slr_exposure*).

#### Resilience Score

EF were then assigned a "Resilience Score", calculated as:

$$resilScore = \ allresil\_pc - slr\_exposure$$

Because the two input components are based on proportional coverage of polygons, the resulting Resilience Score can range from -1 ("not on resilient land and fully inundated in 2080") to 1 (“fully on resilient land and not exposed to coastal inundation in 2080”). The Resilience Score was divided into five classes (Table 1).

### *Protection Status*

We measured the protection status of ECS as a combination of conserved lands coverage and vulnerability to development.

#### Conserved lands

The VNHP maintains the Virginia Conservation Lands Database (VCLD), from which we acquired boundaries for all conservation lands in Virginia. We created a planar version of the VCLD polygons based on the Biodiversity Management Intent (BMI) score attribute, preferring the lowest-value BMI score (indicating stronger biodiversity management intent) in areas of overlap. For each EF, we calculated a “BMI Score”, which is a BMI-weighted sum of the polygon’s percent coverage of conserved lands. The BMI Score can range from 0-100, and is calculated using the formula below:

$$BMI_{Score} = PercBMI_1 * 1 + PercBMI_2 * 0.8 + PercBMI_3 * 0.6 + PercBMI_4 * 0.4$$

#### Development Vulnerability

The Virginia ConservationVision Development Vulnerability Model (“DVM”; VNHP, 2017) is a raster (gridded) layer that quantifies the predicted relative risk of conversion from "natural", rural, or other open space lands to urbanized or other built-up land uses. The DVM vulnerability values range from 0 (lowest vulnerability) to 100 (highest vulnerability), with the special values “-1” indicating fully protected (BMI-1) lands, and “101” indicating already-developed lands. The current DVM was developed using baseline data from 2019. We made several adjustments to the base DVM layer prior to use in this project. First, we used the June 2023 VCLD to update scores on conservation lands. We also reassigned BMI-1 lands from a value of -1 to 0 and reassigned already-developed lands from a value of 101 to “No Data”, so that the adjusted DVM layer values ranged from 0-100. We then summarized the mean DVM value within EF (attribute: *devVuln*). Since PF polygons were in some cases smaller than a single 30-m pixel in the DVM raster, we buffered the PFs by 15-m for this analysis.

#### Protection Status Score

Each Essential Feature was then assigned a “Protection Status Score”, calculated as:

$$protScore = BMI\_Score/100 - devVuln/100$$

Like the Resilience Score, the Protection Status Score ranges from -1, interpreted as “not on conserved lands and most vulnerable to development” to 1, interpreted as “fully protected by conserved lands with BMI-1”.

### *Protection Prioritization*

We considered Protection Priority for EF in the coastal zone to be a function of their climate change resilience and protection status. Thus, we calculated a Protection Priority Score using the following formula:

$$protPrior = [(resilScore + 1) * (protScore - 1)] \div 4$$

The Protection Priority Score ranges from 0-1, favoring the combination of higher Resilience Scores and lower Protection Status scores. EF having the minimum Resilience Score (-1; not resilient) or the maximum Protection Status score (1; fully protected) will always result in a score of 0, indicating the lowest protection priority.

### Protection Priority Summary

For both ECS and parcels, we then calculated a Protection Priority Summary score, to represent the relative overall value of each [site/parcel] polygon towards new or expanded protection of resilient, essential NHR in the Coastal Zone.

We first associated PFs with ECS and parcel polygons.[38] For each PF-polygon association, we calculated an adjusted Protection Priority score. The adjusted score modifies the PF's Protection Priority score based on the number of PFs included in the EO, and for parcels only, a distance decay factor incorporating the distance between boundaries from the PF to the parcel being scored:

$$protPrior_{adj} = protPrior * prop_{eo} * dist_{decay}$$

where:

$$prop_{eo} = 1 \div number\ of\ PFs\ in\ the\ EO$$

$$dist_{decay} = (100 - distance\ (m) from\ parcel\ to\ PF) \div 100$$

The Protection Priority Summary is the sum of the adjusted protection priorities (i.e. for all PF-polygon associations):

$$protPrior_{sum} = sum(protPrior_{adj})$$

Because the Protection Priority Summary score is a sum, there is no defined maximum value, and can be >1 when the polygon contains or is close to two or more EEOs. We applied a classification scheme to Protection Priority Summary scores, to categorize polygons into one of five prioritization classes (Table 2).

#### *Additional attributes*

Several additional fields were added to the EF and Parcel layers, providing attributes to assist conservation assessments. See Appendix A for the full list of fields included in the layers. A key field included in both the PF and parcels layers was a classified "Protection Coverage" attribute (*pfProt* and *parcelProt*, respectively), which can be used to quickly filter PF's and/or parcels based on their existing coverage by conserved lands. Table 3 describes the attribute assignment for this field.

## Site Conservation Action Team (SCAT) Review of Parcels

Although the land protection priority results of the three-year focal project may serve as stand-alone conservation targets in the VCZ, VNHP also considers additional prioritizations and analyses before committing resources to the long-term protection of natural areas and NHR. These include consistency with the Natural Heritage Plan (*in prep*) as well as internal conservation planning decisions made by the VNHP Site Conservation Action Team (SCAT). This project helped revise and formalize aspects of the SCAT review process.

SCAT reviewed those parcels with a Protection Priority Summary score greater than 0.75, categorized as "Very High Priority" parcels (Table 2). SCAT conducted desktop reviews of each Very High Priority parcel using current aerial imagery and PF. Each parcel was ranked into one of six subcategories according to its support of PF, as follows:

[38] We associated PFs with parcels when within 100-m of one another, measured between boundaries. Since Conservation Sites are designed around PFs, we only associated PFs with intersecting Conservation Sites. Thus, the distance decay factor was not used for the ECS calculation of Protection Priority Summary.

**SCAT 1** - parcels which overlap PF and lack developed features that would present incompatibility issues for permanent conservation;
**SCAT 2** - parcels that overlap PF but included minimal developed features such as structures, farm fields, artificial ponds, etc. that diminish overall conservation values of the given parcel;
**SCAT 3** - parcels lacking overlap with PF but which provide key NHR habitat;
**SCAT 4** - parcels lacking overlap with PF but which provide ecological buffer, bolster resilience, or advance manageability and stewardship (i.e., smoke buffers for prescribed burning activities);
**SCAT 5** - parcels with extensive development, that largely or completely hinder the conservation values.
**SCAT 6** - parcels on Military lands

Additionally, three parcels in the Very High Priority subset contained multi-part features such that multiple polygons were found to delineate property lines that appeared to be mapped as separate entities but were attributed with identical parcels identifying information (tax map number and/or PIN). These parcels were split into unique units for the purposes of SCAT protection planning, resulting in the original subset of 80 Very High Priority parcels increasing to 87 discrete property units.

## Results

### Element Occurrence and Conservation Site updates

Results of the field surveys carried out in Year 2 of this project are described in a previous report (Chazal et al., 2023). Reports from these surveys and other recent inventory work from the VCZ were entered into the Biotics database prior to June 2023. Compared to the EO data from the start of this project in November 2021, information for 58 new EO (from 40 unique NHR) were entered into the Biotics database. A further 164 EO (from 108 unique NHR) were updated to include new source features ($n$ = 135) and/or more recent observation dates ($n$ = 160; *mean change* = 9.6 years, *maximum change* = 36.4 years). A summary of EO updates by element group is provided in Table 4. The number of Terrestrial Conservation Sites in the VCZ increased over the course of the project, from 531 to 545. A total of 35 sites were newly created, while 21 sites no longer contained site-worthy PFs and were excluded from further use.

### Conservation Prioritization Analyses

#### *Essential Element Occurrences and Conservation Sites for the Coastal Zone*

A total of 1,589 site-worthy EOs and 545 Conservation Sites were utilized for the custom ECS analysis. From these, 734 EOs (from 374 unique elements) and 285 Conservation Sites were identified as essential relative to other coastal zone conservation sites. Table 5 summarizes EEO and ECS by prioritization tier.
The custom analysis resulted in more EO (13.6%, n=100) and Conservation Sites (9.5%, n=27) being designated as essential for the VCZ than in the concurrent statewide analysis.
Additionally, 26.8% ($n$ = 197) of EEOs and 22.1% ($n$ = 63) of Conservation Sites were assigned to

different tiers in the custom analysis. Except for one EEO and two ECS, all changes were the result of higher tier assignments in the VCZ analysis, due to the relative rarity of elements in the zone when compared to the rest of the state.

### *Essential Feature Prioritization*

As detailed in the methods, metrics describing Resilience, Protection Status, and Protection Priority were calculated for each Essential Feature (EF) layer. For brevity, in this section we mostly discuss results for EEOs only, though a summary for all EF layers is included in Table 6. The resilience scores of 472 of 734 EEOs suggest they will not be completely inundated by sea level rise (Figure 2). Further, 14.7% (*n* = 108) of EEOs had the maximum possible Resilience Score (1), being fully on resilient lands which are not vulnerable to sea level rise. The custom ECS associated with these EEOs are displayed by resilience scores in Figure 3.

For the Protection Status score, 72.9% (*n* = 535) of EEOs had scores above zero, indicating that the conservation lands BMI Score outweighed the development vulnerability score. Approximately 15.7% of EEOs (n = 115) had the maximum Protection Status score (1), being fully on conservation lands with a BMI rank of 1.

The Protection Priority Scores of EEOs, which combines the 2 preceding scores, ranged from 0-0.72, with 17.0% having the lowest possible score (0), due to already being protected on BMI 1 lands and/or very low resilience. In Figure 4, Protection Priority Scores of EEOs are represented in a scatter plot as a function of Resilience and Protection Status scores.

The Protection Priority Summary score for ECS and parcels are summarized in Table 7. Many parcels in the VCZ had Protection Priority Summary scores above zero (*n* = 6,264), indicating potential for new or expanded protection of resilient ECS. Smaller sets of parcels had scores ≥0.5 (*n* = 438) and ≥1 (*n* = 43). Most parcels with scores above zero were in the lowest protection coverage class (77.7%), meaning less than 10% of the parcel is conserved. Figure 5 depicts tax parcels by Parcel Protection Priority score class. Table 8 lists the locality and ECS associations of the 80 Very High Priority tax parcels in the VCZ.

### Conservation Targeting

Of the 38,211 parcels identified, 80 received Protection Priority Summary scores of >0.75, and thus were categorized as Very High Priority parcels (Figure 5). Of the 80 Very High Priority parcels, a total of 15 were excluded from further analyses and assessment due to being located on fully protected, BMI-1 conservation lands (*n = 3)*, being completely developed and unsuitable for land protection (*n* = 3) or being located on military installations (*n = 9).* Three parcels were split into discrete property units resulting in an increase in the number of Very High Priority parcels *(n = 7).* The SCAT results for Very High Priority tax parcels associated with ECS in the VCZ are summarized in Table 9. Following the categorical exclusions and additions, 72 Very High Priority parcels remained for further assessment.

Of the 72 parcels that remained, forty-four parcels were ranked SCAT 1, Twelve parcels were ranked SCAT 2, three parcels were ranked SCAT 3, four parcels were ranked SCAT 4, nine parcels were ranked SCAT 5 and fifteen parcels were ranked SCAT 6 (Figure 6, Table 9). Figure 7 shows ECS centroids in the VCZ intersecting very high priority parcels and the parcels' SCAT protection designations.

## Discussion

Virginia's Coastal Zone supports ~23% of the statewide documented EO and 32% of Virginia's EEO (Figure 8). The region also includes several "endemic" biodiversity elements, not found outside this region in VA. Examples of these endemics include natural communities such as Maritime Live Oak Forest and Sea-level Fen as well species such as Kentucky Lady's-slipper (*Cypripedium kentuckiense*), Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*), Glossy Swamp Snake (*Liodytes rigida*), Oak Toad (*Anaxyrus quercicus*), and Sea-Beach Knotweed (*Polygonum glaucum*). The large number of rarities that are under threat from development, climate factors, and other stressors are why this region has been a focal area for biodiversity conservation work. To this end, VNHP has established 30 different Natural Area Preserves in the region, comprising nearly 39,000 acres, at a combined acquisition cost of over $64,000,000. A few examples of other conservation investments in the region that are exemplary in terms of the large numbers of different NHRs they help protect include Assateague Island National Seashore and Chincoteague Island National Wildlife Refuge (together protecting ~ 30 NHR), Back Bay National Wildlife Refuge and False Cape State Park (together protecting ~ 47 NHR), First Landing State Park (29 NHR), Fisherman Island National Wildlife Refuge (21 NHR), Newport News Park and Grafton Ponds State Natural Area Preserve (together protecting 18 NHR), and Great Dismal Swamp National Wildlife Refuge (29 NHR). Some of these investments and exemplary conservation areas would not have been protected if not for the detailed knowledge of their biodiversity significance. In most cases, these supporting data are field collected, ranked using standardized methodology, and cataloged by VNHP in the Biotics database and tracked as EO. These data form the building blocks for many tools developed by VNHP that have been widely incorporated into statewide and regional planning tools, including the Coastal VEVA (Coastal Virginia Ecological Value Assessment), Coastal GEMS (Geospatial & Educational Mapping System), Virginia NHDE (Natural Heritage Data Explorer), ConserveVirginia, ConservationVision, and the Virginia Wildlife Corridor Action Plan. Thus data on the current location and condition of these biodiversity elements are fundamental and essential to decisions and assessments related to biodiversity conservation. Many conservation prioritizations and planning efforts would be incomplete and under-informed without EO data. Consequently, it is imperative that these data are current, accurate, and as comprehensive as possible.

This project resulted in 58 new and 164 updated EO records, 35 newly mapped conservation sites, and the elimination of 21 formerly significant sites. These updates will more accurately inform conservation and planning decisions in the VCZ. However, these updates reflect only a small percentage of the true informational updates needed. For example, approximately 495 EO were assigned to "high" or "very high" priority classes for inventory work in Year 2 of this project (Chazal et al., 2023) but only 61 of these were able to be updated with available funding in this project and related constraints. Therefore, supporting further inventory work to update EO should continue to be a high priority for the Virginia Coastal Zone Management Program and other partners to assure the highest quality data products and information to make land conservation decisions.

This project employed a "custom" analysis, using methods developed by VDNH, and applied to the geographic boundaries of the VCZ. Not surprisingly, these results contrasted between the same analyses conducted at the statewide level. VDNH recognizes that both boundaries have potential flaws based on reliance on boundaries that are not ecologically or biologically meaningful. In contrast, “ecoregions” have been developed by a host of entities (e.g., USEPA, USDA Forest Service, WWF, TNC and others) with near universal agreement that such units are more useful and relevant units for understanding ecological principles as well as setting conservation priorities (e.g., Smith et al. 2018). For future efforts VDNH proposes to conduct analyses using an appropriate set of ecoregions.

As noted above, existing resilience datasets do not explicitly incorporate ongoing and predicted sea-level rise. However, VDNH has attributed significant degradation of several existing Natural Area Preserves to this threat. For example, The Dameron Marsh Natural Area Preserve (Northumberland County) has lost a significant amount of land and beach (Figure 9). In addition, Mutton Hunk Fen Natural Area Preserve (Accomack County) has undergone a vegetational shift, resulting in the extirpation (or presumed extirpation) of 5 different biodiversity elements the preserve was established to protect (VNHP, unpublished data).

Data generated during this project reveal that these observations are not likely to be isolated cases. Resilient scores indicate that only ~ 64% of the VCZ EEO are resilient (n=472/734) (Figure 2). Of these, only 14.7% (*n* = 108) of EEOs analyzed had the maximum possible Resilience Score, indicating they are not vulnerable to sea level rise. This number is surprisingly low given the geographic extent of the VCZ, with so much of the region located so far inland from the coast. Prior to this study, the informal consensus on the most severe threat to biodiversity in the VCZ was development. However, our analysis shows that approximately 20% of EEO that are considered partially or wholly “protected” are not resilient. Examples given elsewhere in this report (e.g., Figure 9) further illustrate that even areas with the highest biodiversity management intent are not immune from external threats such as sea-level rise (see cover photo, Savage Neck Dunes Natural Area Preserve). At this time, VNHP is unaware of any conservation measures which will counter sea-level rise and improve the protection and resilience of already protected lands. However, this project does prioritize parcels which are resilient and contain NHR in need of protection. In addition, the policies and actions on already protected lands with high resilience could be strengthened to improve protection.

### Protection Priorities

Identifying Protection Priorities for EEO using the approach suggested by models developed and presented here would target the lands with the highest scores (Figure 4, upper left quadrant), as they are both most resilient and least protected. The second highest protection priorities are identified as lands of high resilience but with insufficient protection (Figure 4, left 2/3 of the upper right quadrant). EEO represented in the lower left and right quadrants of Figure 4 would need to be evaluated further to confirm their low resilience before investments in land conservation were made. This project highlights the complexities involved in identifying and selecting parcels of land for conservation purposes.

The Protection Priority scores for tax parcels associated with sites represented in the custom ECS are shown in Figure 5. As with the EEO, a Protection Priority score of zero (0) means that the parcel is either already sufficiently protected or it may not be worthy of conservation investments. A majority of parcels, about 78%, scored above zero but had less than 10% of their area conserved. The highest priority parcels (classified as Very High Priority, with scores > 0.75) were further reviewed by SCAT. This additional review necessitated development of an additional standardized scoring approach to ensure that parcels were consistently assigned and ranked. The rank assignments and their distributions are shown in Figure 6.

Certain parcels indicated in Figure 5 may qualify as protection candidates for state and federal conservation agencies, conservation NGO, and land trusts within VCZ. Some figures in this report have been redacted (i.e., Figures 3 and 5) because they, and their underlying data, include sensitive location data. However, the full strategy, and its underlying data, would be available to partners under license agreement. In addition, the updated EO database will inform conservation planning tools developed by VNHP and be included in the next update of the Coastal Virginia Ecological Value Assessment (CVEVA) and Natural Heritage Data Explorer.

### Summary and Conclusions

The VCZ is home to about one-quarter of Virginia's rarest biodiversity and is under multiple threats, including sea-level rise and urbanization. Given the rates of change from these threats and pressures, any conservation planning must include up-to-date data on the location and condition of NHR. The data workflows developed for and used in this report, based on best available biodiversity data, show that there are lands within the coastal zone that are both resilient to climate change and contain NHR to be protected. Prioritizing the purchasing of these tracks or improving the protections on already owned lands would be a prudent step for VCZ partners to consider. To be successful, more funding for inventory, Biotics management, model development, and protection projects is needed.

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## Tables

*Table 6. Resilience Score classes for Essential Features.*

| Class Value | Class Name | Resilience Score range |
|---|---|---|
| **4** | Outstanding resilience | (0.9 – 1] |
| **3** | High resilience | (0.5 – 0.9] |
| **2** | Medium resilience | (0 – 0.5] |
| **1** | Low resilience | (-0.5 – 0] |
| **0** | Not resilient | [-1 – -0.5] |

*Table 7. Protection Priority Score classes for Essential Element Occurrence Procedural Features and tax parcels.*

| Class Value | Class Name | Protection Priority Score range |
|---|---|---|
| **5** | Very High Priority | > 0.75 |
| **4** | High Priority | (0.5 – 0.75] |
| **3** | Medium Priority | (0.25 – 0.5] |
| **2** | Low Priority | (0.125 – 0.25] |
| **1** | Very Low Priority | [0 – 0.125] |

*Table 8. Protection Coverage classes assigned to Essential Element Occurrence Procedural Features and tax parcels.*

| Protection Coverage Class | All conserved lands coverage | Conserved lands with BMI 1 coverage |
|---|---|---|
| **0: not conserved** | <10% | <10% |
| **1: partially conserved** | 10% – 95% | <95% |
| **2. conserved (not fully BMI 1)** | ≥95% | <95% |
| **3. conserved (BMI 1)** | ≥95% | ≥95% |

*Table 4. Number of new or updated Element Occurrences in the Coastal Zone over the course of the project (2021-2023), by element group. The "Vertebrate Animal" type also includes one updated EO for a Bird Nesting Colony.*

| Element Group | New Element Occurrences | Updated Element Occurrences | Total |
|---|---|---|---|
| **Vertebrate Animal** | 5 | 11 | 16 |
| **Invertebrate Animal** | 5 | 20 | 25 |
| **Vascular Plant** | 35 | 95 | 130 |
| **Non-vascular Plant** | 1 | 1 | 2 |
| **Natural Community** | 12 | 37 | 49 |

*Table 5. Element Occurrence and Conservation Site counts from the Virginia Coastal Zone Conservation Portfolio analysis. The top four tiers (Irreplaceable, Critical, Vital, and High Priority) are included in the portfolio and considered "Essential".*

| Prioritization Tier | No. of Element Occurrences | No. of Conservation Sites |
|---|---|---|
| **Irreplaceable** | 142 | 69 |
| **Critical** | 184 | 74 |
| **Vital** | 111 | 24 |
| **High Priority** | 297 | 118 |
| **General** | 458 | 173 |
| **N/A (not eligible)** | 397 | 87 |

*Table 9. Means and ranges of scores calculated for Essential Features.*

| Essential Feature layer | Count | Resilience score | Protection Status score | Protection Priority score |
|---|---|---|---|---|
| **Procedural Features** | 3071 | 0.39 (-1 – 1) | 0.45 (-0.96 – 1) | 0.17 (0 – 0.88) |
| **Element Occurrences** | 734 | 0.37 (-1 – 1) | 0.40 (-0.95 – 1) | 0.19 (0 – 0.72) |
| **Conservation Sites** | 285 | 0.22 (-1 – 0.99) | 0.04 (-0.93 – 1) | 0.29 (0 – 0.68) |

*Table 7. Means and ranges of Protection Priority Summary scores and associated EOs for Essential Conservation Sites and tax parcels. The count and summaries for tax parcels includes only those parcels which were associated with at least one EO.*

| Layer | Count | Protection Priority Summary score | Sum of Proportional EOs associated | Number of Unique Elements associated |
|---|---|---|---|---|
| **Conservation Sites** | 285 | 0.47 (0 – 11.81) | 2.58 (0.03 – 46.98) | 2.87 (1 – 40) |
| **Tax parcels** | 7805 | 0.10 (0 – 6.36) | 0.68 (0.02 – 31.88) | 1.48 (1 – 31) |

*Table 8. Locality and Essential Conservation Site associations of 80 Very High Priority tax parcels in the Coastal Zone.*

| Essential Conservation Site | Parcel Count | Locality |
|---|---|---|
| ASSAWOMAN CREEK FEN | 1 | Accomack County |
| BALLARD CREEK RAVINES | 1 | York County |
| BLACK SWAMP RAVINES AND FLATWOODS; KING CREEK RAVINE; BLOWS MILL RUN; HALSTEAD ROAD SINKHOLE PONDS; ROOSEVELT POND RAVINES | 1 | York County |
| BLANTONS POWERLINE | 2 | Caroline County |
| BUCK HILL; BULL RUN BLUFFS AND LOWLANDS; BALD HILL | 1 | Prince William County |
| CAT PONDS | 3 | Isle of Wight County |
| CHESTER SEEPS | 3 | Chesterfield County |

| | | |
|---|---|---|
| COARDS BRANCH POND | 2 | Accomack County |
| COBB ISLAND | 1 | Northampton County |
| DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS | 1 | Fauquier County |
| DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS; NORTHWESTERN QUANTICO SLOPES; CAMP BARRETT RAVINES; AQUIA - CANNON - LONG BRANCH TRIBUTARY SLOPES; PRINCE WILLIAM FALL-LINE SLOPES | 1 | Stafford County |
| DISPUTANTA | 2 | Prince George County |
| DRAGON RUN | 1 | Middlesex County |
| FIRST LANDING - FORT STORY | 2 | Virginia Beach City |
| FISHERMANS ISLAND | 1 | Northampton County |
| GREAT DISMAL SWAMP | 1 | Suffolk City |
| GREAT DISMAL SWAMP: NORTHWEST SECTION | 1 | Suffolk City |
| GROVE CREEK | 2 | James City County |
| HARROD LANE POND | 9 | York County |
| HORNET CANE WOODS; OCEANA PONDS AND FOREST; VACAPES SANDPIT PONDS AND DUNES; LONDON BRIDGE FOREST; OCEANA AT HORNET DRIVE | 1 | Virginia Beach City |
| HUNTLEY MEADOWS; ACCOTINK WETLANDS; POHICK CREEK; AREA T-17 RAVINES; ACCOTINK CREEK NEAR FARRAR DRIVE; DOGUE CREEK WETLANDS | 1 | Fairfax County |
| KILBY NORTHWEST POWERLINE | 3 | Suffolk City |
| LITTLE COBB ISLAND; COBB ISLAND | 1 | Northampton County |
| LOWER COLLEGE RUN | 1 | Surry County |
| MOUNT CREEK SLOPES - LYON ROAD; MARTINS CORNER - NAULAKLA TRIBUTARY; BRANDYWINE; GOULDMANS CORNER; MARACOSSIC CREEK; ROLLINS FORK RAVINES; HERNS POND TRAILS; UPPER WARE CREEK - MEADOW CREEK EAST; HICKORY FORK - MASHBOX RUN SEEPS; CARTERS CORNER; CATTLET CREEK - TURKEY TRACK CREEK; GOLDENVALE CREEK TRIB JAMBOREE AREA; MILL CREEK SLOPES - WILCOX CAMP SEEP | 1 | Caroline County |
| NA | 4 | York County |
| NI RIVER MASSAPONAX FLATWOODS | 5 | Spotsylvania County |
| OCEANA PONDS AND FOREST | 1 | Virginia Beach City |

| | | |
|---|---|---|
| OYSTER POINT ROW | 5 | Newport News City |
| PIPSICO FOREST - EASTOVER RAVINES | 1 | Surry County |
| POTOMAC GORGE | 6 | Fairfax County |
| REEDY CREEK SEEPS | 2 | Caroline County |
| ROUTE 618 PINE BARRENS | 1 | Isle of Wight County |
| SOUTH QUAY | 2 | Southampton County |
| SOUTH QUAY | 1 | Suffolk City |
| SOUTHERN BULL RUN MOUNTAINS | 5 | Fauquier County |
| ST. MARYS CHURCH POWERLINE | 1 | Suffolk City |
| SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | 6 | Prince William County |
| VULCAN GAINESVILLE TRACT | 1 | Prince William County |
| WALLOPS - ASSAWOMAN ISLANDS | 1 | Accomack County |
| WRECK ISLAND | 1 | Northampton County |

*Table 9. Site Conservation Assessment Team (SCAT) results for Very High Priority tax parcels associated with Essential Conservation Sites in the Coastal Zone.*

| Locality | SCAT Score | Essential Conservation Site Name | Site - Parcel Identifier |
|---|---|---|---|
| Accomack County | 1 | ASSAWOMAN CREEK FEN | ASSAWOMAN CREEK FEN - 1 |
| Accomack County | 1 | COARDS BRANCH POND | COARDS BRANCH POND - 1 |
| Accomack County | 1 | COARDS BRANCH POND | COARDS BRANCH POND - 2 |
| Accomack County | 6 | WALLOPS - ASSAWOMAN ISLANDS | WALLOPS - ASSAWOMAN ISLANDS - 1 |
| Caroline County | 1 | BLANTONS POWERLINE | BLANTONS POWERLINE - 1 |
| Caroline County | 1 | BLANTONS POWERLINE | BLANTONS POWERLINE - 2 |
| Caroline County | 6 | MOUNT CREEK SLOPES - LYON ROAD; MARTINS CORNER - NAULAKLA TRIBUTARY; BRANDYWINE; GOULDMANS CORNER; MARACOSSIC CREEK; ROLLINS FORK RAVINES; HERNS POND TRAILS; UPPER WARE CREEK - MEADOW CREEK EAST; HICKORY FORK - MASHBOX RUN SEEPS; CARTERS CORNER; CATTLET CREEK - TURKEY TRACK CREEK; GOLDENVALE CREEK TRIB JAMBOREE AREA; MILL CREEK SLOPES - WILCOX CAMP SEEP | MOUNT CREEK SLOPES - LYON ROAD; MARTINS CORNER - NAULAKLA TRIBUTARY; BRANDYWINE; GOULDMANS CORNER; MARACOSSIC CREEK; ROLLINS FORK RAVINES; HERNS POND TRAILS; UPPER WARE CREEK - MEADOW CREEK EAST; HICKORY FORK - MASHBOX RUN SEEPS; CARTERS CORNER; CATTLET CREEK - TURKEY TRACK CREEK; GOLDENVALE CREEK TRIB JAMBOREE AREA; |

| Locality | SCAT Score | Essential Conservation Site Name | Site - Parcel Identifier |
|---|---|---|---|
| | | | MILL CREEK SLOPES - WILCOX CAMP SEEP - 1 |
| Caroline County | 4 | REEDY CREEK SEEPS | REEDY CREEK SEEPS - 1 |
| Caroline County | 1 | REEDY CREEK SEEPS | REEDY CREEK SEEPS - 2 |
| Chesterfield County | 1 | CHESTER SEEPS | CHESTER SEEPS - 1 |
| Chesterfield County | 1 | CHESTER SEEPS | CHESTER SEEPS - 2 |
| Chesterfield County | 1 | CHESTER SEEPS | CHESTER SEEPS - 3 |
| Fairfax County | 6 | HUNTLEY MEADOWS; ACCOTINK WETLANDS; POHICK CREEK; AREA T-17 RAVINES; ACCOTINK CREEK NEAR FARRAR DRIVE; DOGUE CREEK WETLANDS | HUNTLEY MEADOWS; ACCOTINK WETLANDS; POHICK CREEK; AREA T-17 RAVINES; ACCOTINK CREEK NEAR FARRAR DRIVE; DOGUE CREEK WETLANDS - 1 |
| Fairfax County | 2 | POTOMAC GORGE | POTOMAC GORGE - 1 |
| Fairfax County | 2 | POTOMAC GORGE | POTOMAC GORGE - 2 |
| Fairfax County | 1 | POTOMAC GORGE | POTOMAC GORGE - 3 |
| Fairfax County | 1 | POTOMAC GORGE | POTOMAC GORGE - 4 |
| Fairfax County | 1 | POTOMAC GORGE | POTOMAC GORGE - 5 |
| Fairfax County | 1 | POTOMAC GORGE | POTOMAC GORGE - 6 |
| Fauquier County | 6 | DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS | DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS - 1 |
| Fauquier County | 1 | SOUTHERN BULL RUN MOUNTAINS | SOUTHERN BULL RUN MOUNTAINS - 1 |
| Fauquier County | 1 | SOUTHERN BULL RUN MOUNTAINS | SOUTHERN BULL RUN MOUNTAINS - 2 |
| Fauquier County | 1 | SOUTHERN BULL RUN MOUNTAINS | SOUTHERN BULL RUN MOUNTAINS - 3 |

| Locality | SCAT Score | Essential Conservation Site Name | Site - Parcel Identifier |
|---|---|---|---|
| Fauquier County | 1 | SOUTHERN BULL RUN MOUNTAINS | SOUTHERN BULL RUN MOUNTAINS - 4 |
| Fauquier County | 1 | SOUTHERN BULL RUN MOUNTAINS | SOUTHERN BULL RUN MOUNTAINS - 5 |
| Isle of Wight County | 1 | CAT PONDS | CAT PONDS - 1 |
| Isle of Wight County | 1 | CAT PONDS | CAT PONDS - 2 |
| Isle of Wight County | 1 | CAT PONDS | CAT PONDS - 3 |
| Isle of Wight County | 2 | ROUTE 618 PINE BARRENS | ROUTE 618 PINE BARRENS - 1 |
| James City County | 2 | GROVE CREEK | GROVE CREEK - 1 |
| James City County | 1 | GROVE CREEK | GROVE CREEK - 2 |
| Middlesex County | 1 | DRAGON RUN | DRAGON RUN - 1 |
| Newport News City | 5 | OYSTER POINT ROW | OYSTER POINT ROW - 1 |
| Newport News City | 5 | OYSTER POINT ROW | OYSTER POINT ROW - 2 |
| Newport News City | 5 | OYSTER POINT ROW | OYSTER POINT ROW - 3 |
| Newport News City | 5 | OYSTER POINT ROW | OYSTER POINT ROW - 4 |
| Newport News City | 1 | OYSTER POINT ROW | OYSTER POINT ROW - 5 |
| Northampton County | 6 | COBB ISLAND | COBB ISLAND - 1 |
| Northampton County | 1 | FISHERMANS ISLAND | FISHERMANS ISLAND - 1 |
| Northampton County | 6 | LITTLE COBB ISLAND; COBB ISLAND | LITTLE COBB ISLAND; COBB ISLAND - 1 |
| Northampton County | 6 | WRECK ISLAND | WRECK ISLAND - 1 |
| Prince George County | 1 | DISPUTANTA | DISPUTANTA - 1 |
| Prince George County | 1 | DISPUTANTA | DISPUTANTA - 2 |
| Prince William County | 1 | BUCK HILL; BULL RUN BLUFFS AND LOWLANDS; BALD HILL | BUCK HILL; BULL RUN BLUFFS AND LOWLANDS; BALD HILL - 1 |

| Locality | SCAT Score | Essential Conservation Site Name | Site - Parcel Identifier |
|---|---|---|---|
| Prince William County | 4 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 1 |
| Prince William County | 1 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 2 |
| Prince William County | 1 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 3 |
| Prince William County | 6 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 4 |
| Prince William County | 6 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 5 |
| Prince William County | 6 | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park | SUDLEY SPRINGS DIABASE RIDGE; Poplar Ford Park - 6 |
| Prince William County | 1 | VULCAN GAINESVILLE TRACT | VULCAN GAINESVILLE TRACT - 1 |
| Southampton County | 1 | SOUTH QUAY | SOUTH QUAY - 1 |
| Southampton County | 1 | SOUTH QUAY | SOUTH QUAY - 2 |
| Spotsylvania County | 4 | NI RIVER MASSAPONAX FLATWOODS | NI RIVER MASSAPONAX FLATWOODS - 1 |
| Spotsylvania County | 4 | NI RIVER MASSAPONAX FLATWOODS | NI RIVER MASSAPONAX FLATWOODS - 2 |
| Spotsylvania County | 2 | NI RIVER MASSAPONAX FLATWOODS | NI RIVER MASSAPONAX FLATWOODS - 3 |
| Spotsylvania County | 2 | NI RIVER MASSAPONAX FLATWOODS | NI RIVER MASSAPONAX FLATWOODS - 4 |
| Spotsylvania County | 1 | NI RIVER MASSAPONAX FLATWOODS | NI RIVER MASSAPONAX FLATWOODS - 5 |
| Stafford County | 6 | DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS; NORTHWESTERN QUANTICO SLOPES; CAMP BARRETT RAVINES; AQUIA - CANNON - LONG BRANCH TRIBUTARY SLOPES; PRINCE WILLIAM FALL-LINE SLOPES | DAVIDS CROSSROADS - CANNON CREEK GRASSLANDS; NORTHWESTERN QUANTICO SLOPES; CAMP BARRETT RAVINES; AQUIA - CANNON - LONG BRANCH TRIBUTARY SLOPES; PRINCE WILLIAM FALL-LINE SLOPES - 1 |
| Suffolk City | 1 | GREAT DISMAL SWAMP | GREAT DISMAL SWAMP - 1 |
| Suffolk City | 1 | GREAT DISMAL SWAMP: NORTHWEST SECTION | GREAT DISMAL SWAMP: NORTHWEST SECTION - 1 |
| Suffolk City | 2 | KILBY NORTHWEST POWERLINE | KILBY NORTHWEST POWERLINE - 1 |

| Locality | SCAT Score | Essential Conservation Site Name | Site - Parcel Identifier |
|---|---|---|---|
| Suffolk City | 1 | KILBY NORTHWEST POWERLINE | KILBY NORTHWEST POWERLINE - 2 |
| Suffolk City | 1 | KILBY NORTHWEST POWERLINE | KILBY NORTHWEST POWERLINE - 3 |
| Suffolk City | 2 | SOUTH QUAY | SOUTH QUAY - 3 |
| Suffolk City | 1 | ST. MARYS CHURCH POWERLINE | ST. MARYS CHURCH POWERLINE - 1 |
| Surry County | 1 | LOWER COLLEGE RUN | LOWER COLLEGE RUN - 1 |
| Surry County | 2 | PIPSICO FOREST - EASTOVER RAVINES | PIPSICO FOREST - EASTOVER RAVINES - 1 |
| Virginia Beach City | 1 | FIRST LANDING - FORT STORY | FIRST LANDING - FORT STORY - 1 |
| Virginia Beach City | 6 | FIRST LANDING - FORT STORY | FIRST LANDING - FORT STORY - 2 |
| Virginia Beach City | 6 | HORNET CANE WOODS; OCEANA PONDS AND FOREST; VACAPES SANDPIT PONDS AND DUNES; LONDON BRIDGE FOREST; OCEANA AT HORNET DRIVE | HORNET CANE WOODS; OCEANA PONDS AND FOREST; VACAPES SANDPIT PONDS AND DUNES; LONDON BRIDGE FOREST; OCEANA AT HORNET DRIVE - 1 |
| Virginia Beach City | 6 | OCEANA PONDS AND FOREST | OCEANA PONDS AND FOREST - 1 |
| York County | 1 | BALLARD CREEK RAVINES | BALLARD CREEK RAVINES - 1 |
| York County | 6 | BLACK SWAMP RAVINES AND FLATWOODS; KING CREEK RAVINE; BLOWS MILL RUN; HALSTEAD ROAD SINKHOLE PONDS; ROOSEVELT POND RAVINES | BLACK SWAMP RAVINES AND FLATWOODS; KING CREEK RAVINE; BLOWS MILL RUN; HALSTEAD ROAD SINKHOLE PONDS; ROOSEVELT POND RAVINES - 1 |
| York County | 5 | HARROD LANE POND | HARROD LANE POND - 1 |
| York County | 3 | HARROD LANE POND | HARROD LANE POND - 2 |
| York County | 3 | HARROD LANE POND | HARROD LANE POND - 3 |
| York County | 3 | HARROD LANE POND | HARROD LANE POND - 4 |
| York County | 2 | HARROD LANE POND | HARROD LANE POND - 5 |
| York County | 2 | HARROD LANE POND | HARROD LANE POND - 6 |
| York County | 2 | HARROD LANE POND | HARROD LANE POND - 7 |
| York County | 1 | HARROD LANE POND | HARROD LANE POND - 8 |
| York County | 1 | HARROD LANE POND | HARROD LANE POND - 9 |
| York County | 5 | NA | NA - 1 |
| York County | 5 | NA | NA - 2 |
| York County | 5 | NA | NA - 3 |
| York County | 5 | NA | NA - 4 |

# Figures

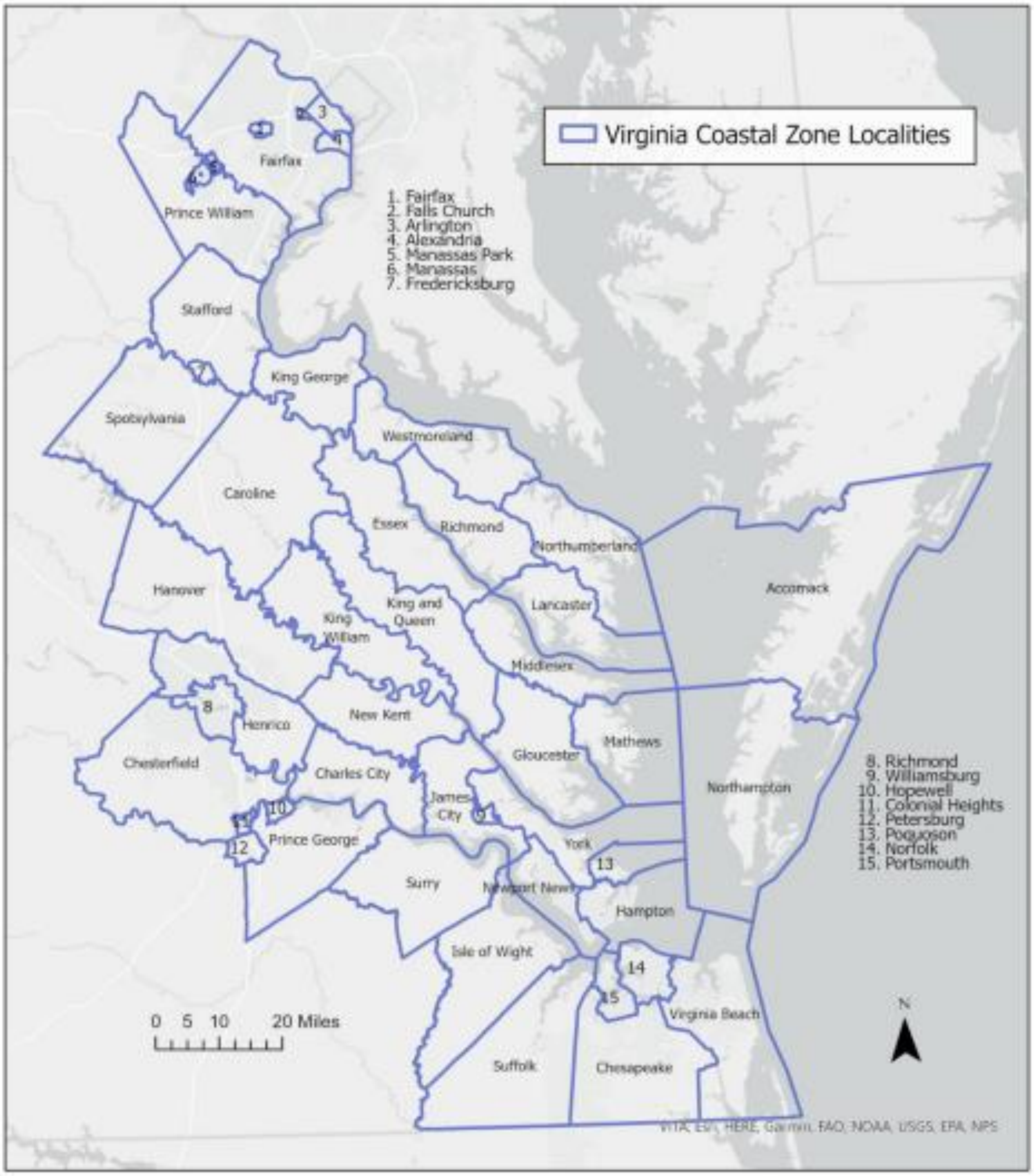


*Figure 1. Localities in the Virginia Coastal Zone, used to define the study area for this project.*

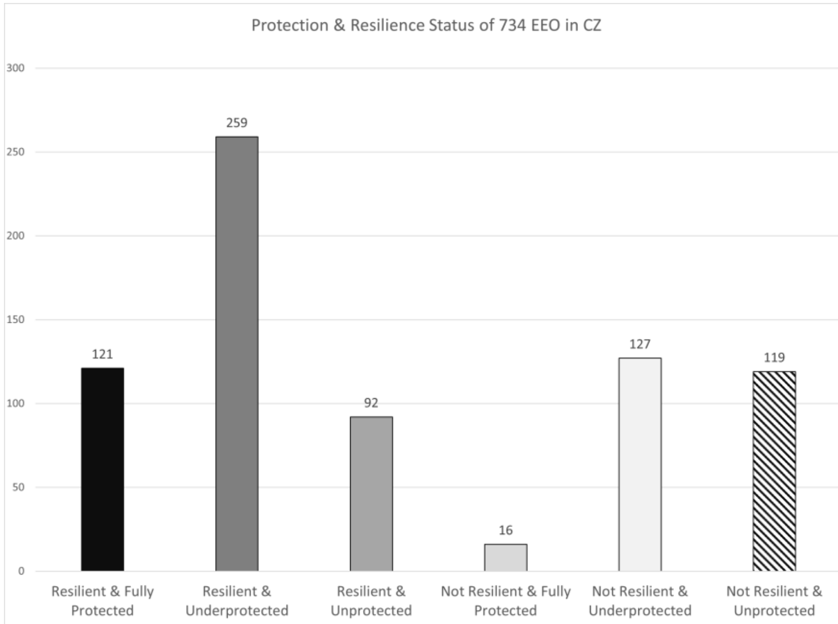


*Figure 2. Estimated resilience and protection status of the custom Essential Element Occurrences developed for the Virginia Coastal Zone.*

REDACTED *Figure 3. Map of Resilience Scores for custom Essential Conservation Sites in the Coastal Zone. To access this figure, contact the Virginia Department of Conservation and Recreation Natural Heritage Program*

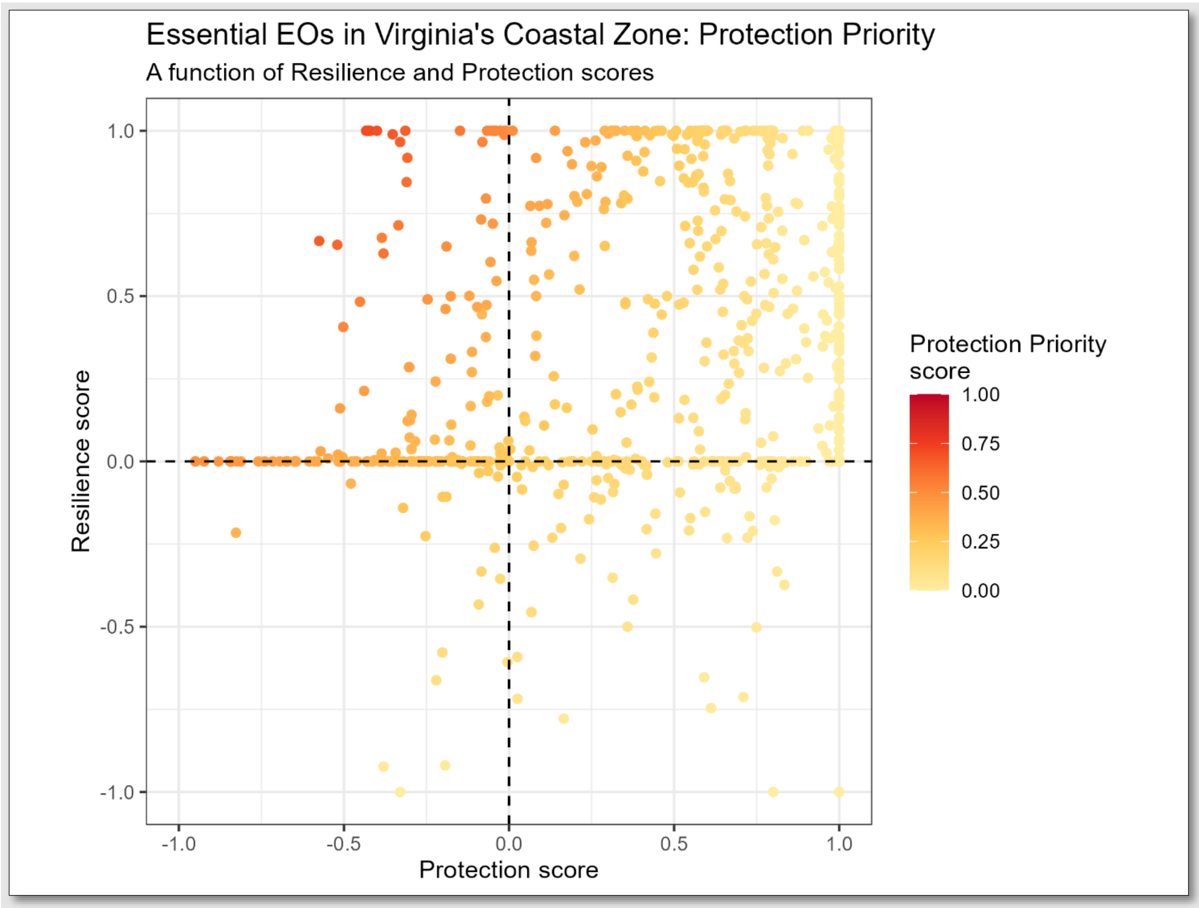


*Figure 4. Scatter plot displaying Protection Priority Scores for custom Essential EOs in the Coastal Zone, as a function of Resilience and Protection Status scores.*

REDACTED. *Figure 5. Map of Protection Priority scores for tax parcels associated with custom Essential Conservation Sites in the Coastal Zone. To access this figure, contact the Virginia Department of Conservation and Recreation Natural Heritage Program*

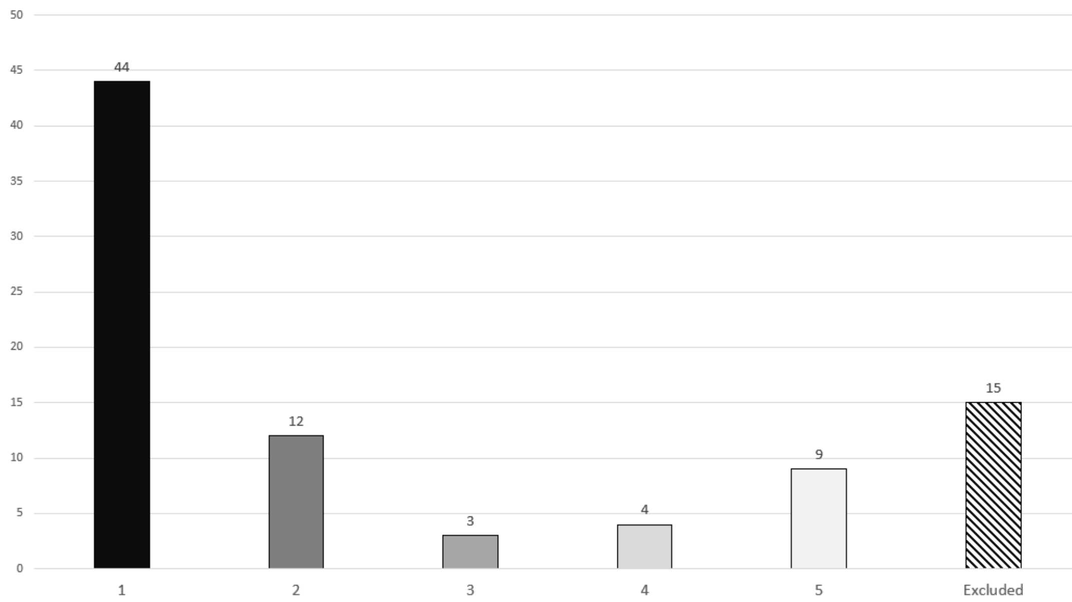


*Figure 6. Distribution of Site Conservation Action Team (SCAT) protection priority ranks for 80 Very High Priority tax parcels associated with custom Essential Conservation Sites in the Coastal Zone. The ranks are: SCAT 1 - parcels which overlap Procedural Feature (PF) and lack developed features that would present incompatibility issues for permanent conservation; SCAT 2 - parcels that overlap PF but included minimal developed features such as structures, farm fields, artificial ponds, etc. that diminish overall conservation values of the given parcel; SCAT 3 - parcels lacking overlap with PF but which provide key NHR habitat; SCAT 4 - parcels lacking overlap with PF but which provide ecological buffer, bolster resilience, or advance manageability and stewardship (i.e., smoke buffers for controlled burning activities); SCAT 5 - parcels with extensive development, that largely or completely hinder the conservation values; SCAT 6 - parcels on Military lands.*

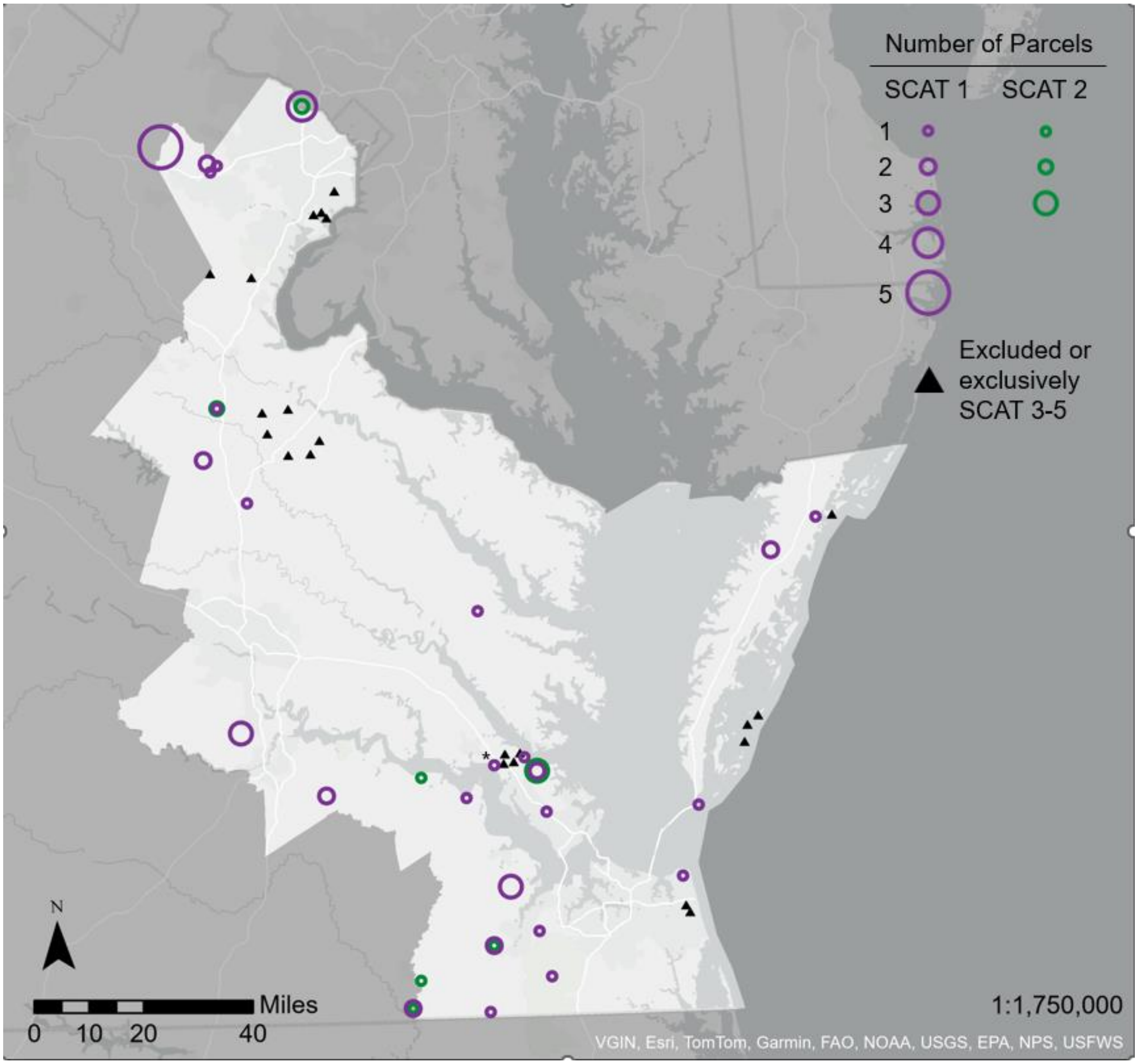


*Figure 7. Custom Essential Conservation Site centroids in the Virginia Coastal Zone intersecting very high priority parcels, symbolized by Site Conservation Action Team (SCAT) protection designations for the parcels, as well at the number of parcels at a location with the same designation. The asterisk indicates a site with the same number of parcels at each designation (i.e., 1 SCAT 1 parcel and 1 SCAT 2 parcel).*

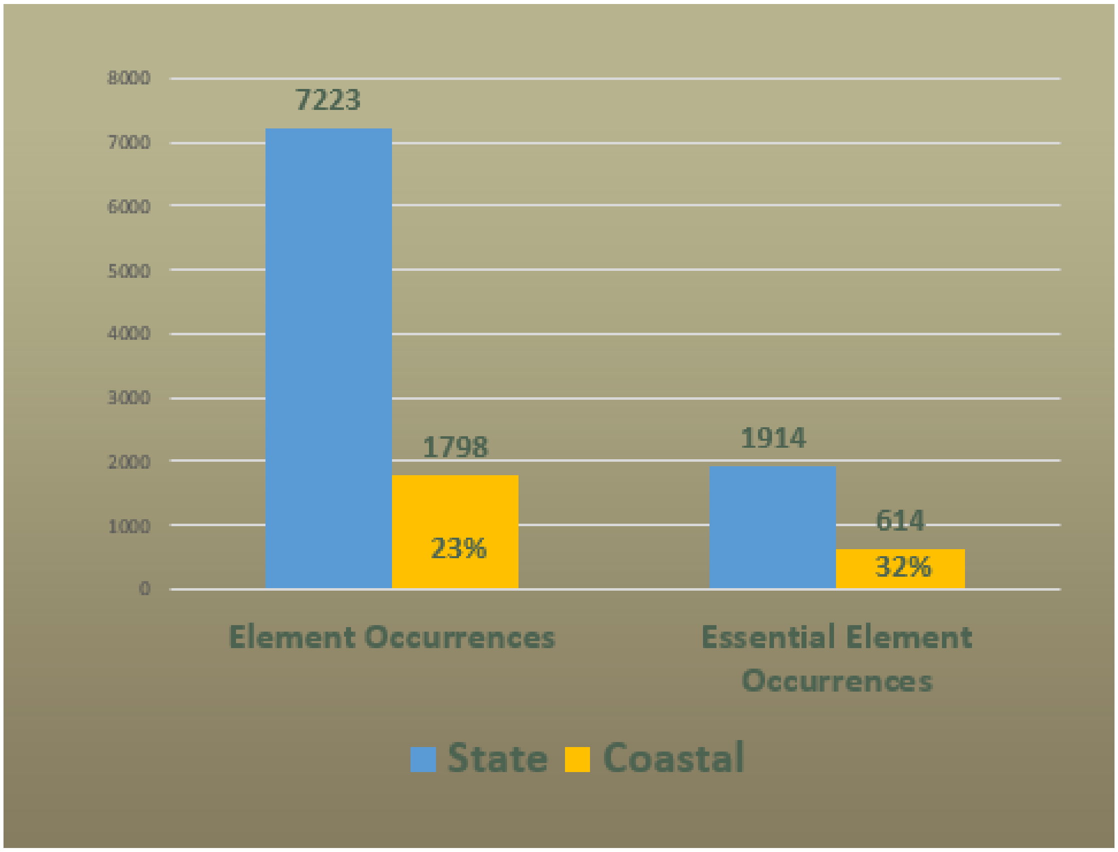


*Figure 8. The Virginia Coastal Zone supports ~23% of the statewide documented EO and 32% of Virginia's EEO (from the statewide analysis, not the custom analysis produced for this project).*


*Figure 9. Loss of shoreline since 1937 at Dameron Marsh Natural Area Preserve (Northumberland County) caused by storm events and sea-level rise.*

## Appendix A. List of fields included in deliverable layers

Layer abbreviations: PF: Procedural Features for Essential Element Occurrences; EEO: Essential Element Occurrences; ECS: Essential Conservation Sites; Parcels: Tax parcels within 100-m of ECS.
When not listed, Virginia Natural Heritage Program is the primary data source.

| Field name | Layers including the field | Field description | Primary data source |
|---|---|---|---|
| **OBJECTID** | PF, EEO, ECS, Parcels | Unique record ID (ArcGIS) | ArcGIS |
| **SF_EOID** | PF, EEO | Element Occurrence ID | Biotics |
| **ELCODE** | PF, EEO | Element ELCODE | Biotics |
| **SNAME** | PF, EEO | Element scientific name | Biotics |
| **FinalRANK** | PF, EEO | Numeric value for EO prioritization tier (Coastal Zone analysis) | - |
| **EEO_TIER** | PF, EEO | Element Occurrence prioritization tier (Coastal Zone analysis) | - |
| **eo_id_num** | PF, EEO | Numeric version of SF_EOID | - |
| **eo_acres** | PF, EEO | EO's acreage (Virginia Lambert projection) | - |
| **Statewide_FinalRANK** | PF, EEO | Numeric value for EO prioritization tier (statewide analysis) | - |
| **Statewide_EEO_TIER** | PF, EEO | Element Occurrence prioritization tier (statewide analysis) | - |
| **pf_id** | PF | Procedural Feature (polygon) ID | - |
| **SITEID** | PF, ECS | Conservation Site ID | Biotics |
| **SITENAME** | PF, ECS | Conservation Site Name | Biotics |
| **MIN_FinalRANK** | PF, ECS | Numeric value for ConSite prioritization tier (Coastal Zone analysis) | - |
| **ECS_TIER** | PF, ECS | Conservation Site prioritization tier (Coastal Zone analysis) | - |
| **site_id_num** | PF, ECS | Numeric version of SITEID | Biotics |
| **Statewide_MIN_FinalRANK** | PF, ECS | Numeric value for ConSite prioritization tier (statewide analysis) | - |
| **Statewide_ECS_TIER** | PF, ECS | Conservation Site prioritization tier (statewide analysis) | - |
| **pf_acres** | PF | PF's acreage (Virginia Lambert projection) | - |
| **pf_count** | PF | Number of PFs (polygons) making up the EO | - |
| **prop_eo** | PF | The PF's proportion of the EO (based on the number of PFs in the EO, not area) | - |
| **coastalResil_ac** | PF, ECS | Acres of polygon covered by TNC Resilient Coastal sites | TNC |
| **coastalResil_pc** | PF, ECS | Proportion of polygon covered by TNC Resilient Coastal sites | TNC |
| **coastalResil** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects TNC Resilient Coastal sites | TNC |
| **resilConn_ac** | PF, ECS | Acres of polygon covered by TNC Resilient and Connected Network | TNC |
| **resilConn_pc** | PF, ECS | Proportion of polygon covered by TNC Resilient and Connected Network | TNC |
| **resilConn** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects TNC Resilient and Connected Network | TNC |
| **marshMig_ac** | PF, ECS | Acres of polygon covered by Marsh Migration opportunities | VIMS |
| **marshMig_pc** | PF, ECS | Proportion of polygon covered by Marsh Migration opportunities | VIMS |

| Field name | Layers including the field | Field description | Primary data source |
|---|---|---|---|
| **marshMig** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects Marsh Migration opportunities | VIMS |
| **nlnCores_ac** | PF, ECS | Acres of polygon covered by NLN cores | - |
| **nlnCores_pc** | PF, ECS | Proportion of polygon covered by NLN cores | - |
| **nlnCores** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects NLN cores | - |
| **allresil_ac** | PF, ECS | Acres of the polygon covered by any resilience layer | - |
| **allresil_pc** | PF, EEO, ECS | Proportion of the polygon covered by any resilience layer | - |
| **allresil** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects any resilience layer | - |
| **nlnCorridor_ac** | PF, ECS | Acres of polygon covered by NLN corridors | - |
| **nlnCorridor_pc** | PF, ECS | Proportion of polygon covered by NLN corridors | - |
| **nlnCorridor** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects NLN corridors | - |
| **nlnDist_m** | PF, ECS, Parcels | Distance from polygon to NLN | - |
| **Cons_all_ac** | PF, ECS, Parcels | Acres of the polygon covered by conserved lands | - |
| **Cons_all_pc** | PF, ECS, Parcels | Proportion of the polygon covered by conserved lands | - |
| **Cons_all** | PF, ECS, Parcels | Binary attribute (0/1) indicating if the polygon intersects conserved lands | - |
| **PERCENT_BMI_1** | PF, EEO, ECS, Parcels | Percent of polygon covered by BMI = 1 lands | - |
| **PERCENT_BMI_2** | PF, EEO, ECS, Parcels | Percent of polygon covered by BMI = 2 lands | - |
| **PERCENT_BMI_3** | PF, EEO, ECS, Parcels | Percent of polygon covered by BMI = 3 lands | - |
| **PERCENT_BMI_4** | PF, EEO, ECS, Parcels | Percent of polygon covered by BMI = 4 lands | - |
| **PERCENT_BMI_5** | PF, EEO, ECS, Parcels | Percent of polygon covered by BMI = 5 lands | - |
| **BMI_score** | PF, EEO, ECS | BMI Score of the polygon (based on BMI 1-4 lands) | - |
| **mlw_2020_ac** | PF, ECS | Acres of the polygon covered by Mean Low Water (2020) | DCR-CRMP |
| **mlw_2020_pc** | PF, ECS | Proportion of the polygon covered by Mean Low Water (2020) | DCR-CRMP |
| **mlw_2020** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects by Mean Low Water (2020) | DCR-CRMP |
| **mlw_2080_ac** | PF, ECS | Acres of the polygon covered by Mean Low Water (2080) | DCR-CRMP |
| **mlw_2080_pc** | PF, ECS | Proportion of the polygon covered by Mean Low Water (2080) | DCR-CRMP |
| **mlw_2080** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects by Mean Low Water (2080) | DCR-CRMP |
| **tidal_2020_ac** | PF, ECS | Acres of the polygon covered by Mean High Water (2020) | DCR-CRMP |
| **tidal_2020_pc** | PF, ECS | Proportion of the polygon covered by Mean High Water (2020) | DCR-CRMP |
| **tidal_2020** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects by Mean High Water (2020) | DCR-CRMP |
| **tidal_2080_ac** | PF, ECS | Acres of the polygon covered by Mean High Water (2080) | DCR-CRMP |
| **tidal_2080_pc** | PF, ECS | Proportion of the polygon covered by Mean High Water (2080) | DCR-CRMP |

| Field name | Layers including the field | Field description | Primary data source |
|---|---|---|---|
| **tidal_2080** | PF, ECS | Binary attribute (0/1) indicating if the polygon intersects by Mean High Water (2080) | DCR-CRMP |
| **slr_exposure** | PF, EEO, ECS | Sea level rise exposure score; mean of low and high water proportion coverage in 2080. | DCR-CRMP |
| **mlw_pcChg** | PF, ECS | Change in proportion of polygon inundated under mean low water, 2020 to 2080 | DCR-CRMP |
| **tidal_pcChg** | PF, ECS | Change in proportion of polygon inundated under mean high water, 2020 to 2080 | DCR-CRMP |
| **devVuln** | PF, EEO, ECS | Mean Development Vulnerability score in the polygon (see notes) | - |
| **resilScore** | PF, EEO, ECS | Resilience Score: combines resilience coverage and SLR exposure | - |
| **resilClass** | PF, EEO, ECS | Resilience Score Class. 0: Not resilient (< -0.5), 1: Low resilience (-0.5 - 0), 2: Medium resilience (0 - 0.5), 3: High Resilience (0.5 - 0.9), 4: Outstanding resilience (> 0.9) | - |
| **protScore** | PF, EEO, ECS | Protection Score: combines conserved land coverage and development vulnerability | - |
| **protPrior** | PF, EEO | Protection Priority Score (PF) (combines resilience score and protection score) | - |
| **protPriorAdj** | PF | Protection Priority Score (PF), adjusted for the number of PFs in the EO. | - |
| **pfProt** | PF | PF Protection Status class. Numeric class with text description, indicating protection status of the PF based on Conserved lands coverage. | - |
| **resilProtClass** | PF, EEO, ECS | Class summarizing the resilience and protection score categories for the polygon, with modifier for fully-protected (BMI 1) polygons | - |
| **resilScoreCS** | PF | Resilience score of the ConSite containing the PF | - |
| **resilClassCS** | PF | Resilience class of the ConSite containing the PF | - |
| **protScoreCS** | PF | Protection Score of the ConSite containing the PF | - |
| **protPriorCS** | PF, ECS | Protection Priority Score (ConSite): (combines resilience score and protection score) | - |
| **resilProtClassCS** | PF | Class summarizing the resilience and protection score categories of the ConSite containing the PF | - |
| **resilScore_max** | EEO | Maximum resilience score (among PFs in EO) | - |
| **protScore_max** | EEO | Maximum protection score (among PFs in EO) | - |
| **protPrior_max** | EEO | Maximum protection priority score (among PFs in EO) | - |
| **best_BMI** | EEO | best (lowest) BMI rank conserved land within 0.25 miles of the polygon | - |
| **resilClass_PFMax** | ECS, Parcels | Maximum resilience class among PFs [in the ConSite / within 100m of the Parcel] | - |
| **protPrior_SumScore** | ECS, Parcels | Protection Priority Score. Sum of the adjusted protection priority scores among PFs [in the ConSite / within 100m of the Parcel] | - |
| **protPrior_PFMax** | ECS, Parcels | Maximum protection priority scores among PFs [in the ConSite / within 100m of the Parcel] | - |
| **eeo_cover** | ECS, Parcels | Sum of proportions of EOs [in the ConSite / within 100m of the Parcel] | - |
| **elem_uniq** | ECS, Parcels | Number of unique Elements with EOs [in the ConSite / within 100m of the Parcel] | - |
| **VGIN_QPID** | Parcels | attribute from VGIN parcels dataset | VGIN |
| **FIPS** | Parcels | attribute from VGIN parcels dataset | VGIN |
| **LOCALITY** | Parcels | attribute from VGIN parcels dataset | VGIN |

| Field name | Layers including the field | Field description | Primary data source |
|---|---|---|---|
| **PARCELID** | Parcels | attribute from VGIN parcels dataset | VGIN |
| **PTM_ID** | Parcels | attribute from VGIN parcels dataset | VGIN |
| **LASTUPDATE** | Parcels | attribute from VGIN parcels dataset | VGIN |
| **parcel_uid** | Parcels | Unique ID of the parcel polygon | - |
| **EEO_SUMMARY_ALL** | Parcels | Summary of all Essential EOs within 100m of the Parcel | - |
| **resilClass_CSMax** | Parcels | Highest resilience class among ConSites intersecting the Parcel | - |
| **parcelProt** | Parcels | Parcel Protection Status class. Numeric class with text description, indicating protection status of the Parcel based on Conserved lands coverage. | - |
| **resilEEO** | Parcels | "Best" Resilience Score Class from EEO PFs within 100-m of the parcel. Numeric class with text description, indicating highest resilience class among PFs within 100m | - |
| **resilConSite** | Parcels | "Best" Resilient Score class from ECS intersecting parcel. Numeric class with text description, indicating highest resilience class among intersecting ConSites | - |

## Appendix 4 Stakeholders Meeting and Notes

Attended one, or more Stakeholder Meetings

Brianna Heath NNPDC
John Bateman NNPDC
Lewie Lawrence MMPDC
Curtis Smith MMPDC
Ben McFarlane HRPDC
Jessica Steelman ANPDC
Kevin McLean DEQ
Ben Sagara DWR
Becky Gwynn DWR
Rachael Peabody VMRC
Jill Bieri TNC
Suzan Bulbulkaya DCR
Ian Blair Wetlands Watch

Conservation Targeting
CZM Focal Area Task 71 Year Three
October 28, 2022
Join Zoom Meeting
https://cwm.zoom.us/j/96973627308
Meeting ID: 969 7362 7308
+1(646)558-8656)

**AGENDA**

1. Introductions

2. Overview of the project outputs
    a. Modeled data
    b. Discussion

3. Data Service Needs/ Approach
    a. Service
    b. Time steps
    c. Display

4. Other outputs/ Needs

# AGENDA

CZM Conservation Targeting Steering Committee
May 16, 2023
3pm
Room 201 Davis Hall, VIMS
Join Zoom Meeting
https://cwm.zoom.us/j/99067925667
+1 301 715 8592 US (Washington DC)

1. Introductions
2. Overview of project and partners
   a. CCRM: Pam Mason
   b. Heritage: Joe Weber
   c. VCPC: Gray Montrose
3. Presentation of modeled data – Robert Isdell
   a. landscape changes, species implications
4. Discussion of data service and visualization
   a. Where (Adaptva interactive mapper, separate viewer)
   b. How: Mapped, data tables, pop-ups
5. Other information needs/ follow on

# AGENDA

CZM Conservation Targeting Steering Committee
Feb 16, 2024
1 pm
Join Zoom Meeting
Pam Mason is inviting you to a scheduled Zoom meeting.

Topic: CZM Conservation Targeting Stakeholders
Time: Feb 16, 2024 01:00 PM Eastern Time (US and Canada)
Join Zoom Meeting
https://cwm.zoom.us/j/96754188214
Meeting ID: 967 5418 8214

1. Introductions
2. Overview of project and partners- Pam Mason, VIMS
3. Presentation of modeled data – Robert Isdell, VIMS
    a. landscape changes, species implications
4. Discussion of data service and visualization
    a. Propose Adaptva interactive mapper
    b. How: Mapped layers
5. Other Analyses:
    a. Wetland envelopes and current Landuse/ Landcover
    b. Specific intersects: Roads, Critical Infrastructure
    c. Other natural features, wetland species

Notes from stakeholder meeting - February 16, 2024 1 pm – 2 pm

Participants:

CCRM

Pam Mason
Robert Isdell
Christine Tombleson

STAKHOLDERS

Joseph Weber – Natural Heritage
Suzan Bulbulkaya – DCR Office of Land Conservation
Brianna Heath – NNPDC
Lucas (Ben) Manweiler – VA CZM
Ian Blair – Wetlands Watch

Kevin McLean – VA DEQ
Will Isenberg – VA CZM
Martha Little – VA Outdoors Program
Dan Hannon – VA Natural Heritage Program
Ben Sagara – VA DWR
Ben McFarlane – HRPDC

Pam: Introductions

Conservation Targeting for Resilience – Stakeholder meeting. 3rd year of three-year project. This is the third steering committee meeting.

Includes folks who influence decisions in areas of natural resources, funding, easements, non-profits, local governments, PDCs, etc. Broad range of folks interested in using data from this project to inform the decision making process.

CZM/NOAA funded project

Will Isenberg is program manager of grant

Tasks of this project include:

1- Convene Steering Committee

2- Develop and serve/deliver support materials based on models and data

3- Suggest habitat priorities and rankings

Steering members input and agencies' plans

Social and economic data such as EPA Environmental and Justice Screening Tool

Wetland decision support data from WetCAT and SMM

We are looking for input and feedback on #3.

Now that we have data, we have the ability to do additional analyses, if requested and not too much additional effort.

Robert explained the major output/products of the project:

- Select RTE (rare, threatened, and endangered) species modeled habitats in the coastal zone – potential habitat for species using species distribution models and how they overlap with existing conservation lands
- Wetland Elevation Envelopes per decade from 2030-2100

Upper limit: 1.5 x intertidal range from MLW

Lower limit: MLW

- Took the NOAA intermediate curve for where the predicted SLR would be for 2030-2100, every decade to determine the maximum envelope of the wetland area potential.
- Extracted (Existing, clarified later in the meeting) Land use within the wetland envelope
- Generated locality level summaries – how those envelopes changing – Identify where conflicts exist. Show tidal wetland movement. Projections for 2030 Wetland Envelope was shown. Robert indicated that the data was cleaned up pixels were cleaned that put noise into the data.
- You can zoom to Google to see the transitions
- The upper extent of the wetlands were mapped for each decade
- In the 2030 projected tidal wetland envelope example shown, there is no upper limits beyond 2070 because by 2060 everything is wetland, there is no other land use but marsh.
- In 2100 in the example, start to see subtidal area in people's yards

Display/Serving of Data and Data Analyses

Pam: We have an opportunity to display/serve the data layers of the analyses.

Are there places where people might like to see analytical output – to use the wetland envelope output with other datasets.

Pam suggested using putting the data layers in AdaptVA under the Tools Tab, in the Interactive Map in Vulnerability/Risks

No one responded with alternative places to put the data. Will Isenberg stated he would like to have it all in one place.

Pam suggested AdaptVA for the Data but suggested the Data Analyses could go in a Data Dashboard on the CCRM Webpage. The CCRM Shoreline Inventory Dashboard was shown as an example, but this particular dashboard is more complicated than the dashboard for displaying these analyses probably needs to be. Is there a preference? Do people know of examples that are useful? No real input on other examples or where the Dashboard should sit.

<u>Wetland Elevation Envelope term</u>

Pam asked if people like the term Wetland Elevation Envelope for the data or was there a better term?

Ian Blair suggested Wetland Migration. He said his parents would not understand envelope. Robert stated migration would imply the wetlands will migrate however land use such as roads will not allow wetland migrations.

Someone suggested Wetland Migration Potential as the term.

Other suggestions:

Wetland Elevation Area
Wetland Elevation Extent

Wetland Elevation Range
Potential wetland elevation migration

Dashboard Display Comments

Pam asked if there were any preferences for display?

Brianna Heath asked if the data could be viewed by PDC. Robert answered that it is currently viewed by Locality but PDC will be added.

Potential display ideas from Pam

Hot spots of where wetlands can occur, where they can migrate? Wetland migration and roads? Roads and flooding? Add social vulnerability that is included in a lot of tools lately. What are decisions that need to be made? Everyone makes decisions on different scales. Not a lot of suggestions were provided so Pam offered to share the slides and let people think about it. Asking people to think about what questions they would want to ask of the data?

Will I stated he liked the idea of everything being together, being able to view the graphs and the maps on the same page instead of having to go somewhere else to view data.

A suggestion was made to overlay with VIVA. Pam stated Karinna is updating VIVA with this data. Shoreline management model will incorporate the data. We have the shoreline covered; we want to hear from others make different types of landscape decisions. No other real suggestions provided.

Closing

Pam stated she would:

o Put together ideas for nomenclature

o Provide color ramps for data

o Provide concepts for data dashboards

o Will have statewide, locality and in between

o Share the slides

o Robert would share the list of species considered

Suzan Bulbulkaya with the Virginia Office of Land Conservation stated that she used the vulnerability data for people as to how to score what lands to protect in vulnerable populations. She was thinking of how to use the vulnerability of the land to determine what lands the state should protect. Does the state want to spend money on lands that will disappear? Or invest in migration paths? Pam commented on thinking about conservation categories beyond habitat. Conservation conserves more than habitat.

Benefits provided by wetlands such as water quality, erosion control etc that are being lost. Criteria need to be developed to determine which lands…this is for another project.