Virginia Commonwealth University

Coastal VEVA Data Synthesis Update and Coastal GEMS Application Update

October 1st 2016 – September 30th 2018

NOAA Grant # NA16NOS4190171

Grant Year FY2016, Task # 11

Acknowledgements

This project, FY16 Task #11 was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant # NA16NOS4190171 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

Introduction

This report provides a summary of tasks performed and products created under task #11 by staff of Virginia Commonwealth University during the grant (October 1st 2016 – September 30th 2018). For further documentation of tasks summarized in this report, contact nick.meade@deq.virginia.gov.

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Executive Summary

This project, FY16 Task #11, is the second of two VCU tasks to complete an update to the Coastal Virginia Ecological Value Assessment (Coastal VEVA) and enhance the Coastal GEMS mapping application.

The first task, FY14 Task #13, included coordinating with partners to compile and resample Coastal VEVA data inputs, preparing the final GIS model to update the Coastal VEVA synthesis, surveying local governments, PDCs, non-profit groups, and other stakeholders to evaluate the use and application of Coastal VEVA, and the creation of a 3D viewer tool for Coastal GEMS. FY14 Task #13 was completed concurrently with additional VA CZM tasks funding VANHP (through FY 14 Task #12) and VADGIF (through FY14 Task #14) to update their conservation priority datasets, which are inputs to the Coastal VEVA model. Summaries of these updated component datasets are included in this report.

This second task, FY 16 Task #11, included running the GIS model to complete the Coastal VEVA update, executing Coastal VEVA outreach efforts guided by the results of the FY14 survey deliverable, updating the Coastal GEMS application to allow users to display VBMP imagery and load map services from outside sources, creating Coastal GEMS story maps, and creating a new Coastal GEMS landing page.

Although the original start date for FY 16 Task #11 was October 1, 2016, it was not signed into contract until February 9, 2017 and work on deliverables did not begin in earnest until May 1, 2017, as staff were working to complete the deliverables of FY14 Task #13 during that time period.

Coastal VEVA Data Update

Introduction

The Coastal Virginia Ecological Value Assessment (Coastal VEVA), originally developed with VA CZM funding through FY10 Task #11, synthesizes geospatial component datasets representing the conservation priorities of Virginia's Natural Heritage Program (VANHP) and Department of Game and Inland Fisheries (VADGIF) as well as aquatic resource spatial data from Virginia Commonwealth University (VCU) and Virginia Institute for Marine Science (VIMS). Coastal VEVA identifies lands and surface waters important for conservation of wildlife, plants, and natural communities and is intended to be used to prioritize areas for preservation, protection, or other specific management actions. Building on FY14 tasks to update and compile Coastal VEVA partner component datasets, this task completed an update (version two) of the Coastal VEVA dataset.

Background

Habitat loss, fragmentation, and degradation represent the most significant threats to the effective conservation of wildlife species and natural, communities. At the same time, however, the capacity to purchase, conserve, and manage lands has diminished significantly due to declining budgets and rising land costs. This problem is compounded by the rapid conversion of lands from traditional rural and agricultural uses, which may support a broad diversity of wildlife, to industrial or residential uses, which create landscapes inhospitable to many species and aquatic systems. Habitat loss and fragmentation cannot be stopped but their repercussions can be managed proactively via well-informed, comprehensive planning that recognizes the critical importance of conserving and managing terrestrial

and aquatic species habitats and the ecosystem functions they help constitute. This function is the foundation for a healthy, sustainable environment.

Two major ideas have become clearer alongside our understanding of the impacts of habitat loss and fragmentation. First, most land conservation happens locally. This is due in part to the fact that specific decisions about how parcels of land will be used are made locally, and at this level, public input and funding possibilities are most closely linked with the conservation of a specific place. Second, all lands/resources are not equal in their contribution to a healthy functioning ecological network. Each conservation opportunity displays a unique set of conservation values that can be used to weigh the benefits of conserving one parcel over another. Considering the reality that funding for conservation is typically very limited at the local level, having tools to identify conservation opportunities that maximize our ability to conserve and manage the most important areas in the most financially sound ways is key.

Virginia natural resources agencies have independently quantified important conservation opportunities. Specific conservation tools used for this purpose include the Virginia Conservation Lands Need Assessment (VCLNA) which was developed by the Virginia Department of Conservation and Recreation – Division of Natural Heritage (DCR-DNH) and the Virginia Wildlife Action Plan, developed by the Virginia Department of Game and Inland Fisheries (DGIF). Both the Ecological Model (Virginia Natural Landscape Assessment or VaNLA) of the Virginia Conservation Vision and the mapped tiered-species habitats from the Wildlife Action Plan identified conservation priorities spatially. However, each of these efforts were formed with different perspectives and assumptions and therefore, presented very different results. Concurrently, Virginia Commonwealth University's Center for Environmental Studies (VCU-CES) has developed methods to rate aquatic resource integrity based on fish and macro-invertebrate community sampling and the VIMS College of William and Mary Center for Coastal Resource Management Cumulative Resource Assessment have developed an Aquatic Priority Conservation Area data layer showing where important aquatic resources exist. This provided another way to identify conservation priorities. With several tools for mapping conservation priorities, local planners needed to fully evaluate all available options at the risk of under representing a specific conservation perspective. Synthesis was needed to present a unified method of prioritizing conservation opportunities.

The Coastal Virginia Ecological Value Assessment (VEVA) dataset delineates priority conservation areas ranked by level of importance based on VA Dept. of Game and Inland Fisheries' Priority Wildlife Diversity Conservation Areas, VA Dept. of Conservation and Recreation Division of Natural Heritage Conservation Sites Layer (CSL), Natural Lands Network (NLN) and Healthy Waters, VCU Center for Environmental Studies aquatic resource integrity layer and Healthy Waters data, and VIMS College of William and Mary Center for Coastal Resource Management Cumulative Resource Assessment layer. These ecological resources are defined as lands, aquatic resources and surface waters identified as important for conservation of Virginia's wildlife, plants, aquatic communities and resources and natural communities. The data are ranked on a scale of 1 to 5, with a 5 representing the highest conservation priority. The identified lands/waters can be used to prioritize areas for preservation, protection or specific management action. This dataset is not intended to replace on the ground surveys or consultations with biologists as appropriate.

Coastal VEVA Component Datasets

Virginia Department of Conservation and Recreation Division of Natural Heritage

Virginia DCR-DNH prepared two data layers components for the Coastal VEVA synthesis. These layers were selected because together they provide a fine filter and a coarse filter conservation planning tool. In short, coarse filter tools are designed to conserve high percentages of species by conserving adequate diversity, distribution, and abundance of ecological communities, ecological land units (e.g., alliances of ecological communities, physical environments and landscape-level ecological phenomena). Coarse filter tools are complimented by fine filter approaches, which focus on specific habitats of individual rare species, or species that specialize on a small and/or unique habitat type. For Coastal VEVA, DCR-DNH prepared data layers derived from DCR-DNH Conservation Sites (Conservation Sites ranked by B-rank; fine filter) and the Virginia Natural Landscape Assessment (VaNLA) (Virginia Natural Land Network; coarse filter). The following text briefly describes these two inputs.

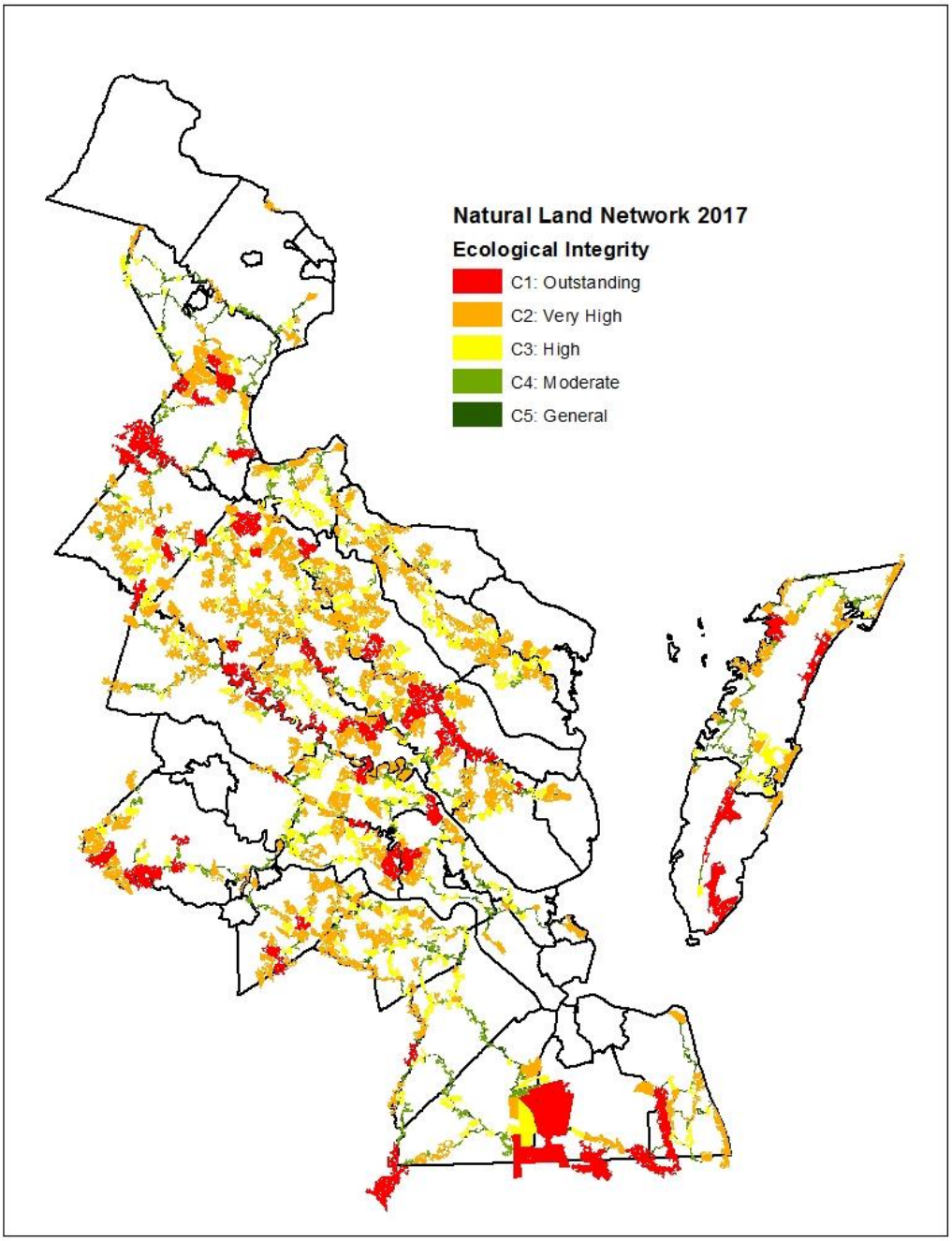
Virginia Natural Land Network – Coarse Filter

The Virginia Natural Land Network is a focused subset of lands identified in the VaNLA, a landscape-scale GIS analysis for identifying, prioritizing, and linking natural habitats in Virginia, which was developed by the DCR-DNH with funding from the Virginia Coastal Zone Management Program. Using land cover data derived from satellite imagery, the VaNLA identifies un-fragmented natural habitats called Ecological Cores, or large patches of natural land cover with at least 100 acres of interior conditions. Cores consist mainly of upland forests and forested wetlands statewide, but also marshes, beaches, and dunes in the coastal plain. Large, medium, and small Ecological Cores are identified, along with smaller Habitat Fragments that may be important in more urban localities. Ecological Cores provide habitat for a wide range of species, from those dependent upon interior forests to habitat generalists, as well as species that utilize marsh, dune, and beach habitats. Cores also provide benefits in terms of open space, recreation, water quality (including drinking water protection), and carbon sequestration, along with the associated economic benefits of these functions.

All VaNLA cores are given an ecological integrity score. This score is derived from a ranking method resulting from the calculation of several attributes from all cores that assess a core's relative contribution to ecosystem functions (e.g. rare terrestrial and aquatic species locations from the SWAP and Natural Heritage Plan, locations of rare community types, total core area, length of core interior streams, variety of unmodified wetlands, etc.). Via this process, each ecological core was assigned an ecological integrity score of C1 – Outstanding to C5 – General.

In the interest of identifying an entire ecological network upon which to base conservation decisions, landscape corridors were also identified using GIS to identify the most suitable linkages between the two highest ranks of cores (C1 andC2). Suitable corridors that link cores allow animal movement between cores and help to facilitate seed and pollen transfer between cores. In addition to identifying links between C1 and C2 cores, corridors also integrated all landscape cores that they intersected (C3, C4 and C5 cores) as habitat nodes. These nodes provide stepping stones for plant and animal populations over time and help to assure that lands identified as important to core linkages also contribute to the available habitats for some species within the ecological network. More detailed methods and background for the VaNLA can be found on the DCR-DNH website at http://www.dcr.virginia.gov/natural-heritage/vaconvision.

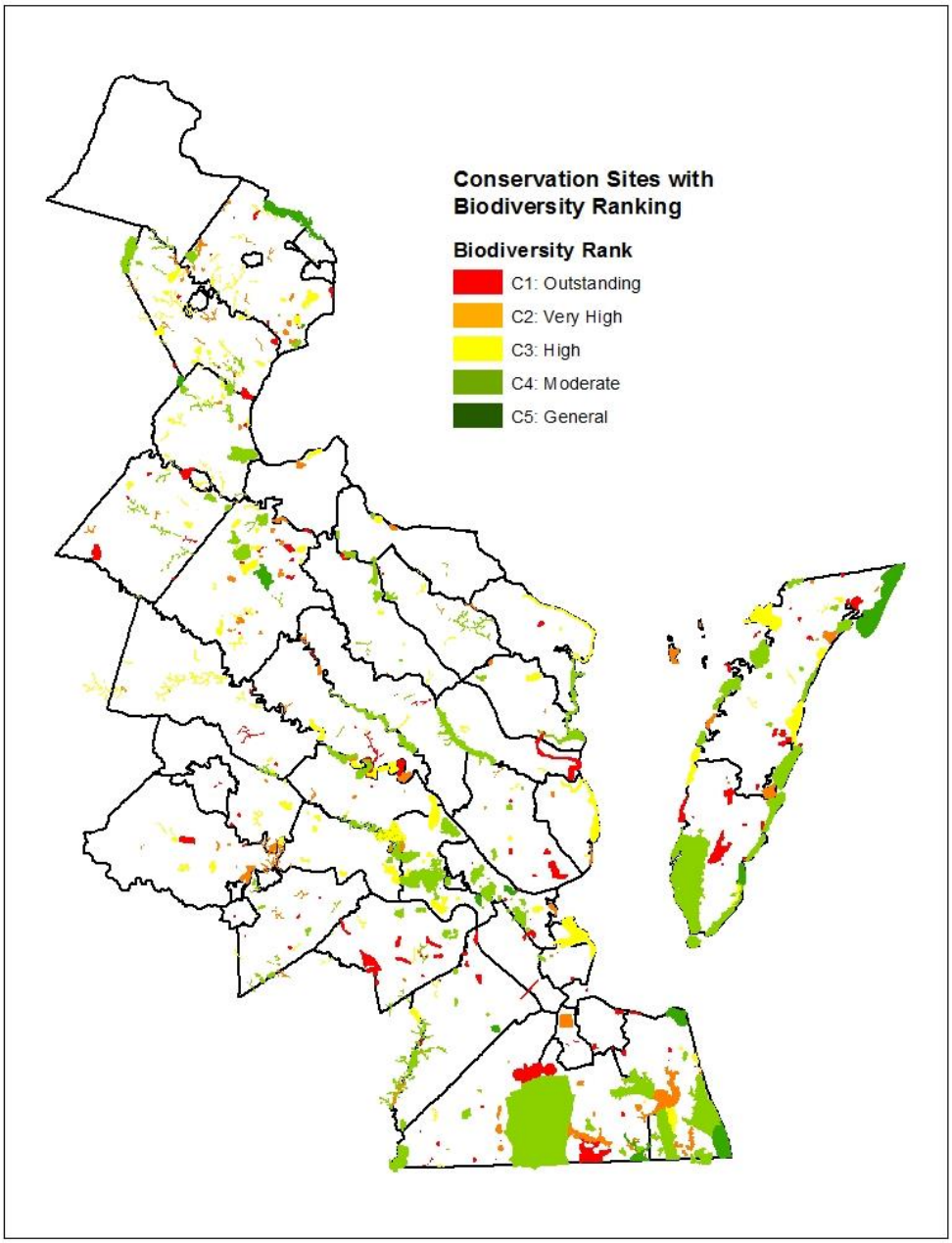
Portions of the VaNLA were selected to provide the coarse filter contribution to the Coastal VEVA synthesis. These are referred to as the Virginia Natural Land Network (NLN). The NLN includes all Ecological Cores ranked C1 or C2, all the Landscape Corridors that connect them, and all nodes that intersect those corridors. The sections of Landscape Corridors that were not coincident with other features in the network were assigned a rank of C5 – General Ecological Integrity only for the purposes of the NLN. This ranking was necessary to retain Landscape Corridors in assessments, such as the updated Coastal VEVA.



Left: The DCR Division of Natural Heritage Natural Land Network

Virginia Conservation Sites – Fine Filter

The DCR-DNH maintains a GIS layer and of the Natural Heritage Plan. A conservation site is a planning boundary delineating the Virginia Natural Heritage Program's best determination of the land and water area occupied by one or more natural heritage resources (exemplary natural communities and rare species) and required to support their long-term survival. The size and dimensions of a conservation site are based on the habitat requirements of the natural heritage resources present and the physical features of the surrounding landscape. Feature taken into consideration include underground and surface hydrology, slope, aspect, vegetation structure, current land uses, and potential threats from invasive species. Conservation sites do not necessarily preclude human activities, but the site's viability may be greatly influenced by human activities. Conservation sites may require ecological management, such as invasive species control or water management, in order to maintain or enhance their viability. Each conservation site is given a biodiversity significance ranking (B-rank) based on rarity, quality, and number of natural heritage resources it contains. (2)



Left: DCR Division of Natural Heritage Conservation Sites with Biodiversity ranks

Virginia Department of Game and Inland Fisheries (DGIF) Priority Wildlife Diversity Conservation Areas

The DGIF maintains several GIS datasets showing the location of important wildlife features. However, DGIF has never produced a map showing how these features should be prioritized and conserved. While, as part of the Wildlife Action Plan, the DGIF mapped habitats of over 250 species of greatest conservation need (Tiered Habitat), these do not include any protective buffer around habitats. Furthermore, there are general conservation actions included in the Wildlife Action Plan that benefit multiple species that had not been mapped. Therefore, it was necessary to create a new GIS dataset to compile wildlife conservation areas. This dataset was called Priority Wildlife Diversity Conservation Areas or PWDCA. The term *diversity* was included to reinforce the wildlife diversity or nongame wildlife conservation focus.

Details of the data used to create this layer are outlined below.

Virginia Important Bird Areas:

The Virginia Important Bird Areas Program was initiated to help ensure the protection of the most essential places for birds in our state. The Virginia Audubon Council partnered with the Virginia Society of Ornithology, the Virginia Department of Game & Inland Fisheries, and the National Audubon Society to establish the program in 2002. The Virginia IBA Technical Committee has recognized 20 IBAs that span the broad diversity of habitats from the sandy coastal beaches to the rugged mountains of the Appalachians and everything in between.

Dataset was clipped to the Coastal Zone Area and a field was added (type: short integer) and priority set to 10. It was projected to NAD 1983 Virginia Lambert. It was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: Virginia Important Bird Area Coordinator and the Audubon Society, http://www.audubon.org/important-bird-areas/state/virginia

Date: 2009

National Wetlands Inventory:

This data set represents the extent, status, and location of National Wetland Inventory wetland mapping projects for NWI Version 2, Surface Waters and Wetlands.

Dataset was clipped to the Coastal Zone Area. Two new feature classes were created from the original data; one for wooded wetland and one for non-wooded wetland. The wooded wetland was buffered to 200 meters and the wooded wetland was erased from the buffer. The non-wooded wetland was buffered to 150 meters and the non-wooded wetland was erased from the buffer. Fields (type: short integer) were added to all four feature classes and priorities were set as follows: wooded wetland = 8, wooded buffer = 6, non-wooded wetland = 5, non-wooded buffer = 4. Both buffers were then dissolved based on the priority. All feature classes were projected to NAD 1983 Virginia Lambert. All four feature classes were converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a file geodatabase created to house it. The field used to assign values to the output rasters were all set to priority.

Source: NWI Program – US Fish and Wildlife Service, https://www.fws.gov/Wetlands/nwi/

Date: 2016

Unique Terrestrial Areas

Unique terrestrial areas were selected from DCR-DNH's Conservation Lands layer, and from DCR's Jurisdictions layer. Unique terrestrial areas also include areas delineated by DGIF Biologists to denote remaining potential habitat for certain wildlife species.

Digitized areas (in NAD 1983 Virginia Lambert) were assigned a priority of 1 and converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house them. The field used to assign values to the output rasters were set to priority.

Source: Virginia Department of Conservation and Recreation, Division of Natural Heritage, and the Virginia Department of Game and Inland Fisheries, http://www.dcr.virginia.gov/natural-heritage/ and https://www.dgif.virginia.gov/

Date: 2016

Threatened and Endangered Species Waters

This information identifies and delineates the boundaries of stream reaches containing federal and state threatened or endangered aquatic species. The species included in this analysis were limited to species inhabiting primarily lotic, or riverine, habitats including fish, mollusks, crayfish, snails and the wood turtle (Clemmys insculpta). The reaches were delineated based on the presence of a threatened or endangered species and extended to include suitable habitat if known.

Dataset was clipped to the Coastal Zone Area and buffered to 300 meters. A script was created where duplicate species were removed, overlaps were identified, and final weights (priority) were calculated as the highest weight plus half the total of the additional weights in each polygon. The buffered data was then projected to NAD 1983 Virginia Lambert and converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: Aquatic resource professionals from the Virginia Department of Game and Inland Fisheries reviewed several data sources in the development of this spatial information. The spatial data used for development include DGIF's T&E Species Observations (DGIF 2016) a hydrography data layer (USGS, NHD 1:24,000K), a county boundary data layer (DCR, 2016), and a roads data layer (VDOT 2007). Additional data sources included regional scientific literature and professional resource experience. https://www.dgif.virginia.gov/

Date: 2017

Streams:

Feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system.

Dataset was clipped to the Coastal Zone Area, buffered to 100 meters, and assigned a priority of 3. The buffered data was then dissolved based on the priority and projected to NAD 1983 Virginia Lambert. The data was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: U.S. Geological Survey in cooperation with U.S. Environmental Protection Agency, USDA Forest Service, and other Federal, State and local partners. https://nhd.usgs.gov/data.html

Date: 2012

Species Observation:

This dataset includes all verified species documentations maintained by the Virginia Department of Game and Inland Fisheries. DGIF's Species observations database contains species observations data derived from ten different sources, including: the Virginia Breeding Bird Atlas Project; Cold Water Stream Survey; WMA Bird Surveys; Rare Bird Sittings: Mid-winter Bald Eagle survey; Bald Eagle Nest Database; VDGIF Scientific Collections, TE, and salvage permit data; Colonial Waterbird locations: and Colonial Waterbirds 2003 data.

Dataset was clipped to the Coastal Zone Area and buffered to 200 meters. A script was created where duplicate species were removed, overlaps were identified, and final weights (priority) were calculated as the highest weight plus half the total of the additional weights in each polygon. The buffered data was then dissolved based on the priority and projected to NAD 1983 Virginia Lambert. It was then converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: Virginia Department of Game and Inland Fisheries, https://www.dgif.virginia.gov/

Date: 2016

Potential Aquatic and Terrestrial Habitat (Habitat Condition)

Habitat Condition for Imperiled Species is one of a suite of products from the Nature's Network project (naturesnetwork.org). Nature's Network is a collaborative effort to identify shared priorities for conservation in the Northeast, considering the value of fish and wildlife species and the natural areas they inhabit. This product represents a regional network of habitats critical for sustaining populations of imperiled species, currently based on over 600 Species of Greatest Conservation Need (SGCN). Areas scoring highly on Habitat Condition can be viewed as areas that are relatively intact which contain habitats likely to support high levels of biological diversity, rare species, and/or imperiled species in any given landscape. Generally speaking, this analysis indicates that riparian areas, including associated sandplains and other unique lowland habitats, are the most critical for the imperiled species assessed.

Dataset was clipped to the Coastal Zone Area and projected to NAD 1983 Virginia Lambert. The priority is based on the "value" field (0-200). The highest scoring locations are expected to be the most ecologically intact.

Source: North Atlantic Landscape Conservation Cooperative, U.S. Fish and Wildlife Service, https://nalcc.databasin.org/datasets/fe56881af5d44d79934f4503dd438c80

Date: 2017

Ecological Cores:

The Virginia Natural Landscape Assessment (VaNLA), a component of the Virginia Conservation Lands Needs Assessment (VCLNA), is a landscape-scale GIS analysis for identifying, prioritizing, and linking natural habitats in Virginia. Using land cover data derived from satellite imagery, the VaNLA identifies unfragmented natural habitats called Ecological Cores, large patches of natural land cover (mainly upland forests and forested wetlands statewide, but also marshes, beaches, and dunes in the coastal plain) with at least 100 acres of interior conditions. Large, medium, and small Ecological Cores have been identified, along with a smaller feature type called Habitat Fragments that may be important in the more urban localities. Ecological Cores provide habitat for a wide range of species, from those dependent upon interior forests to habitat generalist, as well as species that utilize marsh, dune, and beach habitats. Ecological Cores also provide benefits in terms of open space, recreation, water quality (including drinking water protection), and carbon sequestration, along with the associated economic benefits of these functions.

The priority is based on the ecological integrity score (1 – 5). The dataset was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: Virginia Department of Conservation and Recreation, Division of Natural Heritage, http://www.dcr.virginia.gov/natural-heritage/

Date: 2017

Colonial Water Birds:

Colonial waterbirds include herons, egrets, ibises, gulls, terns, skimmers, cormorants, and pelicans. These birds share the unusual characteristic of nesting in dense assemblages. The result of this behavior is that they typically breed in very few locations such that the loss of a few breeding areas may have profound consequences on a population level. Due to their position in the aquatic food web, they are considered to be good indicators of ecosystem health. The most significant threats to colonial waterbirds include human disturbance, predation, habitat loss, and contaminants. Protection of sensitive colonies clearly depends on the availability of timely locational information. Development of strategic management plans to protect these species and breeding areas requires a broader understanding of population trends.

Dataset was clipped to the Coastal Zone Area and buffered to 300 meters. The buffered data was then assigned a priority of 8 and dissolved based on the priority and projected to NAD 1983 Virginia Lambert. The data was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: The Center for Conservation Biology, http://www.ccbbirds.org/what-we-do/research/species-of-concern/species-of-concern-projects/va-colonial-waterbird-survey/

Date: 2013

Confirmed Anadromous Fish Use Areas:

This dataset identifies reaches that are confirmed or potential migration pathways, spawning grounds, or nursery areas for anadromous fish. The species included in this assessment are alewife (Alosa pseudoharengus), blueback herring (A. aestivalis), American shad (A. sapidissima), hickory shad (A. mediocris), striped bass (Morone americana), and some populations of yellow perch (Perca flavescens). Certain time-of-year restrictions apply to areas used by anadromous fish. Data associated with each reach include stream name, reach length, status (confirmed or potential), species confirmed in the reach (if confirmed), watershed, and upstream boundary. Upstream boundaries were established at impediments or where habitat became unsuitable.

Dataset was clipped to the Coastal Zone Area and buffered to 100 meters. The buffered data was then assigned a priority of 4 and projected to NAD 1983 Virginia Lambert. The data was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

Source: Virginia Department of Game and Inland Fisheries, https://www.dgif.virginia.gov/

Date: 2017

Potential Anadromous Fish Use Areas:

This dataset identifies reaches that are confirmed or potential migration pathways, spawning grounds, or nursery areas for anadromous fish. The species included in this assessment are alewife (Alosa pseudoharengus), blueback herring (A. aestivalis), American shad (A. sapidissima), hickory shad (A. mediocris), striped bass (Morone americana), and some populations of yellow perch (Perca flavescens). Certain time-of-year restrictions apply to areas used by anadromous fish. Data associated with each reach include stream name, reach length, status (confirmed or potential), species confirmed in the reach (if confirmed), watershed, and upstream boundary. Upstream boundaries were established at impediments or where habitat became unsuitable.

Dataset was clipped to the Coastal Zone Area and buffered to 100 meters. The buffered data was then assigned a priority of 2 and projected to NAD 1983 Virginia Lambert. The data was converted to raster using the Feature to Raster tool (output cell size set to 30 meters) and saved to a new file geodatabase created to house it. The field used to assign values to the output raster was set to priority.

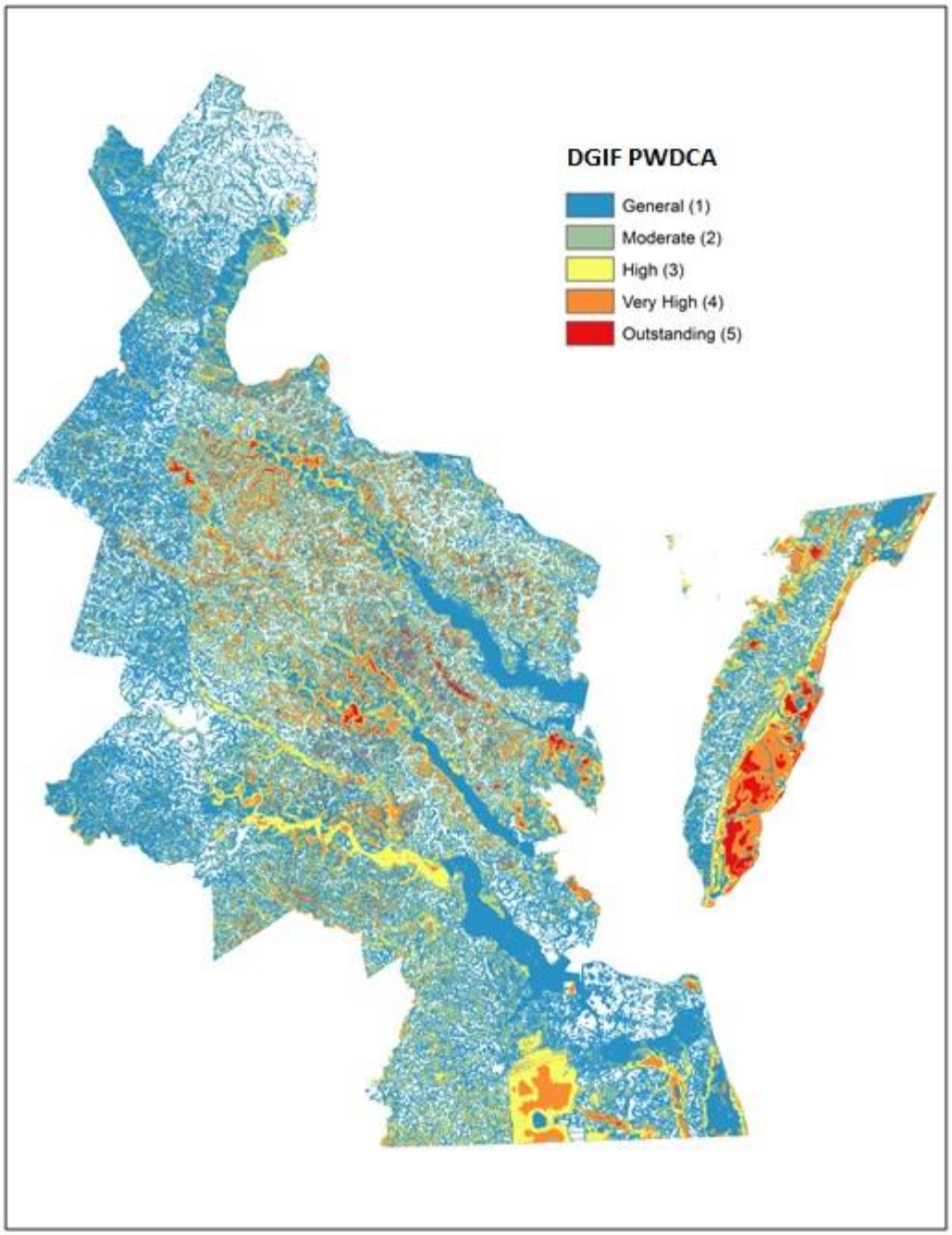
Source: Virginia Department of Game and Inland Fisheries, https://www.dgif.virginia.gov/

Date: 2017

Priority Wildlife Diversity Conservation Layer

The final raster layers were summed to get a total score for all locations. This was accomplished using the Mosaic to New Raster Tool. The following parameters were used in the tool: Pixel Type = 8 Bit

Unsigned, Cellsize = 30 Meters, Number of Bands = 1, Mosaic Operator = Sum, Mosaic Colormap Mode = First. The rasters were combined in series as the tool was overwhelmed adding them all at once. The outputs were saved to a new file geodatabase created to house them. Using the Standard Deviations classification method, the combined raster was broken into 5 categories with 1 being lower priority and 5 being the highest conservation priority.



Left: VA DGIF Priority Wildlife Diversity Conservation Areas

Virginia Commonwealth University Center for Environmental Studies (VCU CES) Aquatic Resource Integrity Layer

This layer was created by Virginia Commonwealth University Center for Environmental Studies (VCU-CES) to aid in the characterization of stream health in the Commonwealth. This layer is a combination of both a local scale assessment and a watershed based approach to stream health. The assessment was aided by the Interactive Stream Assessment Resource (INSTAR).

The Center for Environmental Studies at Virginia Commonwealth University has created a statewide dataset to attribute streams with an ecological health score category. The process was to produce a fish species list within each 12th order hydrologic unit of the National Watershed Boundary Dataset (https://water.usgs.gov/GIS/huc.html). Data were obtained from Virginia Department of Game and Inland Fisheries (VA DGIF) , Virginia Department of Conservation and Recreation Natural Heritage (VA DCR NH) , and INSTAR – maintained by the Center for Environmental Studies at VCU (CES – VCU). The species list was then run against the modified Index of Biotic Integrity (mIBI) containing 6 metrics to determine watershed integrity/health. The 6 metrics (variables) that are used for Watershed Integrity are:

- Native Species Richness (total number of species indigenous)
- Number of Rare, Threatened, or Endangered Species (data from VA DGIF and VA DCR-NH included here)
- Number of Non-indigenous Species (number of introduced species, see list)
- Number of Significant Species (ecologically or economically important)
- Number of Tolerant Species (species that are tolerant to pollution, sedementation, or habitat alteration)
- Number of Intolerant Species (species that are intolerant to degraded stream conditions) as this number is high, high watershed integrity can be inferred)

Nested inside those larger watersheds are catchments that were found to be ecologically unique and biologically healthy based on modeling performed by CES – VCU. The ecological health of stream reaches is based on percent comparability of empirical data collected at each site/stream/reach to the appropriate (e.g. basin, stream order) reference model. Hydrologic modeling was performed to delineate watersheds for every healthy or outstanding catchment in Virginia. The values for each of these healthy or outstanding catchments override the value for an entire national Watershed Boundary dataset hydrologic unit creating a more detailed healthy waters outlook for Virginia.

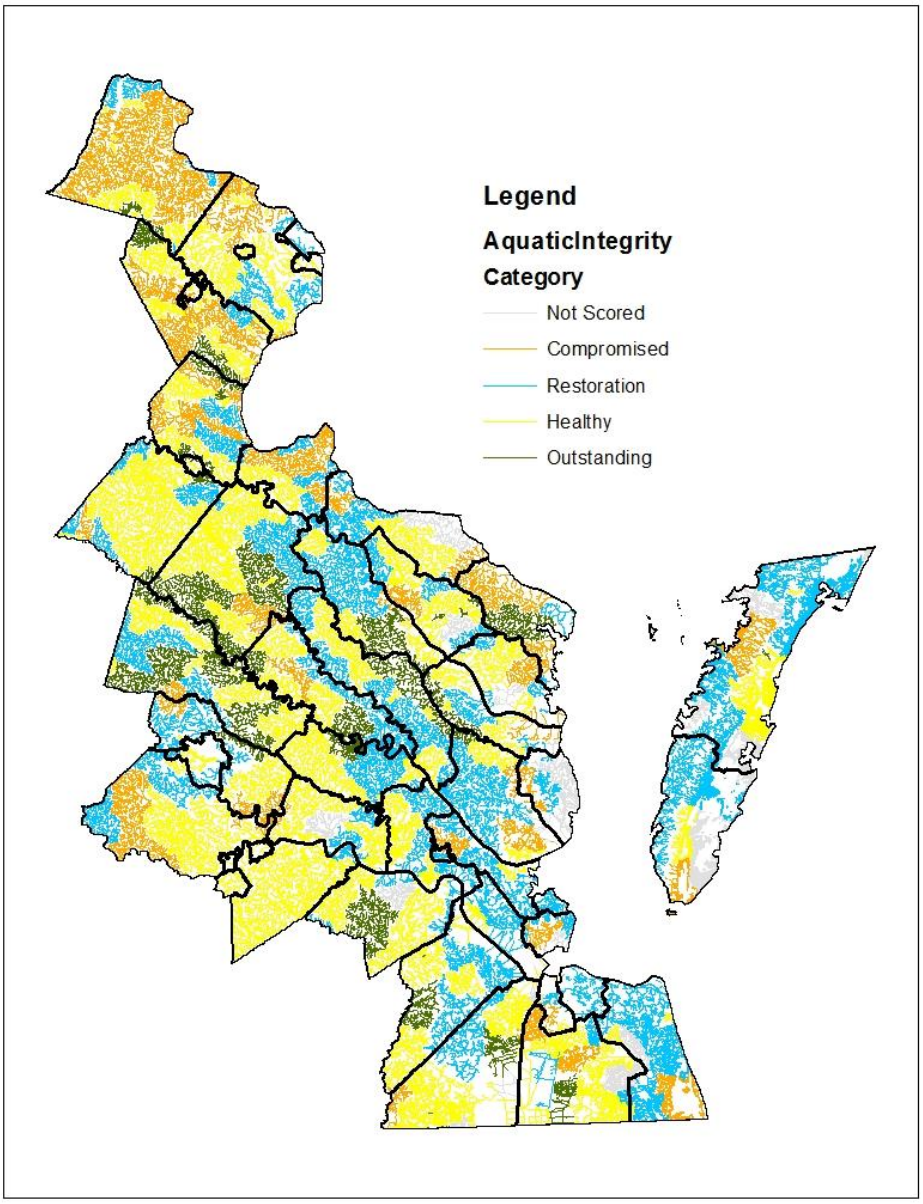
For usage and analysis, the attribute “mibi_cat_2” should be used with the following scores and associated relevance:

- Score = 1, Not Scored. These are streams where no data base been collected within that watershed. This is typical of coastal areas, estuarine areas, or small watersheds.
- Score =2, Compromised. These are watersheds that could have the following attributes: low diversity, high percentage of introduced species, a high number of tolerant species, a low number of rate, threatened or endangered species, low numbers of significant species.
- Score = 3, Restoration Candidate. Watersheds that have a healthy species richness, potentially some non-native species, but also a number of intolerant species indicating moderately clean water

quality and other attributes. A system that could be restored in some ways, or could also be showing a trend to move to compromised.

- Score = 4. Healthy. This category would score low in non-native species, showing a more native, non-introduced community, species that are somewhat intolerant of pollution, and other factors indicating better than average water quality and habitat.
- Score =5, Outstanding. These watersheds are much higher in biological integrity/health and show large species richness of native species, potentially rare, threatened and endangered species, have some intolerant species, and some species are significant economically or ecologically. These are systems that should be preserved or protected to enhance the existing community to prevent loss and/or conversion.

Stream reaches from the National Hydrography dataset were intersected with the watershed layer and scored based on intersecting watershed. The data were then buffered by 30 meter and converted to a raster.



Left: VCU Center for Environmental Studies Aquatic Resource Integrity Layer

Virginia Institute of Marine Science Coastal Center for Resource Management (VIMS CCRM) Cumulative Resource Assessment

"A Cumulative Resources Assessment (CRA) was developed for the tidal waters of the Virginia portion of the Chesapeake Bay as well as the Back Bay region located in Virginia Beach, Virginia. In a separate activity (Task 96.01, FY 07) the assessment was expanded to include the seaside of the Eastern Shore of Virginia. The tasks to be accomplished in developing the CRA include collection and review all relevant data sources. Specifically, this includes a review of data within the current Coastal GEMS application, NOAA's 2004 Environmental Sensitivity Index Atlas for Virginia, products developed by the Virginia Department of Conservation and Recreation, the Virginia Department of Game and Inland Fisheries (DGIF), the Virginia Marine Resources Commission (VMRC), Virginia Commonwealth University (VCU), The Nature Conservancy, and others. Estuarine data found in the Center for Coastal Resources Management's (CCRM) Blue Infrastructure tool was also reviewed for currency and inclusion" (2).

The Cumulative Resource Assessment was originally developed by the Virginia Institute of Marine Science Center for Coastal Resource Management (VIMs CCRM) for the first VEVA model development. The CRA was created using the following input layers:

Layer Creation:

Data were projected to Virginia Lambert NAD 1983 and resampled to 100 meter cell sizes. Class values were assigned to the rasters. The classes assigned to the APCA and their corresponding values are as followed:

- Exceptional Habitat Value: 3
- Very High Habitat Value: 2
- Good Habitat Value: 1

Recoded data such as:

3) Shellfish Suitability	4
4) Reef Restoration Sites	5
5) Oyster Reefs	5
6) Artificial Fishing Reef	3
9) Seed Areas	3
10) Aquaculture sites	4
11) Turtle Nest	5
12) SAV (1999 – 2008)	5
17) Regulated Areas	3

Using the ArcMap® tool set "Mosaic to New Raster Tool (Mosaic Method: Maximum)" rasters were superimposed and combined by cell (100m cell size). Using this technique, the output raster retains the maximum cell value on each overlapping cell. Therefore an area with only two resources that score a value of 3 each are not outweighed by an areas with 4 resources with values of 1 each.

VCU Center for Environmental Studies and VA Coastal Zone Management Program updated data, where available, in an effort to update the CRA model. Here is a summary chart of the input datasets identifying if the original input from the first CRA was used or an updated layer was created:

Dataset	Originator	Layer Name	NOTES	VIMS Rank
Shellfish Suitability	VIMS CCRM	shell_30m_f2	Shellfish vulnerability	2
Reef Restoration Sites	VMRC/VIMS CCRM	rrest_30m	Use original from VIMS first CRA run	3
Oyster Reefs	VMRC/VIMS Eastern Shore Lab/ CCRM	oyreef_30m_f2	Seaside oyster density from Coatal GEMS	3
Artificial Fishing Reef	VMRC	fishreef_30m	Use original from VIMS first CRA run	1
Seed Areas	VMRC/VIMS CCRM	seedarea_30m	Use original from VIMS first CRA run	1
Aquaculture sites	VMRC/VIMS CCRM	aquasite_30m	Use original from VIMS first CRA run	2
Turtle Nest Density	NOAA Environmental Sensitivity Index Atlas & VA DGIF Sea Turtle Database	turtle_30m_f	Downloaded new data from http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-sensitivity-index-esi-maps.html. Now a polygon data layer. Data procured from VA DGIF.	3
SAV (1999 – 2008)	VIMS Submerged Aquatic Vegetation Program	sav_30m_f	Downloaded new SAV data and created layerhttp://web.vims.edu/bio/sav/gis_data.html	3
Regulated Areas	VMRC/VIMS CCRM	regareas_30m_f	Use original from VIMS first CRA run	1

The CRA model data included:

Turtle Nest Density: A dataset showing turtle nesting density.

Turtle nest density data was downloaded data from the NOAA Sensitivity Index Maps: http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-sensitivity-index-esi-maps.html and obtained from VA DGIF. Data were buffered at 200 meters when point locations, converted to a 30 meter raster and attributed with rank 5.

Date: 2017

Oyster Reefs:

A dataset showing areas of "varying oyster densities throughout the coastal bay system along the Eastern Shore of Virginia. They are based on habitat-specific oyster estimates" (3).

Data was obtained from the VA CZM Coastal GEMS, Seaside Oyster Density layer. Data was converted to a 30 meter raster and a rank value of 5 assigned.

Date: March 2007 to July 2008 (3)

SAV

"Chesapeake Bay SAV data were mapped from aerial imagery, primarily at a scale of 1:24,000, for the following regions: western shore, Va. only - 1971 & 1974; lower Bay, Va. only - 1980 & 1981; upper Bay, selected sections, 1979; Baywide, 1978, 1984 - 1987, and 1989 - 2016. Each area of SAV was classified into one of four density classes by the percentage of cover as determined from the aerial imagery (methodology is described in each annual report - e.g. see Orth et al., 2016). Starting in 2010, the SAV beds are stored as ArcGIS shapefiles using the quality control procedures documented in the individual metadata files. Data for prior years are stored as ArcInfo GIS coverages. Data were collected by the Virginia Institute of Marine Science and can be attributed by including a reference to the associated annual SAV distribution and abundance report" (4).

Data was downloaded from http://web.vims.edu/bio/sav/gis_data.html for years 2008 up to and including 2015. Data was unioned together and areas where data was present for 6-10 years was used

as an indicator or persistence (3). Data were attributed with a rank value of 5 and converted to a 30 meter raster.

Date: 2008 to 2015

Aquaculture Suitability = Shellfish Suitability

"The Aquaculture Vulnerability Model was developed to assist current and future shellfish growers identify locations where current conditions could support an aquaculture growing operation in Virginia Waters" (5).

The Virginia Aquaculture Vulnerability Model from VIMs CCRM was obtained from the Virginia Coastal Zone Management Program. According the documentation, Level 1 and Level 2 areas represent optimal and suitable areas for shellfish aquaculture, so those two categories were used per VIM's methods.

Data were buffered at 200 meters (per VIM's methods) and attributed with a rank value of 4. Data were converted to a 30 meter raster.

Date: 2015

Regulated Areas

The regulated area layer is a composite of layers from VMRC including broodstock management area, oyster management area, SAV sanctuary, shellfish management area, striped bass spawning sanctuary, harvest area, black drum management area, and blue crab sanctuary area. Data from the original CRA was used.

Date: 2009

Reef restoration sites

Reef restoration site layer information was constructed by the Virginia Marine Resources Commission. The structures are built on public Baylor Grounds (6). The data layer had not been updated so the original layer was used for the model. A rank value of 5 was set.

Date: 2008

Artificial Fishing Reef

Artificial fishing reefs are shipwrecks or structures in the ocean. These rarely change over time, and with no updated layer, the original CRA layer was used. A rank value of 3 was set.

Date: 2005

Seed Areas

Seed areas represent areas where seed oysters, which are oysters that are less than the 3-inch market size, can be harvested during the public season (Tamia Rudnicky, personal communication, June 29 2017). Certain restrictions apply to harvesting seed oysters.

This dataset was not updated so the original CRA layer was used. A rank value of 3 was set.

Date: 2008

Aquaculture Sites

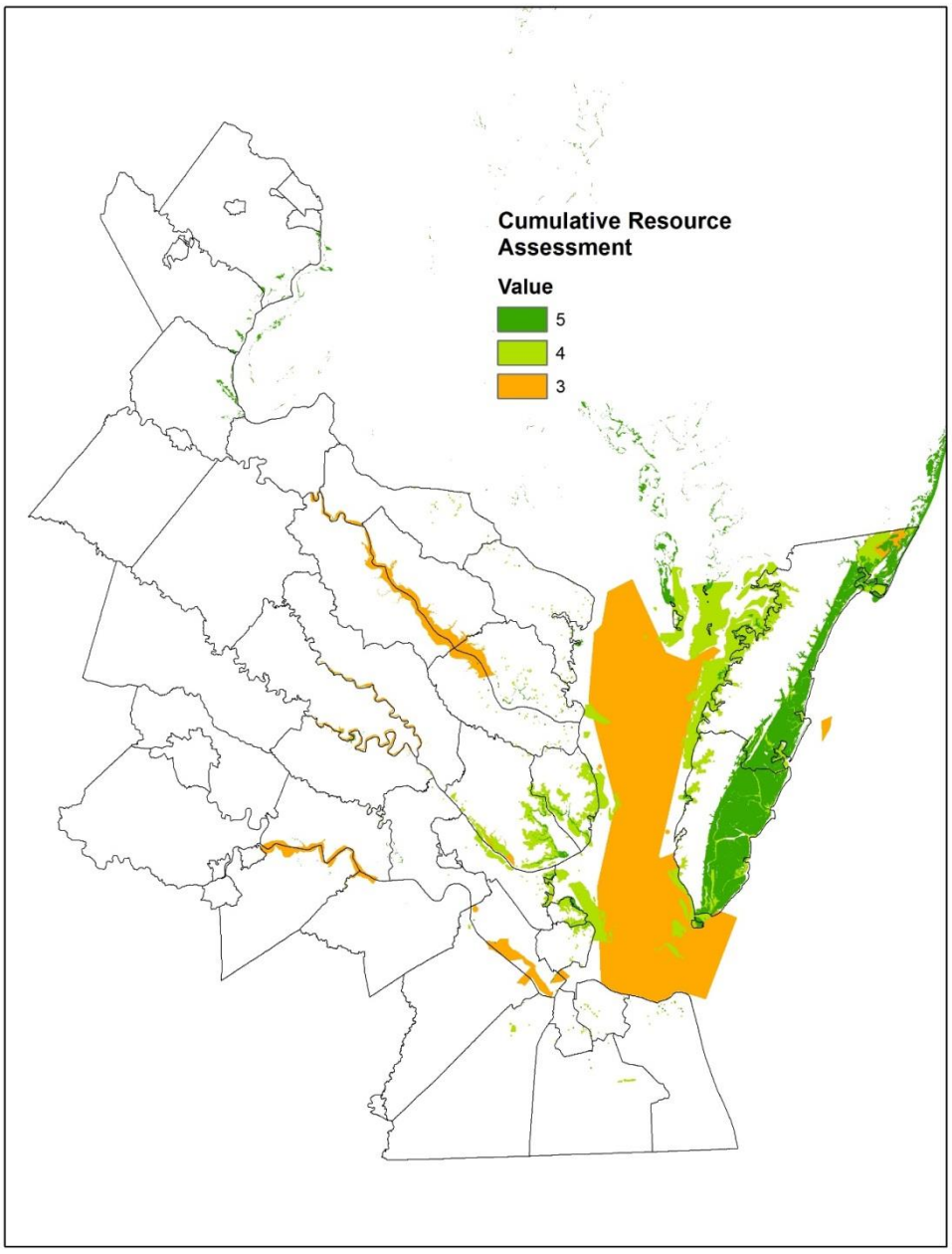
"Aquaculture permit sites are allocated areas for bottom aquaculture of shellfish (primarily oysters and hard clams). These data points are managed by Virginia Marine Resource Commission (VMRC) in order to better assess, plan, and manage aquaculture development in Virginia" (7). The data were created by VIM's CCRM.

This dataset was not updated so the original CRA layer was used. A rank value of 4 was set.

Date: 2002

Final Cumulative Resource Assessment:

All data were converted to a 30-meter grid and original ranking retained. The values of the input layers were reclassified to scale the rank to match the VEVA ranking by adding a value of 2. The input layers were combined using Mosaic to New Raster tool with the Mosaic Operator set to MAXIMUM.



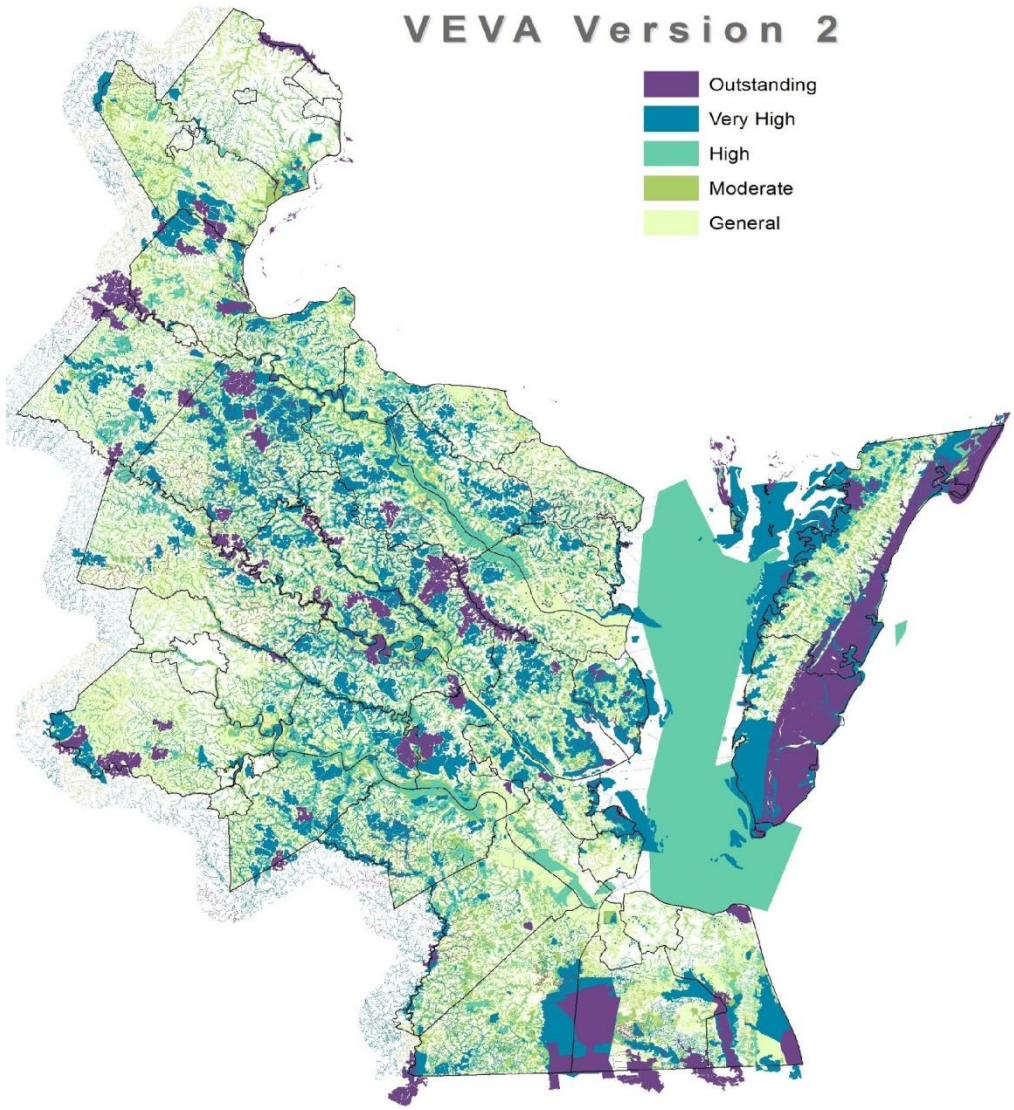
Left: Cumulative Resource Assessment

Final Coastal VEVA Dataset

To combine the input layer, the Cell Statistics tool was used with the Maximum Overlay Statistic option set. All input grid NODATA values were set to a value of 0. To smooth the data, a Majority Filter was applied with the specifications for FOUR number of neighbors and using the MAJORITY replacement threshold.

The final grid is called **veva_final**. A polygon feature class was created representing the VEVA polygon boundaries attributed with maximum ecological value (data were not generalized). An additional layer was created which unioned all the inputs with the final VEVA layer, called **veva_all_inputs**. This layer represents the final veva layer unioned with all the input layers. This layer was created to show where individual inputs are on the ground for end users interested in what entity polygon is where. The layer can be symbolized based on total VEVA value and the end user will still have the same representation of data as the final VEVA.

Feature representation was created in the final geodatabase to store symbology based on using the VEVA_Value field. FGDC metadata was generated using ESRI ArcCatalog metadata tool. Data are available from the Virginia Coastal Zone Management Program as vector or as an ArcGIS feature service.

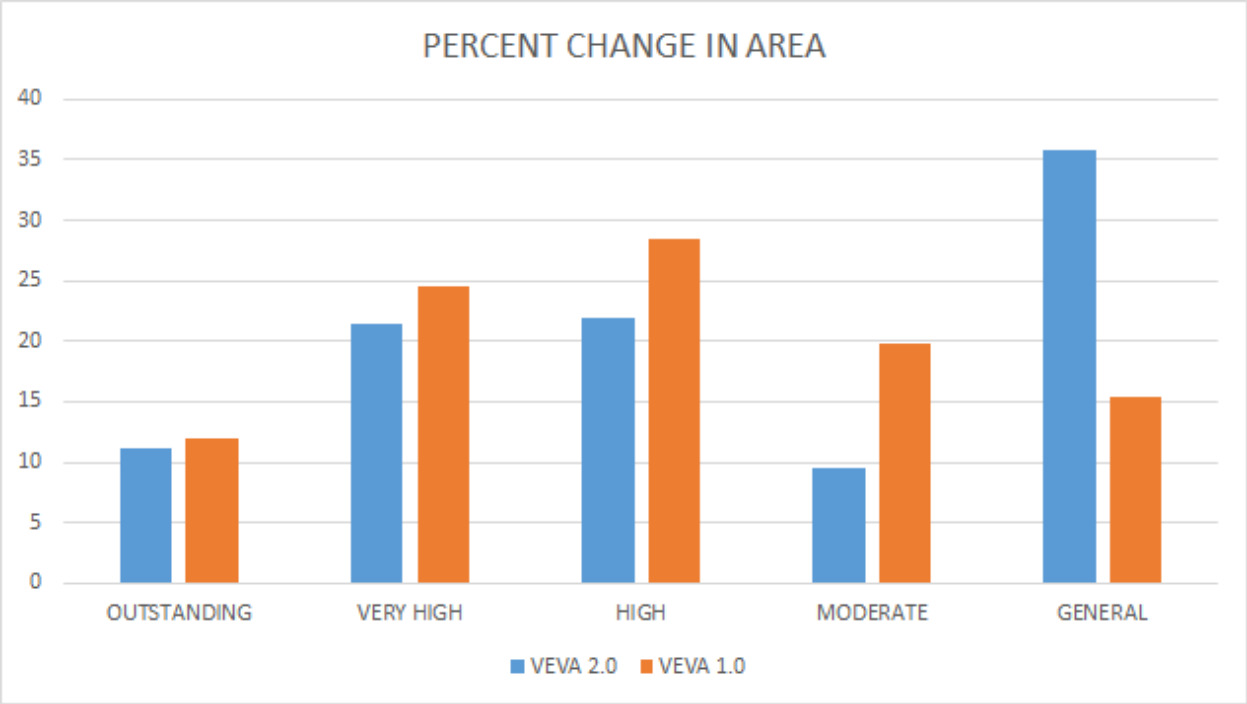


Left: Coastal VEVA version 2 final map

Change Analysis

The change in area was quantified by assessing the percent area of each rank for each VEVA model as the total area for model 1 and model 2 were different. Percent changes in area are quantified as:

RANK	VEVA 2.0	VEVA 1.0	% CHANGE
OUTSTANDING	11	12	-1
VERY HIGH	22	24	-3
HIGH	22	28	-6
MODERATE	10	20	-10
GENERAL	36	15	20



Discussion

VCU staff convened a Coastal VEVA Partner Meeting on November 28, 2017 in the VA DGIF Board Room in order to review version 2 of Coastal VEVA and validate the data and discuss changes from version 1. Participants in attendance included David Whitehurst, Becky Gwynn, Jay Kapalczynski, Ed Laube, and Ruth Boettcher from VA DGIF, Joe Weber from DCR-DNH, Jennifer Ciminelli and Will Shuart from VCU, Marcia Berman from VIMS, Chip Neikirk from VMRC, and Laura McKay and Nick Meade from VA CZM. The changes from version one of Coastal VEVA are summarized below.

The updated VEVA model is different from the original VEVA model due to natural processes and human influences on the landscape over the six-year time period. Other factors identified as driving change come from enhancements made to the individual input layers.

DCR – DNH Landscape Assessment: The DNH Landscape Assessment used much more extensive fragmentation layers (roads and structures) in 2017 run. Some changes can be attributed to actual landscape change, but much of the change is data driven with many larger cores being fragmented by the updated road and structures data. This caused an increase of small high priority cores, including many associated with rivers.

DGIF Priority Wildlife Diversity Conservation Areas: Most input data sets and all weights remained the same as 2011 PWDCA. One key change for 2017 PWDCA was the inclusion of NALCC Terrestrial and Aquatic Potential Habitats data. The extensive coverage of the new NALCC data was likely the source of the most perceptible changes in the 2017 PWDCA.

VCU Aquatic Resource Integrity Layer: VCU samples 100-200 sites each year with the majority being new sites (currently 2900 across state). This causes the data density of this layer to constantly increase.

VIMS CCRM Aquatic Priority Conservation Area (Resource Assessment):

VCU worked with VIMS staff to update layer for 2017. Included updated data for SAV, Shellfish Vulnerability, and Sea Turtle Nest Density. VIMS oyster reef data for the seaside of the eastern shore (not available in previous version) generated a significant change in perceived value of the landscape since the last iteration. As well, the sea turtle nest density layer was originally point data, but in the updated version was polygonal data.

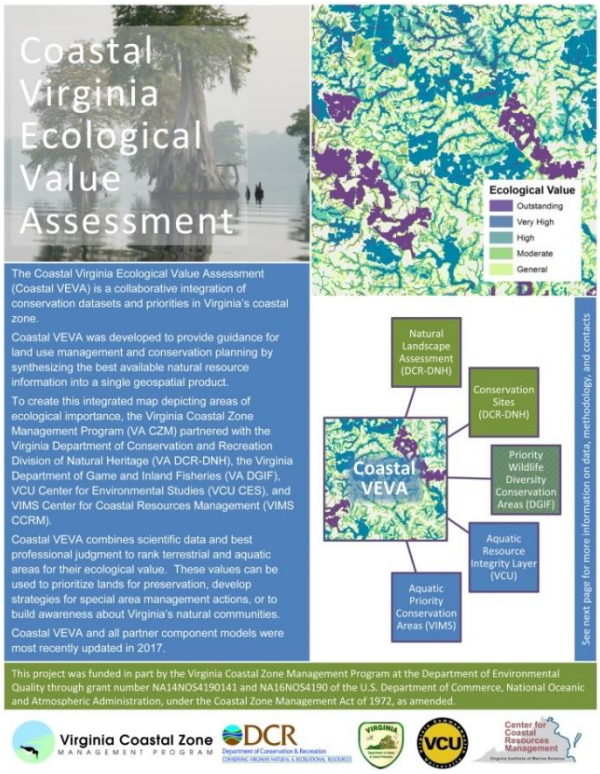
Cell Size

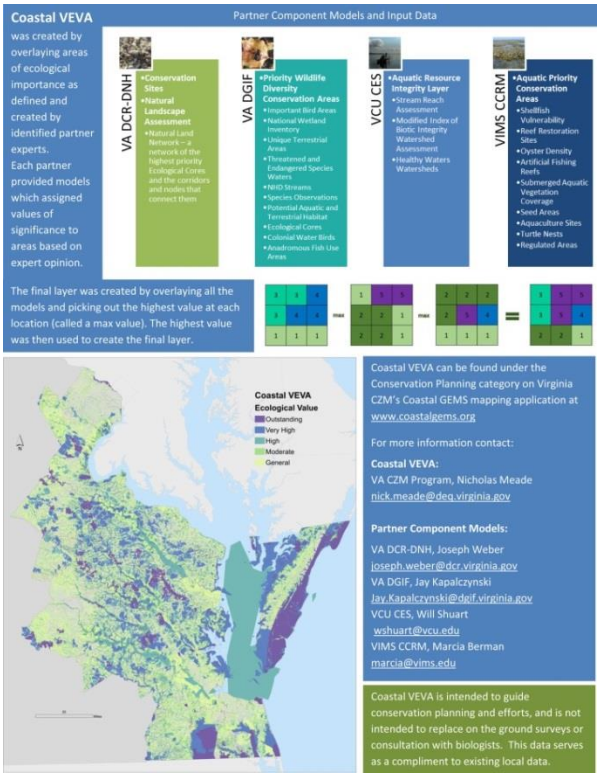
All partners agreed to retain 30-meter cell resolution of 2017 Coastal VEVA instead of 100-meter cell size used in previous version. The 30-meter cell size does not reveal sensitive areas as previously thought and will be a more useful product for local scale conservation planning. VCU created a 100-meter cell size grid only for the purpose of completing a percent change analysis between 2011 and 2017 versions.

The VEVA model process provides us with a unique opportunity to not only update the original data layer, but to capture changes in the landscape over time. The process itself allowed the team to assess where methods could be updated and how data can be disseminated and used in a more productive and useful manner.

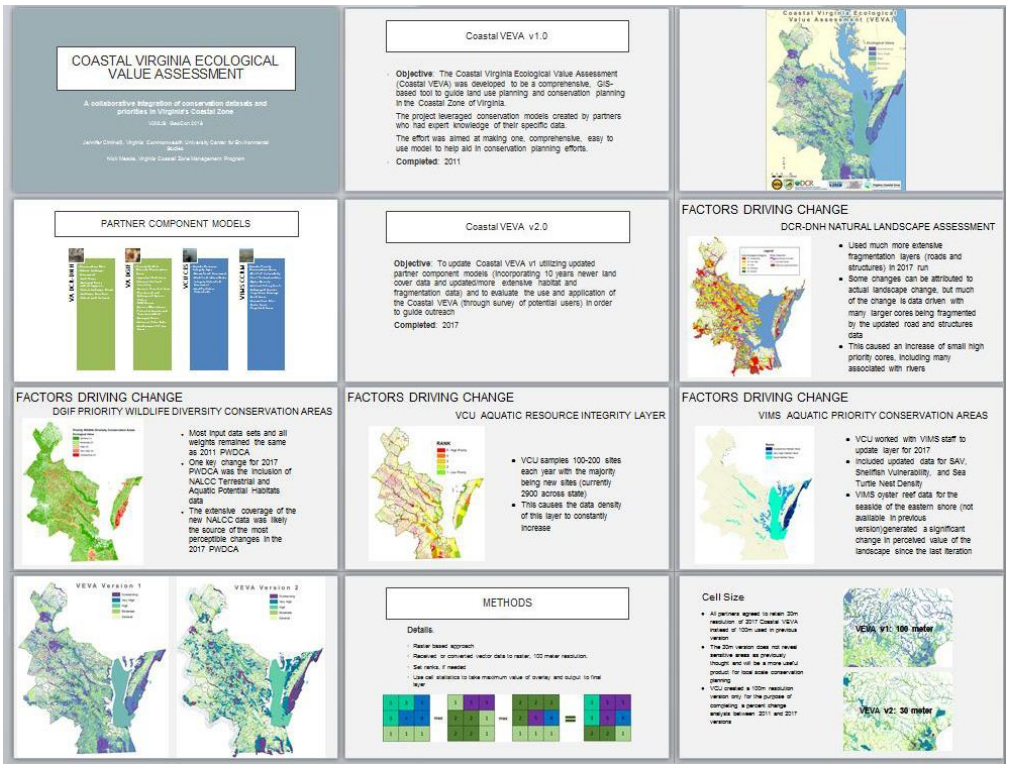
Coastal VEVA Educational Materials and Outreach Efforts

VCU staff worked with VA CZM to create a two page Coastal VEVA handout providing information about the data, how it was created, and its intended uses through both text and infographics. See below:





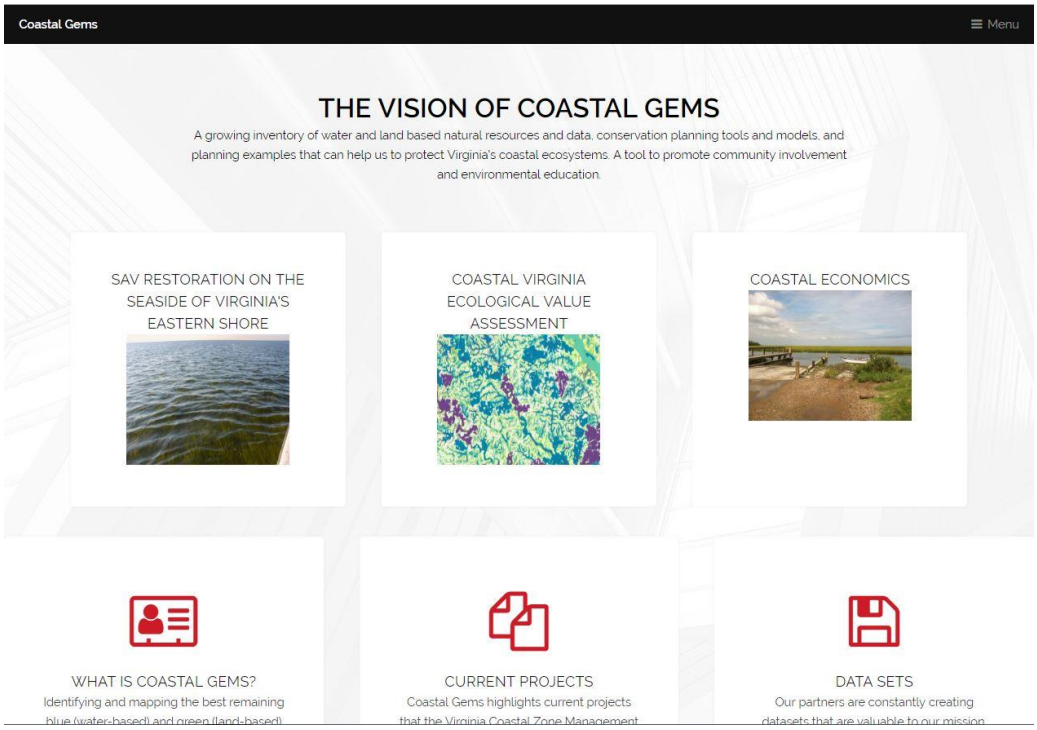
VCU staff presented Coastal VEVA at the Virginia GIS Conference, at a DCR-DNH all staff meeting, and at a VIMS green infrastructure workshop, including slides explaining the data and methodology, exploring changes between Coastal VEVA version 1 and version 2, and reviewing intended uses of the data.



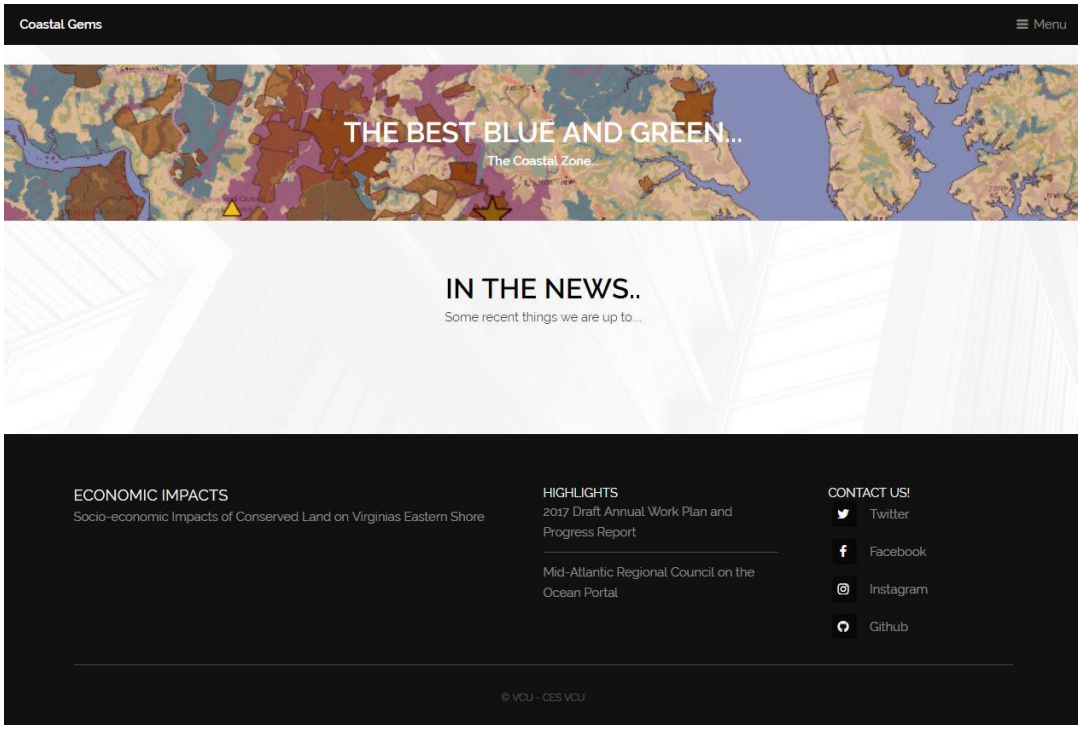
Left: Coastal VEVA presentation slides

Coastal GEMS Landing Page

VCU staff created a new Coastal GEMS landing page which includes information about Coastal GEMS and links to launch the mapping application and launch Coastal GEMS map stories, as well as links to relevant VA CZM web pages. This page is live and can presently be found at this temporary address: http://128.172.160.131/gems_redo/. VCU staff are currently working with VA CZM staff to make some tweaks to the text and layout of the new landing page before it is pushed out publically and moved to the www.coastalgems.org URL.

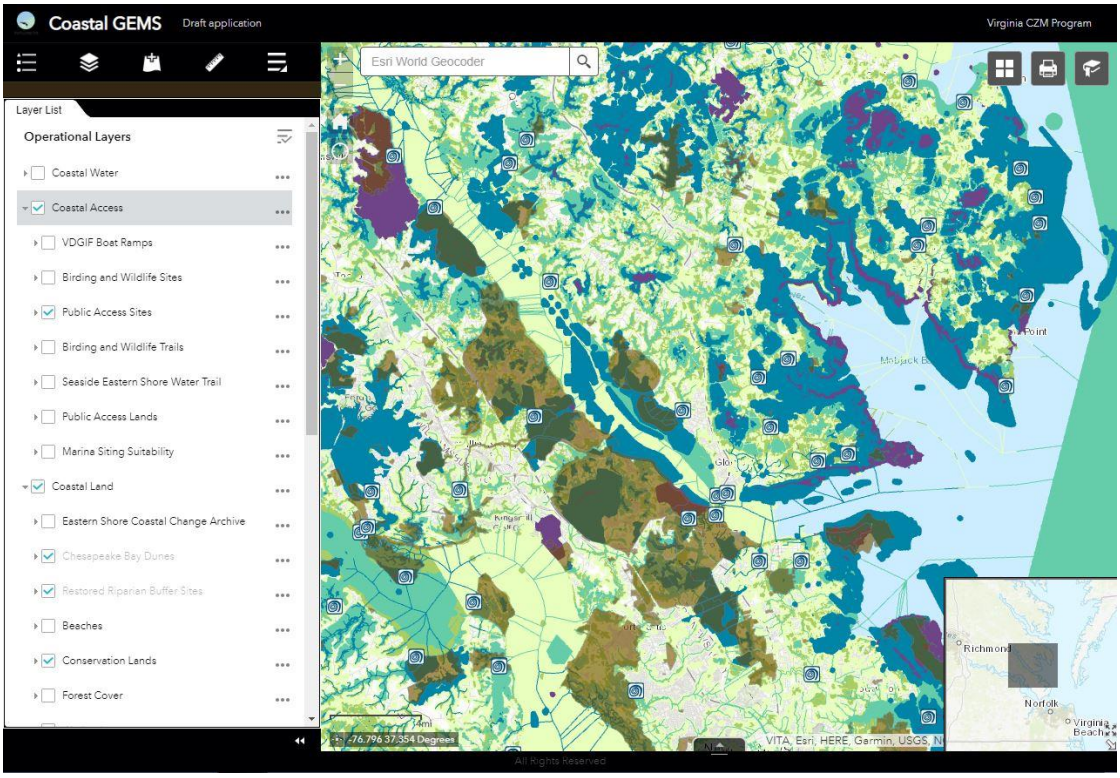


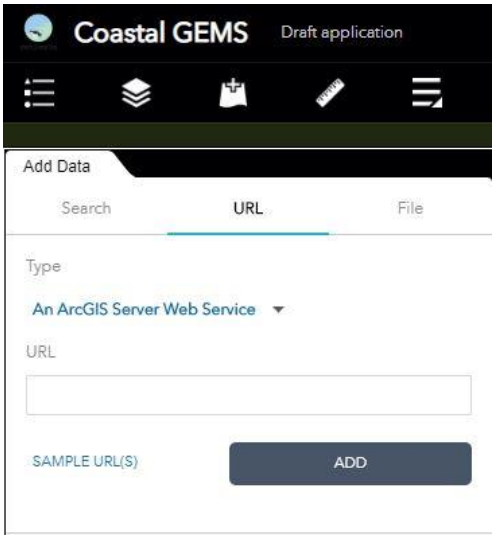
Left and Below: Screenshots from new Coastal GEMS landing page

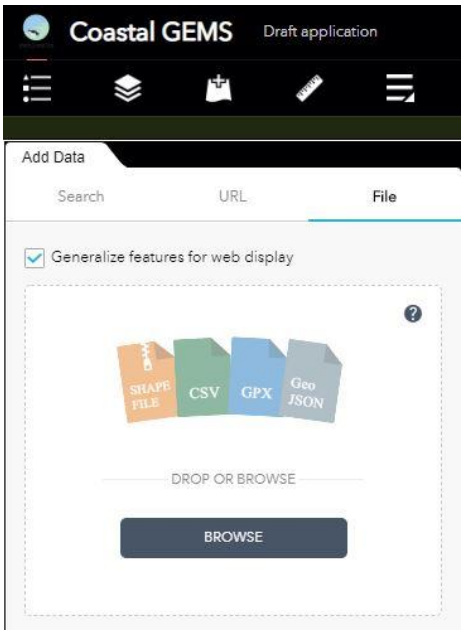


Coastal GEMS Mapping Application Updates

VCU staff created a new draft Coastal GEMS mapping application which includes the ability to view multiple years of VBMP imagery and add data (map services) from outside sources. The original deliverable outlined in the grant proposal for this task called for these two functionalities to be added to the current version of the Coastal GEMS mapping application, but it became apparent during development that for these functionalities to operate as desired would require the entire mapping application platform to be updated.



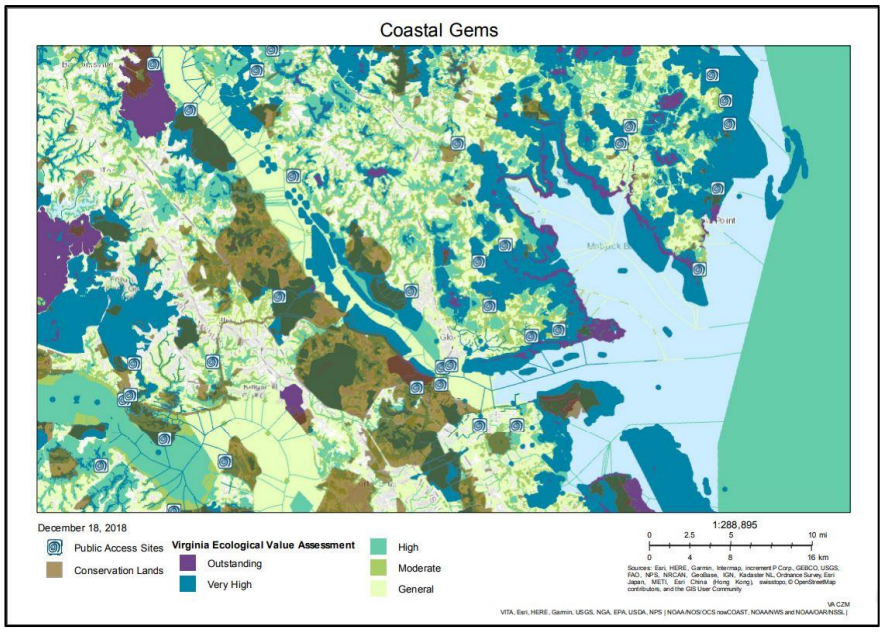




Above: New Coastal GEMS draft mapping application

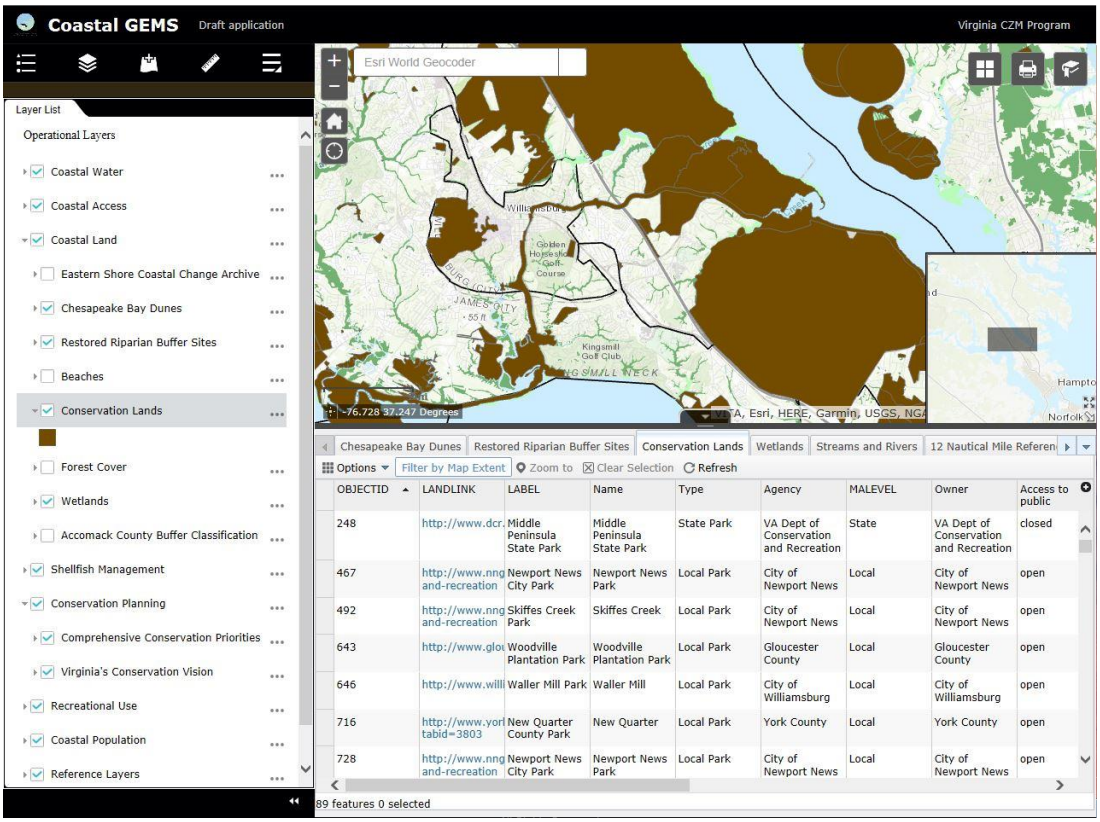
Left: Add data functionalities on new Coastal GEMS draft mapping application including the ability to add web mapping services or spatial data files to the map

Creating a new draft Coastal GEMS mapping application platform had the added benefit of improving on some existing Coastal GEMS functionalities as well as adding some additional functions. These include improved print functions with legends available in all image formats, printable fact sheets that open in separate browser tabs, the ability for users to restore the map extent and layers from their previous session, a pop up disclaimer upon initial application launch, and advanced attribute table functions.



Left: Draft Coastal GEMS mapping application print export layout

Below: Advanced attribute table view and search functions, including filter by map extent



http://gis.vcu.edu/coastalgems/Factsheet.ashx?layerName=He

gis.vcu.edu

Biotic Stream Assessments (INSTAR) Locations

INSTAR (Interactive Stream Assessment Resource) is a dynamic and interactive internet application built on ESRI's ArcIMS application and supported by dedicated servers at Virginia Commonwealth University's Center for Environmental Studies. INSTAR allows users to access and manipulate an extensive, new dataset for stream reaches in Virginia's coastal zone. The data represent fish macro invertebrates, instream habitat assessment, and stream geomorphology. The application supports user-driven database queries, mapping functions, and quantitative biological and habitat assessments of stream reaches and hydrologic units, using algorithms and ecological models that compare selected sites to appropriate regional reference conditions.

HEALTHY WATERS

Status of the data
This layer was developed between 2001 and 2006. Refinements are continuing.

Data Source
INSTAR (2007). Virginia Commonwealth University

N/A

To access this data layer/tool directly, please visit:
http://gis.vcu.edu/instar/

For original datasets, please contact:

William Shuart
1000 West Cary Street
Richmond, VA 23284.00000000
Phone: 804-828-7202
Fax: 804-828-1622
Email: wshuart@vcu.edu

Why should we care?
A key role of Virginia's natural resource agencies is the identification, restoration, and protection of streams, rivers, and riparian corridors that contribute important ecosystem services or represent significant ecological resources. Challenges associated with these important efforts include: 1) development and application of objective, quantitative, and diagnostic stream assessment protocols and 2) defining a set of measurable and appropriate stream conditions, based on empirical data, as goals forrestoration and protection efforts. Both of these challenges require an understanding of, and comparison to, relevant reference conditions that describe accurately and quantitatively the ecological potential of streams and rivers within a specific region. In Virginia, the lack of relatively undisturbed streams to serve as reference systems is especially problematic in the Coastal Zone, Piedmont, northernVirginia, and the Shenandoah Valley, and compromises stream assessment and protection activities for these regions.In response to the problems outlined above, Virginia Commonwealth University, the Virginia Department of Conservation and Recreation, and the Virginia CZM Program initiated a multi-phase project to develop an integrative, objective, and statistically valid stream health assessment application.

Links to find more information:
Description of INSTAR

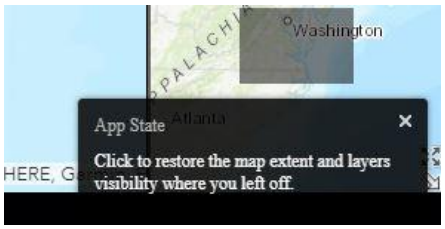
How is this resource managed?
N/A

Links to find more information about how this resource is managed:

Above: Disclaimer pop-up during initial application launch with link to full disclaimer

Left: Printable fact sheet open in separate browser tabs

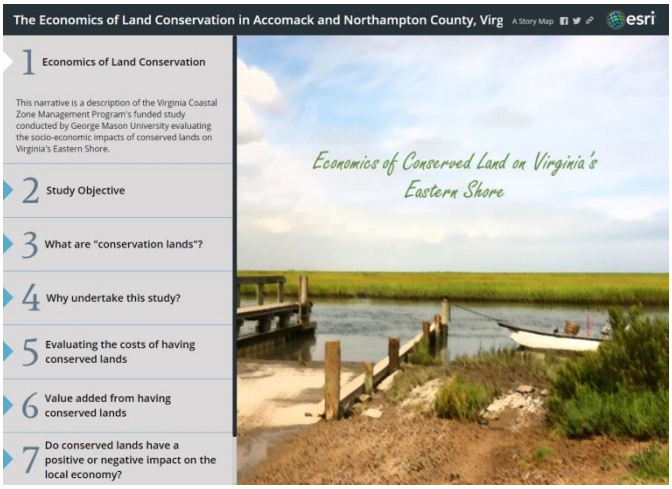
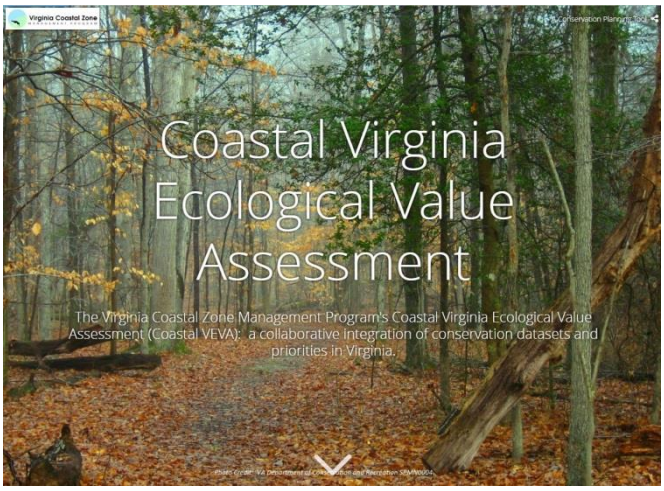
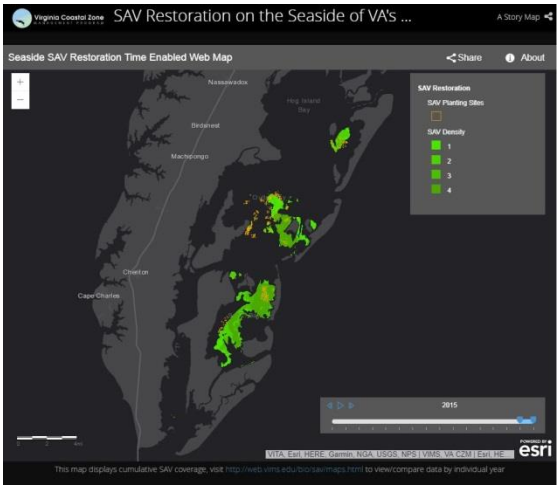
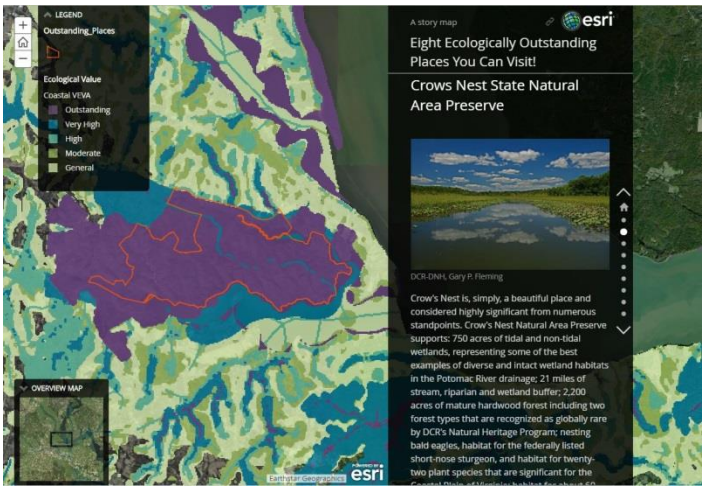
Below: Restore the map extent from previous session function



The new draft Coastal GEMS mapping application can presently be found at this temporary address: https://gaia.vcu.edu/portal/apps/webappviewer/index.html?id=969fb743d86f457e9ecc7eb14482840d.

Along with the new Coastal GEMS landing page, VCU staff are currently working with VA CZM staff to test and fine tune the new draft Coastal GEMS mapping before it is pushed out publically.

Coastal GEMS Story Maps

VCU staff created ArcGIS online logins for VCU and VA CZM staff to utilize the VCU CES ArcGIS Online organizational account in order to create story maps to be made available through the new Coastal GEMS landing page. VCU and VA CZM staff worked together to produce four story maps including a cascade story map describing the Coastal VEVA data, methodology, and intended use; a cascade story map detailing the restoration of eelgrass on VA's Eastern Shore featuring a time enabled interactive map of SAV planting sites and coverage; a story map journal highlighting publicly accessible places in VA's coastal zone ranked in the highest category of the updated Coastal VEVA; and a story map journal describing the results of the VA CZM funded study of economic impacts of conserved lands on VA's Eastern Shore.

Below, Clockwise from Top Left, including links for each story map:
Economics of Conserved Land on Virginia's Eastern Shore https://arcg.is/0m9zv4
Coastal Virginia Ecological Value Assessment https://arcg.is/1zqSi
Eight Ecologically Outstanding Places You Can Visit! https://arcg.is/101bLW
SAV Restoration on the Seaside of VA's Eastern Shore https://arcg.is/C8Pnr