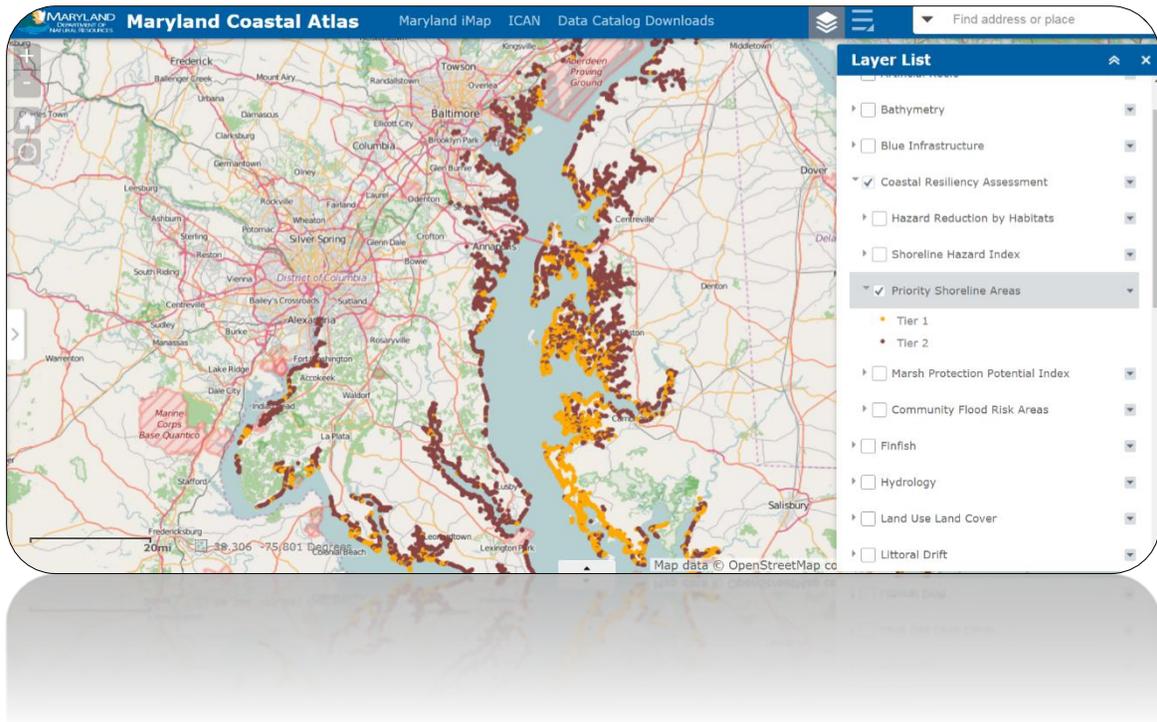# Coastal Resiliency Assessment Training Manual

June 2016

About the Training Manual

This manual is organized into four parts:

1. Navigation of the Coastal Atlas
2. Understanding Maryland's coastal resiliency data
3. Exploration of data applications
4. A series of lessons and exercises that incorporate coastal resiliency data and Atlas tools into real world examples.

Your feedback will direct the expansion and scope of this manual for future trainings.

All Coastal Atlas datasets are estimates based on the best available data and models. In some cases, the resolution of some layers may not be high enough to inclusively consider the impacts to a specific building or parcel. However, the Coastal Atlas can provide a general picture of the environmental conditions in a region and presents valuable insight about the vulnerably of communities and waterfront property owners in relation to coastal hazards.

Funding

Financial assistance for the Coastal Atlas was provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (NOAA).

The Coastal Resiliency Assessment was prepared by The Nature Conservancy and the Maryland Department of Natural Resources under award number NA13NOS4190136 from the Office of Ocean and Coastal Resource Management (OCRM), National Oceanic and Atmospheric Administration (NOAA), through the Maryland Department of Natural Resources Chesapeake and Coastal Service. The statements, findings, conclusions and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

Disclaimer

All of the data contained within the Coastal Atlas and derived from these applications are intended for informational use only. This tool should be used strictly as a planning reference or screening-level tool for management decisions and not for navigation, permitting, or other legal purposes. Users rely on information contained in the Coastal Atlas at their own risk, and any conclusions or decisions based on the use of these tools are the responsibility of the user. The data and maps in this tool are provided "as is," and all features should be verified with a site visit.

The Coastal Atlas brings together multiple data layers from different sources, and thus is challenged by spatial and temporal scales. In the coastal environment, this is most evident when comparing data originally referenced to different shoreline bases and mapped at different scales. While every effort has been made to provide useful coastal planning tools in the Coastal Atlas, the State of Maryland, its agencies, officers, employees, agents, and representatives cannot guarantee the accuracy, reliability or timeliness of any information contained in the Coastal Atlas. The entire risk associated with the results and performance of these data is assumed by the user.

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Background

With its extensive shoreline, Maryland's coasts experience flooding and erosion, caused by tides and storms and exacerbated by sea level rise. Furthermore, almost 70% of Maryland residents live in counties or cities impacted by these coastal threats. In October 2012, Hurricane Sandy made landfall on the United States' East Coast. The resulting storm surge devastated coastal populations from North Carolina through Maine, with more than $41 million in damages estimated throughout Maryland. Although Maryland was not the most hard-hit state among those affected, much debate surrounds the impacts of the next hurricane, tropical storm, or Nor'easter.

The Maryland Department of Natural Resources (DNR) has the lead role among State agencies in advancing the scientific understanding of Maryland's vulnerability to climate change, and in advocating for sound planning to avoid or minimize anticipated impacts. In 2010, DNR reaffirmed its role in mitigating impacts to the State's people, natural resources, public lands, and investments through the *Building Resilience to Climate Change Policy*. In 2014, Maryland signed the Chesapeake Bay Watershed Agreement, thus agreeing to increase the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure and communities, to withstand adverse impacts from changing environmental and climate conditions.

One means of increasing coastal community and ecological resiliency is through the pursuit, design, and implementation of coastal conservation and restoration projects. Natural features such as tidal wetlands/marshes, forests, submerged aquatic vegetation, oyster reefs, beaches, dunes, and Bay islands can enhance coastal resiliency through wave attenuation, shoreline stabilization, and infiltration. Understanding the role natural features play in risk-reduction is essential as the state works to adapt to changing environmental and climate conditions and enhance the resiliency of our coastal communities and ecosystems.

Coastal Resiliency Assessment Overview

To pursue conservation and restoration efforts where habitats can further enhance coastal community resiliency, DNR partnered with The Nature Conservancy (TNC) to complete a Coastal Resiliency Assessment. Through close collaboration with the Natural Capital Project, the US Army Corps of Engineers, and other state, federal and non-profit partners, the DNR/TNC project team identified and assessed the role of Maryland's existing natural features in coastal community protection. Shoreline and marsh areas where natural features currently play a low to high role in risk-reduction were identified and priority areas were selected for coastal conservation and restoration actions. The Assessment was completed for tidal regions of Maryland's Coastal Zone, which is defined as the furthest extent of a flood hazard event. State, federal, and non-profit partners participated on a Steering Committee to advise the development and completion of Maryland's Coastal Resiliency Assessment.

Coastal Resilience: Terms, Definitions and Data

The following data products were developed through completion of the Assessment:

- **Shoreline Hazard Index (Point Data):** identifies high, moderate, and low hazard shorelines based on sediment type, historic erosion rates, elevation, localized sea level rise risk, wave power, and storm surge height. Shoreline segments are represented by points every 250 meters along the shoreline.

- **Habitat Role in Hazard Reduction (Point Data)**: identifies shorelines where habitats play a high, moderate, low, or nonexistent role in hazard reduction. Shoreline segments are represented by points every 250 meters along the shoreline. Only habitats within defined distances from the shoreline were considered.

- **Coastal Community Flood Risk Areas (Polygon data)**: identifies residential areas ranked from very low to very high risk based on probability of exposure to a flood event, population density, and social demographics. The metrics of age (≤ 17 or ≥ 65 years), income (below poverty), and language proficiency (speaks English less than "very well") were applied. Data were analyzed within a 30-meter grid. Infrastructure and non-residential land uses were not considered in this analysis.

- **Priority Shoreline Areas (Point Data)**: Tier 1 and Tier 2 priorities for conservation and restoration actions. Tier 1 and Tier 2 shorelines represent areas where habitats have the potential to play a high or moderate role in risk reduction, respectively, for adjacent coastal communities. Adjacent coastal communities are defined as residential areas within 2 kilometers of the shoreline. Shoreline segments are represented by points every 250 meters along the shoreline.

- **Marsh Protection Potential Index (Polygon Data)**: ranks the potential of existing marshes to protect coastal communities based on marsh size, proximity to coastal hazards, proximity to residential areas, proximity to other coastal habitats, and the likelihood that the marsh will persist into the year 2100. Each marsh is given a score from 1 – 25 and an associated protection ranking (very low to very high protection potential). Marsh health/quality has not been considered in the rankings.

The following terms and definitions were used to guide development and completion of the Coastal Resiliency Assessment.

- **Community Resilience** – The ability of a community to prepare for, respond to, and recover from a coastal hazard event.

- **Coastal Hazard[1]** – Coastal storm and flood events that may increase the likelihood of danger or damage to life and property as a consequence of inundation and shoreline erosion. These hazards are caused by storms and exacerbated by sea level rise.

- **Coastal Communities** – People living within the coastal zone and exposed to coastal storm and flood hazards such as inundation and shoreline erosion. For the purposes of this assessment, we have represented coastal communities by mapping residential populations within the area predicted to be inundated by a Category 4 Hurricane storm surge.

- **Targeted Coastal Communities** – Coastal communities with demographic parameters or community characteristics that limit the population's ability to prepare for, respond to, and/or recover from coastal hazard events. For the purposes of this assessment, we examined population density as well as the social vulnerability metrics of age, poverty, and English proficiency.

- **Community Flood Risk Areas** – Locations within the coastal zone where targeted coastal communities are exposed to periodic coastal storm and flood hazard events with possible impacts from sea level rise

- **Natural Features** – Habitats within the subtidal, intertidal, and coastal environment that enhance coastal community resilience through wave attenuation, shoreline stabilization, infiltration and other storm and flood risk reduction benefits. Maryland's natural features include tidal wetlands and marshes, vegetated buffers, oyster reefs, submerged aquatic vegetation, Bay islands, beaches, and dunes.

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[1] The State Hazard mitigation Plan identifies coastal hazards as: *Hurricanes, nor'easters, and other coastal storm events that result in storm surge inundation, heavy precipitation, flash flooding, and/or shoreline erosion. Coastal hazards also include longer-term hazards such as sea level rise*. We have altered this definition to focus on events at the land/water interface while putting equal emphasis on inundation and erosion.

Guided Exercise 1: Using the Coastal Atlas

What is the Coastal Atlas?

The Coastal Atlas is an online mapping and planning tool that was developed to aid state and local decision-makers in coastal and ocean-planning activities. This platform can be used to explore, map and query spatial ocean and coastal data to better manage Maryland's marine and estuarine resources, as well as understand community vulnerability to coastal hazards. Publically available GIS data supports decision-making for future ocean, near-shore and estuarine activities by highlighting current uses, resources, and risks.

> *In this exercise, you will:*
> - *Familiarize yourself with the Coastal Atlas Platform*
> - *Explore available coastal data and tools*

Accessing the Coastal Atlas

1. Navigate to Maryland's Coastal Atlas through the following webpage:

   http://gisapps.dnr.state.md.us/coastalatlas/WAB/index.html

   Follow the instructions on the Coastal Atlas page to access the interactive map (first time users must agree to terms and conditions). The default window displays a complete view of Maryland and the Chesapeake Bay. An overview of available data can be found on the left panel. Click the white arrow to minimize this information.

Navigating the Coastal Atlas

2. Use the zoom buttons to change the display scale of the map. These are located on the top left of the map window. Notice that the scale legend in the bottom left corner will change accordingly. Clicking the Default Extent button will bring back the full extent of Maryland's state boundaries.
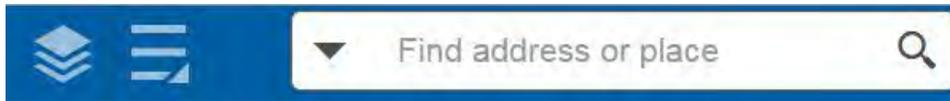
   Zoom In

   Zoom Out

   Default Extent

3. Click the map and drag to pan across the map.

4. Use the **Search Bar** at the top right of the map window to navigate to Saint Mary's City. You may type an address, geographic location, or coordinates in the search bar to find a location. When finished, clear the search and click the Default Extent button.

Layer List   More Tools   Search Bar

5. Click the **Layer List Icon** in the top right corner of the map window next to the search bar. A list of ocean, coastal, and estuarine data will appear. Check the box next to **Blue Infrastructure**. Explore information nested under Blue Infrastructure by clicking the left arrow and expanding the selection. To view the data attributes, click the right down arrow and click "Open Attribute Table." The Attribute Table will appear at the bottom of the map. The Description will appear in a new webpage tab.
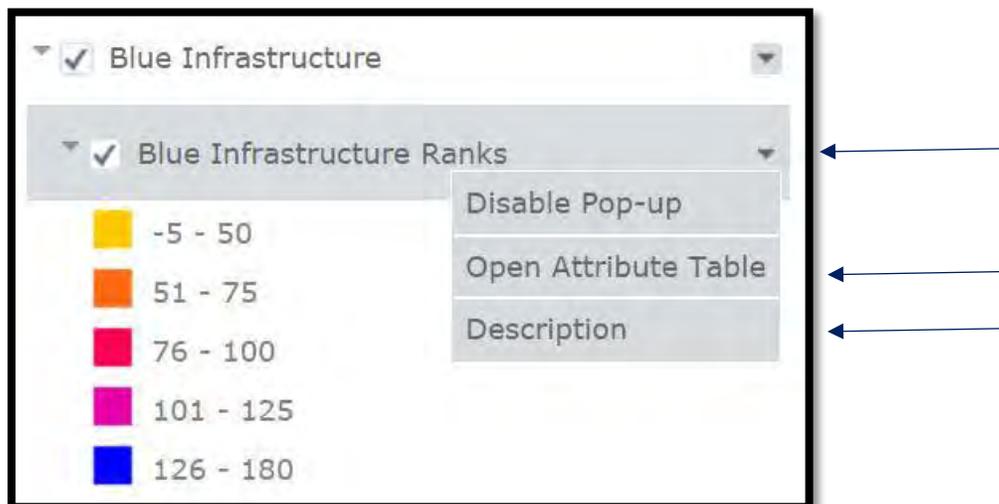

Click on a Blue Infrastructure Segment of your choice. Notice the Pop-Up Box, which includes information about the data with links to resources.

Question: What does the Blue Infrastructure Layer identify?

6. Click the **More Tools Icon** in the top right corner of the map window next to the search bar. A pop-up will appear that includes tools for adding, analyzing, and manipulating data. View your options. Click the **Legend Icon** to see Blue Infrastructure symbology. The Legend will display symbology for all data layers that you have turned on. Notice that the Layer List is replaced with the Legend in the right panel. Click the double arrows to minimize the column or the X to remove the column.
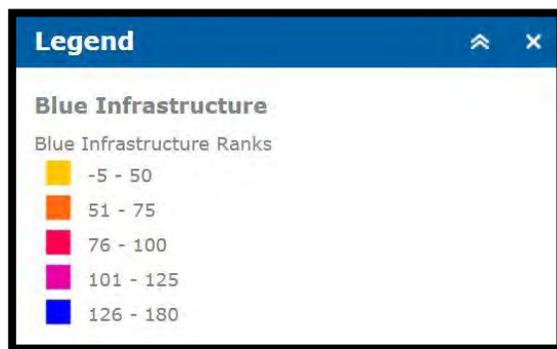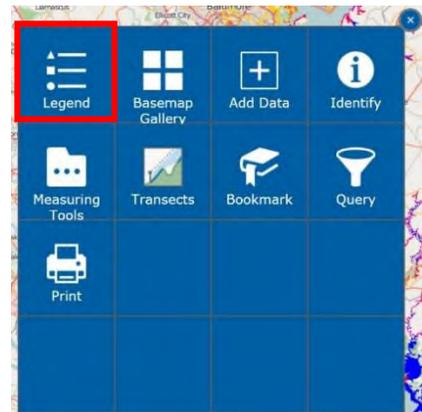
7. Click the **More Tools Icon** to access the **Basemap Gallery** and change the background imagery of the Atlas. You can choose from a variety of basemaps with different labels and geographic features. Notice that the banner icon changes based on the tool that you are using.
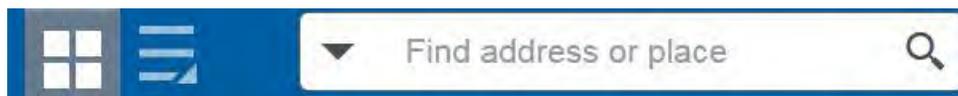

Basemap   More
Icon   Tools

Note: Depending on your screen resolution, multiple icons may appear automatically next to the Search bar and Moor Tools Icon. Try zooming the screen resolution to 150% to view one tool at a time (as shown above).

8. Return to the **More Tools Icon** . Click on the **Identify Tool** and choose a selection method. Information on the selected areas will appear under the Results Tab. The Tool will indicate the number of features selected and information about each feature. Clear your selection and try a different selection method. Click on the first result to zoom to the feature of

interest. Click the red X to remove a result from the list, or press "clear" to remove all selected features. Return to the Identify Tab to start a new selection.
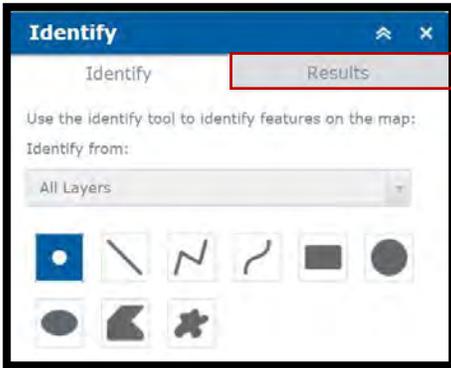
Selected Results

Layer of Interest

Selection Options

9. Click the **Layer List Icon** at any time to return to the data layer list. Turn off the Blue Infrastructure Layer, and turn on the **Sea Level Rise Vulnerability** Layer, 0 – 2 feet and 2 – 5 feet. This layer is a good example of why adjusting transparency is helpful to view the basemap or comparing with relevant layers.
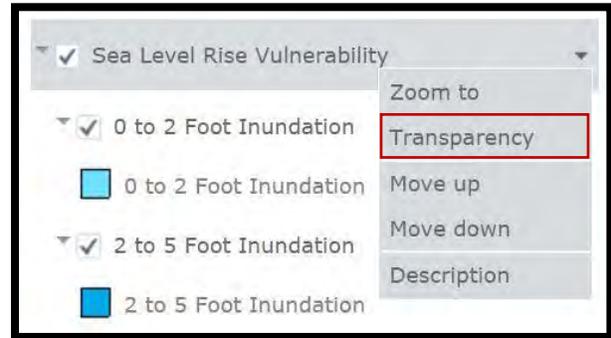
Change the basemap to the "Imagery." Zoom into Kent Island to view sea level rise projections and how sea level rise may affect shorelines. Click on the down arrow next to Sea Level Rise Vulnerability to set the transparency to 50%. Compare the different shades of blue to the legend or turn different inundation layers off and on to identify sea level rise for specific areas.

Question: Will your land be inundated by sea-level rise? If so, at what level? Are there any structures on your property that will be impacted?

10. Turn off the Sea Level Rise Vulnerability Layer and turn on the **Sea Level Rise Wetland Adaptation Areas** to see how existing wetlands near your property might transition as sea level rises. View the Legend to determine high, medium, and low priority adaptation areas where wetlands may migrate if barriers are removed.

11. To determine how vulnerable your property is to coastal flooding during extreme weather, turn on the **Storm Surge** layer. This layer depicts the output from the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model and illustrates the likely extent of storm surge associated with different strengths of hurricanes.

Question: Is your property vulnerable to storm surge? If so, at what category of storm? Are vulnerable buildings/infrastructure on your property adapted to withstand higher than normal

water (elevated, flood-proofed, etc.)?

12. Navigate to the Chesapeake Biological Lab at **146 Williams Street Solomons, MD 20688**. Under the **Shorelines Rates of Change** layer group, turn on only the **Historic Shorelines** layer. This layer shows the change in shorelines over time. Each colored line represents the historic position of the shoreline based on previous maps and aerial imagery. Look at the legend to see the year range to which the shorelines correspond.

    Question: How does the most recent shoreline compare to historical shoreline positions? Has it experienced a lot of change in the past? Are there shoreline structures in place now to reduce erosion? (HINT: Find the Shoreline Inventory/Stabilization Structure Data Layer)

13. Return to the **Shoreline Rates of Change** Data and turn on the **Transects** Layer. Change the Basemap if necessary to better view the Transect lines. This layer depicts transects that run from an inland reference baseline to the oldest historical shoreline record. These transects are used to calculate the rate of shoreline change. Consult the legend to see what the different transect colors represent.

    Navigate to the **Transects Tool** and click the Select Transects button. Click on the map and move your curser over the relevant transects. Double click when finished. The Transect Tool will generate a list of the selected transects and their rate of change per year, as well as the total transect average erosion/accretion per year. Click the zoom icon next to each rate to pinpoint its associated transect on the map. Notice the selected transects will be highlighted red.

    Note: Negative values indicate the distance eroded per year, while positive values indicate the distance accreted per year, both for individual transect locations and the shoreline average.


    Question: What is the average erosion or accretion rate near your property?

14. To better understand wave energy along a shoreline of interest, we can measure the fetch. **Fetch** is the distance of open water available for wave generation. As fetch distance increases, so does the size of the wave that can form. Fetch direction can influence wave heights at a site, with fetch from the northwest and southwest directions having a potential greater impact.

Click on the **Measuring Tools Icon** to access the *Measurement* and *Draw* tools. The Measurement Tool allows you to measure area, distance, and locations. Click on the **Distance Icon** and select a unit of measure. Click on a shoreline location and move your cursor. Notice that the measurement result changes. Draw a line extending northwest to the first other shoreline encountered. Double click to capture the fetch measurement and view results in the *Measurement Result* Window.

15. Explore the **Draw Tool**, located under the Measurement Tool. Notice that the use of this Tool will remove temporary fetch measurements from the screen. Minimize the Measurement Tool to view more Draw options. Select a draw mode (i.e. Freehand Polygon), color, style, transparency, and width. These options must be selected before drawing. Draw a proposed area of interest on the map. Click on the map. Press down to start drawing and let go to finish. Check the "Show Measurements" box before drawing if you would like the drawing to display an area measurement. Click the "Clear" button to clear the drawing from the map. If this option is not available, adjust your screen resolution to zoom out.

16. To measure an area without adding a drawing to the map, open the **Measurement Tool** and click on the **Area Icon** . Select a unit of measurement. Click on the map to start the measurement. Click once to insert a node and double click to compute the final area. Click on the Location Icon to determine the location of your Area of Interest. Closing the Measurement Tool or opening a different Tool will remove the measurement from the map.

17. Turn off the Transect Data and navigate to the full extent of the map. Return to the **More Tools Icon** and click the **Add Data Icon** . All data available through Maryland iMap is available through this tool. Navigate to **Environment / Protected Lands**. Click Add. Refer to the Map Legend to identify land ownership. View the Layer List – notice that Protected Lands has been added as an option to turn on or off. This layer will be available via the Layer List until your session is ended or you refresh the webpage. Zoom in to an area of your interest.
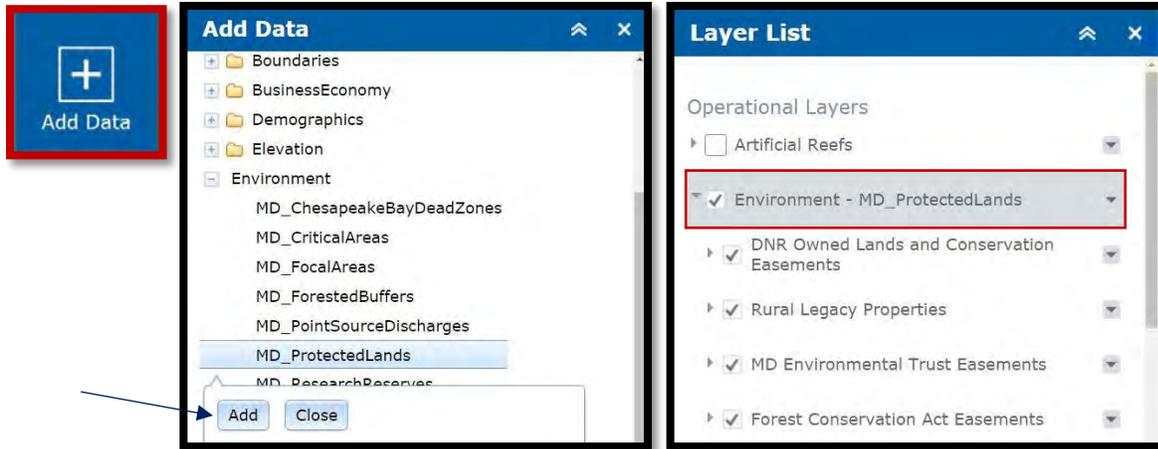
Question: What types of data would be helpful to determine the conservation potential of a parcel of land? Can you locate those data layers?

18. Use the **Add Data Tool** to add and turn on Maryland Parcel Boundaries (PlanningCadastre / MD_ParcelBoundaries). To learn more about a parcel, enable the layer's pop-up, click on the parcel and click the "More Info" link. Property information will open in a new tab.
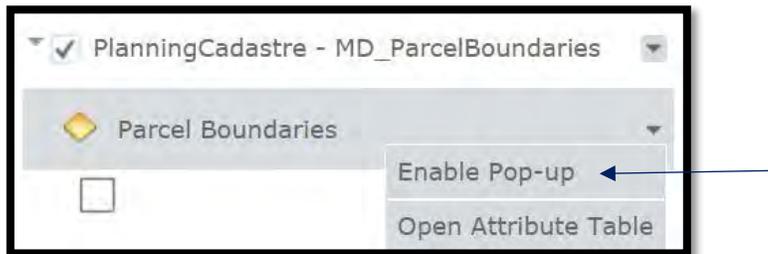
19. At any time, you may bookmark an extent or print your work. Depending on browser settings, Bookmarks may not be saved once you refresh or close the Atlas.

 Zoom to the extent/location of your choosing, click on the **Bookmark Icon** and create a label for your bookmark. Use the plus button to add your bookmark. Use the Delete button to remove bookmarks. At any time during your session, return to this tool to re-visit Bookmarked sites.

 Click on the **Print Icon** to print your map. Select Printing Options and click "Print." Click on the resulting document to open in a new window and print.

You have now explored coastal datasets and tools available on the Coastal Atlas. The **Query Tool** will be explored in Guided Exercise 3.

Guided Exercise 2: Understanding Resiliency Assessment Data Products

Evaluating Community Resilience

Resiliency refers to the ability of a community to prepare for, respond to, and recover from a coastal hazard event. To evaluate resiliency along Maryland's shoreline, planners must answer the following three questions.

1. Where are the people?
2. Where are the hazards?
3. Where are the habitats?

Maryland's Coastal Resiliency Assessment answers these three questions at a statewide scale and uses the answers to identify priorities for conservation and restoration where habitats can help protect coastal communities from flooding and erosion.

> *In this exercise, you will:*
> - *Understand components of resiliency and risk*
> - *Explore available Resiliency Assessment data products*
> - *Brainstorm data applications*

Explore Resiliency Data

1. If needed, zoom to the full map extent and turn off all layers. Turn on the **Coastal Resiliency Assessment** Layer and explore data options. This dataset comprises 5 layers related to resiliency. The default layer depicts Priority Shoreline Areas for conservation, restoration and enhancement. Open the layer description to learn more about this product.

   - Tier 1 = High priority for action
   - Tier 2 = Moderate priority for action
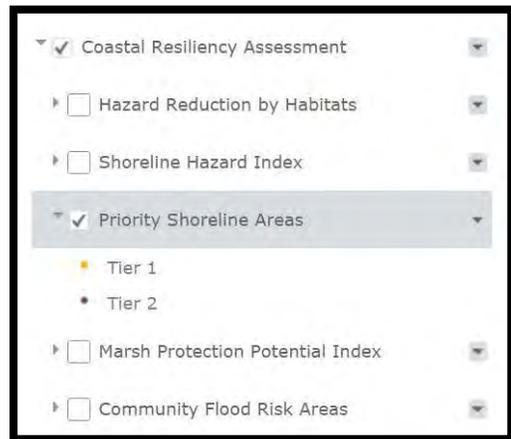
Community Flood Risk

2. Turn off the Priority Shoreline Areas and turn on the **Community Flood Risk Areas**. This layer identifies populations that may be less able to prepare for, respond to, or recover from a coastal hazard event. Rankings were determined based on population density, social vulnerability, and probability of flood exposure. Open the layer description for more information. Note that only **residential areas** are identified. Zoom into an area of interest to better view the data.

Question: Which social metrics were used to identify socially vulnerable populations?

3. Zoom to Crisfield. Click on a "Very High" flood risk area. All areas with the same score and attributes will be highlighted. Notice the pop-up, which provides more information on why these areas were designated as very high risk. Population and social vulnerability were scored out of 100 points each. Probability of inundation is associated with the flood type, which is based on floodplain data.

Question: Why is your area of interest ranked as Very High?

4. Open the Community Flood Risk Areas Attribute Table. The Table includes information on population density, social vulnerability, floodplains, and risk. Population Density and Social Vulnerability are ranked from 20 – 100 with 20 indicating low vulnerability and 100 indicating high vulnerability. Sort by population density and click on a row of interest. Bookmark the Crisfield extent and Zoom to the feature to investigate.

5. Zoom to Annapolis. Compare the coverage of Flood Risk Areas to that of Crisfield. Note that there are less residential areas in Annapolis and that flood risk is more limited due to elevation differences between the western and eastern shores. Find a "Very Low" or "Low" flood risk area.

Question: Why is your area of interest ranked as Low?

Crisfield   **Annapolis**
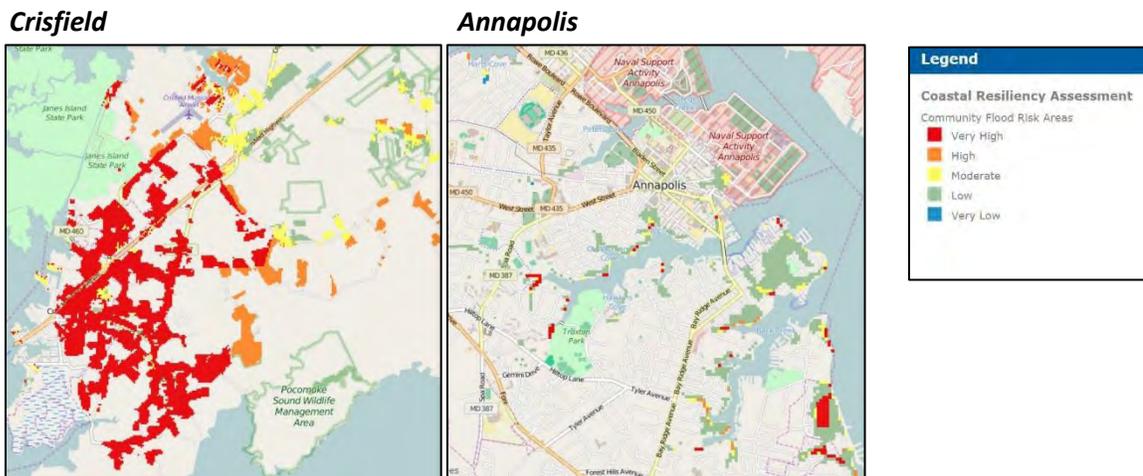
*Keep in Mind: Community Flood Risk Areas represent <u>residential land use</u>. If concerned with critical infrastructure, state highways, historic structures, or other state assets, then data overlays are essential.

*Keep in Mind: Weights were not used in data development. If you are most interested in impacts to the greatest number of people (Population Density Index), or impacts to the most socially vulnerable populations (Social Vulnerability Index), then filter for these areas within the attribute table.

Coastal Exposure and Habitat Role

6. Bookmark the Annapolis Extent and return to the full map extent. Turn off the Community Flood Risk Areas and turn on the **Shoreline Hazard Index**. This layer identifies low, moderate, and high hazard shorelines relative to the entire Maryland coastline. Notice that 250-meter shoreline segments are represented by points.
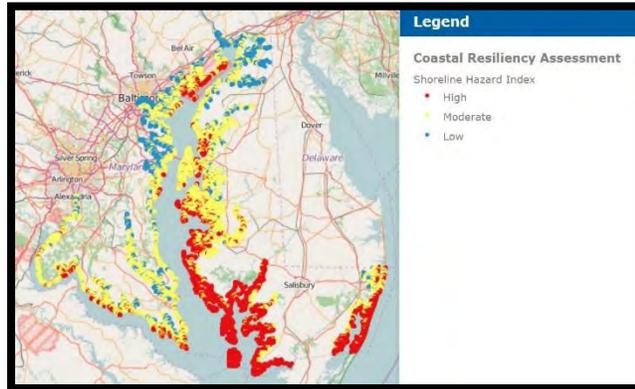
Question: Which counties have a higher percentage of High Hazard Shorelines?

7. Open the Shoreline Hazard Index Attribute Table. The **Hazard_without_Habitats** column was used to symbolize the Shoreline Hazard Index. Seven physical parameters and shoreline characteristics were used to develop this ranking. Click on a High Hazard Area in the map and view the attributes in the pop-up. You can also sort for High Hazard Areas in the attribute table and zoom to an area of interest.

Question: Which physical parameters were used to develop the Shoreline Hazard Index Ranking? Which parameters relate to erosion? Which relate to inundation? Why is your area of interest labeled as High Hazard?

Question: What other data layers could you turn on to visualize coastal hazards?

8. Turn off the Shoreline Hazard Index layer and attribute table. Turn on the **Hazard Reduction by Habitats** layer and use the **Bookmark Tool** to return to Crisfield. This layer indicates the relative role habitats play in reducing exposure to erosion and inundation along the shoreline.

9. Open the Attribute Table. Notice that this layer has some of the same information as the Shoreline Hazard Index, but also includes information on the presence/absence of habitats. Click on a shoreline point of interest.

Question: Are habitats present along the shoreline? Which ones? How do they influence the Hazard ranking? HINT: View the **Hazard_with_Habitats** column. Is the Hazard Rank different from the **Hazard_Without_Habitats** column? Essentially, does habitat presence cause the hazard rank to decrease?

The following metrics were used to determine if a habitat is present or absent and acting as a coastal hazard buffer:

Habitat (from most protective to least protective)	Distance From Shore (m)	Habitat Requirements
Coastal Forest	500	At least 1 acre in size and 120 feet wide
Marshes	250	Estuarine, Palustrine
Dunes	300	Atlantic coast
Underwater Grasses	500	Consistent coverage for at least 7 years from 2004 - 2014
Oyster Reefs	250	Restored oyster reefs at least 1 hectare in size

10. Use the **Bookmark Tool** to return to Annapolis and compare both communities. Turn on the **Shoreline Inventory – Stabilization Structures** layer and compare to the Hazard Reduction by Habitats data.

    Question: Which shorelines do you think are the most important to protect? Which shorelines should be enhanced? Why is habitat playing a minimal or nonexistent role along some shorelines?

Prioritizing Conservation and Restoration Actions

11. Return to the full map extent. Turn off the Hazard Reduction by Habitats layer and turn on the **Priority Shoreline Areas**. Tier 1 shorelines represent areas where habitats play a high role in coastal protection. Tier 2 shorelines represent areas where habitats play a moderate role in coastal protection. The previous shoreline data and Community Flood Risk Areas were used to identify

    these priorities. Shorelines must be within 2 kilometers of a Community Risk Area to be identified as a priority.
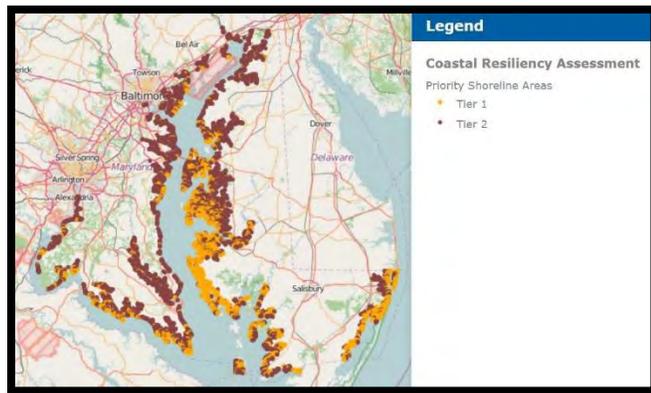
    Question: What other data layers could you turn on to identify conservation and restoration priorities?

12. Zoom to Crisfield, turn off the Shoreline Inventory, and turn on the **Protected Lands** layer (if it is not in the Layer List, use the Add Data Tool and navigate to Environment / Protected Lands). Are any Tier 1 or Tier 2 areas already protected?

Note that the Resiliency Assessment is based on the presence or absence of habitats. It tells us nothing about habitat quality. These areas may still require restoration or enhancement to ensure coastal protection benefits are maintained.

13. Turn off the Priority Shoreline Areas layer and turn on the **Marsh Protection Potential Index**. This layer ranks the ability of marshes to protect coastal communities based on the following considerations: Marsh size, marsh interaction with coastal hazards, marsh proximity to dense and socially vulnerable populations, marsh persistence into the year 2100, and marsh interaction with other protective habitats. Each marsh is given a score from 0 – 5 for each metric, with 5 indicating greater protection potential. Click on a marsh polygon. Notice the ranking and score in the pop-up.
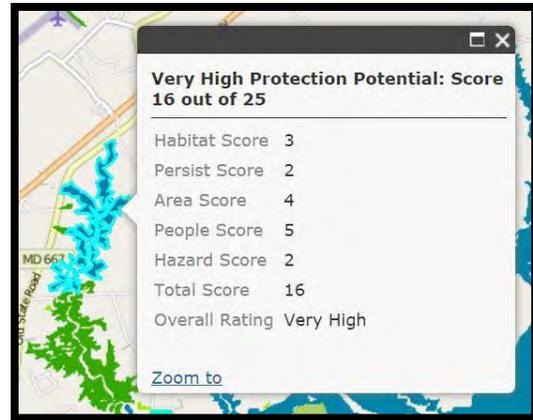
14. Turn on the Community Flood Risk Areas and Shoreline Hazard Index. These layers were applied to the Marsh Index to rank marsh polygons. Marshes adjacent to high flood risk communities and marshes that buffer high shoreline hazards will be ranked as more protective. Turn these layers off and return to the full extent. Note the extent of marshes on the western and eastern shores. This layer provides information on the relative protection benefits of different marshes. Click on a marsh ranked as "Low" or "Very Low."

    Question: Why does your marsh have low protection potential? HINT: Look at individual metric scores. Turn on the Shoreline Hazard Index or Community Flood Risk layers to investigate.

15. The **Identify Tool** can be used to obtain more information about a shoreline or marsh polygon of interest. This tool also provides a link to the project webpage with more information and the full Resiliency Assessment Report.

*Keep in Mind: Data products were developed along 250 meter shoreline segments (about 1/6th of a mile) across the state. Due to this scale, there may not be much variation in rankings along the shoreline when zooming to a specific location.

*Keep in Mind: All shoreline data were ranked relative to the entire state. Therefore, a community may still be at risk to coastal flooding even if the shoreline is ranked as low hazard. These shorelines are just at lower risk to BOTH flooding and erosion when compared to other regions of the state. For example, Annapolis is ranked as Low Hazard despite the fact that it has experienced a rapid increase in nuisance flooding during the last 50 years.

*Keep in Mind: The shoreline analysis was developed via a coastal model. Riverine systems and tidal creeks may not be ranked based on channel width and morphology. The Shoreline analysis is also based on existing coastal habitats within specific distances from the shore.

Guided Exercise 3: Identifying Relevant Program Data

Applying Coastal Resiliency Data

The simplest method of applying the Coastal Resiliency Assessment is to turn on the Priority Shoreline Areas. This dataset identifies high priority and moderate priority shorelines where conservation and restoration efforts can enhance coastal community resiliency. However, there are many ways to query and apply these datasets to identify priorities that are most relevant for your organization or program.

> *In this exercise, you will:*
> - *Explore pre-defined queries*
> - *Learn how to query and download data (for GIS users)*
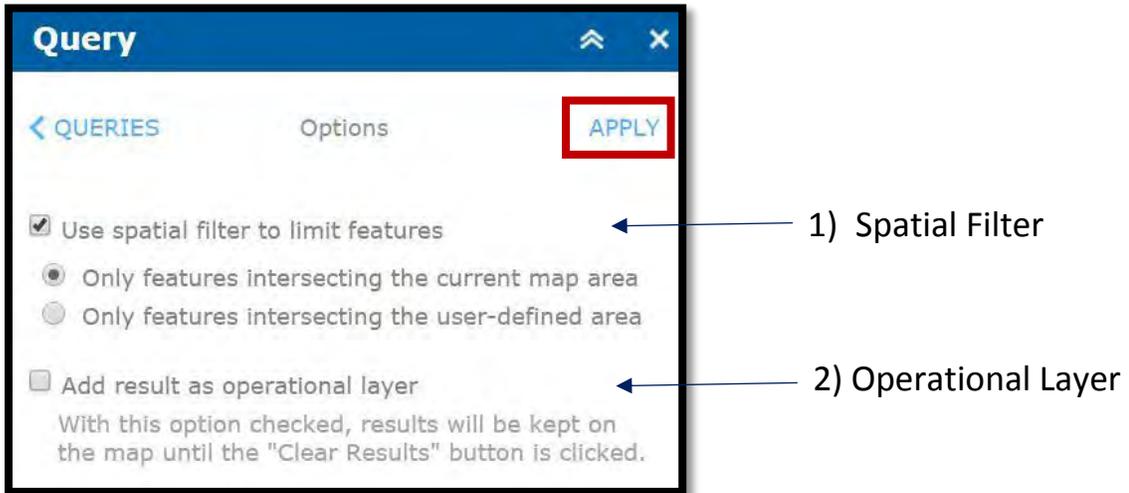
Using the Query Tool

1. If needed, zoom to the full map extent and turn off all layers. Navigate to the **Query Icon** within the More Tools pop-up. This tools allows users to view data in different ways. DNR has developed 4 pre-defined queries for your use (explored below). If none of these options meet your needs, please contact the Chesapeake & Coastal Service and we can work with you to create a personal query.
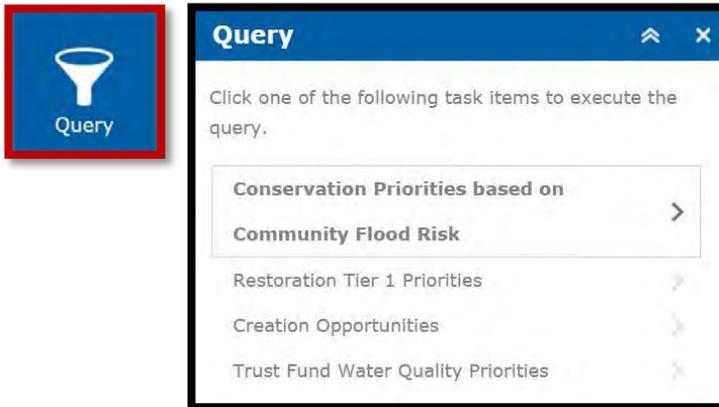
2. Click on **Conservation Priorities based on Community Flood Risk**. This query narrows the Priority Shoreline Areas dataset by highlighting shorelines adjacent to the highest Community Flood Risk Areas.

    The Query Tool provides two options for querying the data. The first option is a **spatial filter**. Only data within your map extent or a user-defined area will be queried and displayed. This query is temporary and will be deleted if another query is applied. The second option applies the query to the entire dataset. This query will be preserved as an **operational layer** in the Layer

list if another query is applied.


1) Spatial Filter

2) Operational Layer

3. Check option 2, **Add result as an operational layer**, and click Apply. The Query Tool will list the results and indicate the total number of shoreline points that meet the query. Return to the Layer List and note that the results have been added as an operational layer. Turn on the Priority Shoreline Areas and zoom to an area of interest. The query circles and highlight shorelines adjacent to "Very High" community flood risk area. Return to the Query Tool and click the "Clear Results" button. The Tool will refresh and the operational data layer will disappear.

4. Click on **Restoration Tier 1 Priorities**. This query narrows the Priority Shoreline Areas dataset by highlighting Tier 1 shorelines where habitat plays a low or moderate role in risk reduction. Restoration actions may enhance the role habitat plays in coastal protection along these shorelines. Check option 1, **Use spatial filter to limit features**, and keep the default setting (only features intersection the current map area). Click Apply. Zoom out and notice that only shorelines within the map extent were identified.

5. Return to the Query Options and re-run the query under option 2, **Add result as operational layer**. Make sure to un-check the spatial filter option. Notice that the original query layer was deleted and a new layer was created. Return to the layer list. Notice that an operational layer was created.

6. Return to the Query Tool and click the "Clear Results button." Click on **Creation Opportunities**. This query narrows the Priority Shoreline Areas dataset by highlighting shorelines where habitat plays no role in risk reduction, but shoreline hazards are moderate or high. Due to shoreline structures, roads, and development along the coasts, some areas in Maryland have lost their risk-reducing natural habitats. Creation of green infrastructure or hybrid approaches, such as living shorelines that incorporate structural components, may be more appropriate in these areas.

7. Return to the Query Options without clearing the results by clicking on the following back arrows.

‹ OPTIONS   ‹ QUERIES

Click on **Trust Fund Water Quality Priorities**. The Chesapeake & Atlantic Coastal Bays Trust Fund (Trust Fund) provides funding to implement non-point source pollution control projects. High, medium, and low priority watersheds were identified to encourage water quality best management practices in locations that deliver the highest nutrient and sediment loads to the mainstem of the Chesapeake Bay.
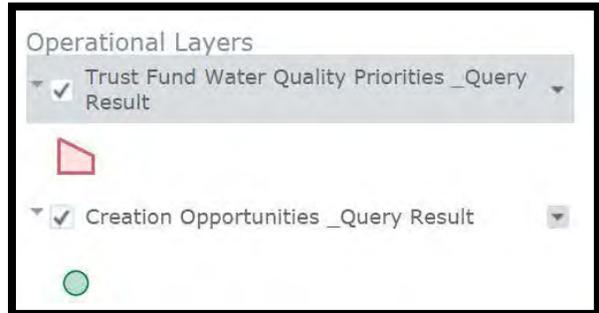

Add the result as an operational layer to the map. This query identifies high priority Trust Fund Watersheds. Navigate to the Layer List. Notice that the Creation Opportunities layer is still available in the map because you did not clear it. These queries can be turned off and on as you investigate areas to focus green infrastructure projects that will enhance coastal resiliency and address water quality concerns.

Question: Do these queries meet your Program needs? If not, which components of resiliency are most important for you?

Filtering Data

8. Another means of viewing specific data is through the **Filter Tool**, which is available through any attribute table. Turn off all data layers except the Priority Shoreline Areas and open the Attribute Table. Explore the attribute table toolbar.
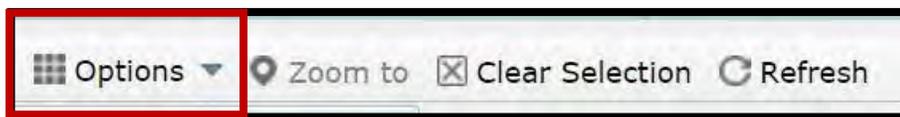
Attribute Table Toolbar

9. Click on the **Options** icon and select **Filter**. This tool will filter the dataset so that the attribute table only shows data meeting specified criteria.

Click **"Add a filter expression"** and explore the options in the lefthand dropdown menu. You can filter by any category listed in the attribute table. Select by County. Notice that there are various options for selecting data by county. Keep the default "is" and enter "Somerset" as the value in the text
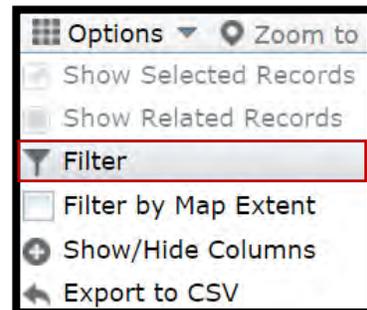
box. To select from options, click on "Unique" and choose from the drop down menu. Click OK.

Notice that the attribute table changes from displaying 14,328 features to 1,329 features. Only shoreline points from Somerset County are displayed in the table. Select a row of interest and click the **Zoom to** icon in the attribute table toolbar to view the area of interest. You may also clear the selection using the toolbar. Remove the Filter by returning to the Filter Tool and clicking the X next to the entry.

Notice other options for viewing attribute data, including the **Filter by Map Extent** and **Show/Hide Columns** options.

10. To select for features meeting multiple criteria, return to the Filter Tool and click **"add an expression set."**


11. Select for "Shoreline Priority Area" is "Tier 1" AND "Community_Flood_Risk_Nearest" is "Very High." Set the expression so **All** of the expressions in the set are true. This Selection will identify high priority conservation/restoration areas adjacent to the highest community flood risk areas.

Question: What percentage of the shoreline was selected? What if you add an expression for "County" is "Talbot" or County" is "Anne Arundel?"

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12. Develop an expression to select for data within an area of interest for you, your program, or community. Keep this attribute table open and filter in place for the next exercise.

Downloading Data – For GIS Users

13. To download a subset of the data, perform a filter as described above. Select the **Options Icon**, click on **Export to CSV** and click OK.
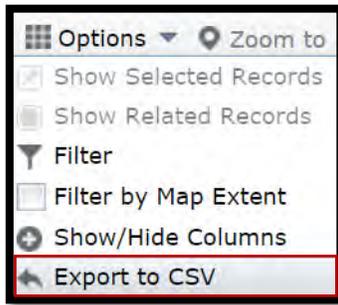
An excel spreadsheet will download into the Downloads Folder. Notice that only rows viewable by the filter were downloaded. Latitude and Longitude information is included and can be used to export into ArcMap. Data should by projected to WGS_1984_Web_Mercator_Auxiliary_Sphere.

14. Selecting feature rows in the attribute table can also be used to download a small subset of the data. Clear the filter and select a row in the table. To select more than one row, click on the first row of interest, hold the Shift Key, scroll to the end of the table, and click on the final row. All rows between the first and last row selected will now be downloadable via the Export to CSV option. To select nonconsecutive rows, select the first row of interest, hold the Ctrl Key, and click on the remaining rows of interest. Then Export to CSV.

    Note that the Atlas platform only allows about 150 rows to be selected at one time, so multiple selections may be required for larger downloads.

15. To download the entire data layer, clear your selection and Export to CSV.

16. To download the entire Coastal Resiliency Service, navigate to the following metadata link, scroll to the end of the page, and click **MDiMapDataDownload**:
    http://geodata.md.gov/imap/rest/services/Environment/MD_CoastalResiliencyAssessment/MapServer

    This link can be reached by clicking on the Description link for the Service. All resiliency data is available for download.

The above filtering, selection, and downloading methods can be applied to any dataset on the Coastal Atlas. Queries must be pre-defined by DNR staff. If interested in a specific query, please contact the Chesapeake & Coastal Service for assistance.

Independent Exercises

The exercises below were developed to provide real world examples of how the Coastal Resiliency Assessment data products can be applied to direct statewide conservation and restoration efforts. Please contact the Chesapeake & Coastal Service if you would like to discuss data applications to your work or develop a program-specific query for display on the Coastal Atlas.

I. Targeting Conservation for Co-Benefits

Situation: A local non-profit is interested in purchasing a parcel of land that has both ecological and coastal protection benefits in southern Maryland. The selected site will serve as a demonstration project for outreach efforts along the Potomac River.

Required Data:

- Coastal Resiliency Assessment
- Blue Infrastructure
- Protected Lands
- Parcel Boundaries

Analysis Steps:

1. **Identify coastal protection priorities in Southern Maryland:** Filter for Tier 1 Shorelines in Calvert, Charles, and St. Mary's Counties. These features can be downloaded for GIS analysis or explored within the map interface, depending on your preference.

   Question: How many priority areas are identified in Southern Maryland? _____

2. **Narrow to the Potomac River:** Zoom to a portion of the Potomac River and Filter by Map Extent.

3. **Narrow priorities by community:** Add to the initial selection to identify priorities closest to communities with Very High flood risk. Add a filter expression to filter for Community_Flood_Risk_Nearest = Very High

   Question: How many priority areas are identified in your map extent adjacent to very high flood risk communities? _____

   NOTE: If less than ~150 shoreline segments have been filtered, then select all features in the attribute table. Selected features will be highlighted on the map.

4. **Narrow by ecological benefits:** Turn on the Blue Infrastructure layer. Do any of the selected shorelines fall within a higher priority shoreline segment? Zoom to and Bookmark areas of interest.

   Question: The Blue Infrastructure Shoreline Segments represent one data layer that ranks coastal areas based on ecological criteria. What other data layers could be used to determine ecological benefits?

Turn on 1 or more additional data layers to help narrow priority shorelines. (Example: Add Data / Environment / MD_FocalAreas / Targeted Ecological Areas)

5. **Narrow by protection status:** Turn on the Protected Lands layer to determine if an area is already protected. Return to the Layer list. Turn the Blue Infrastructure and Protected Lands layers off and on as necessary and explore your bookmarked shorelines.

    Question: Do priorities exist adjacent to an already protected parcel?

6. **Identify property parcels:** Turn on the Parcel Boundaries data layer (Navigate to Add Data / PlanningCadastre / MD_ParcelBoundaries and add if necessary). Identify parcels of interest (HINT: Enable pop-ups for the parcel layer to gather more information).

7. **Narrow by Marsh benefits:** Turn on the Marsh Protection Potential Index. Identify parcels that intersect with moderate, high, or very high protective marshes to target ares where marshes have a greater potential to protect nearby communities.

    Question: Identify 2-3 properties of interest. What is each parcel's primary use? Why are these parcels strategic investments?

    Question: Is there another method of initiating this analysis, such as using the Query Tool or a different coastal resiliency data layer? Where would you start?

II. Easement Analysis

Situation: The Maryland Department of Natural Resources is interested in pursuing easements that align with specific program priorities; namely, coastal resilience, forest and wildlife goals.

- **Coastal Resilience Easements** protect properties in the coastal zone that will allow for wetland migration as sea level rises. These easements must contain wetland adaptation areas.
- **Forest Legacy Easements** protect environmentally sensitive forest from conversion to non-forest use and must occur within state priority areas.
- The **2015 Maryland State Wildlife Action Plan** identifies conservation priorities, including the most important sites throughout the state for wildlife diversity.

Required Data:

- Coastal Resiliency Assessment
- Sea Level Rise Vulnerability
- Wetland Sea Level Rise Adaptation Areas
- Forest Legacy Priority Boundaries
- BioNet
- Protected Lands
- Parcel Boundaries

Analysis Steps:

1. **Identify coastal resilience marsh priorities**: Filter the Marsh Protection Potential Index so that the Overall Rating is Medium, High, or Very High to target areas where marsh is playing a higher role in community protection..

2. **Narrow by impact to residential areas:** Add PeopleScore = 5 to the filter.

3. **Narrow by interaction with coastal hazards:** Add HazScore = 5 to the filter.

4. **Narrow by protection status:** Select a subset from the filtered table and zoom to the selection. Turn on the Protected Lands layer to determine if an area is already protected or adjacent to a protected area. Bookmark areas on interest.

5. **Narrow Area of interest**: Zoom into an area of interest based on selected marshes that are not protected, or adjacent to protected areas.

6. **Select for marsh migration potential**: Turn on the Wetland Sea Level Rise Adaptation Areas. Adjust transparency of the Coastal Resiliency Assessment or move the wetland adaptation area above the Marsh Index in the Layer List. Explore your bookmarks. Identify marshes connected to Medium or High Wetland Adaptation Areas.

7. **Identify property parcels:** Turn on the Parcel Boundaries data layer (Navigate to Add Data / PlanningCadastre / MD_ParcelBoundaries and add if necessary). Identify parcels of interest that include priority marshes or high priority marsh migration areas. (HINT: Enable pop-ups for the parcel layer).

   Question: Identify 2-3 properties of interest. What is each parcel's primary use? Why are these parcels strategic investments? Create Bookmarks for each location.

   Question: Are any of these parcels at risk to 2 feet of Sea Level Rise? If so, do they include important migration corridors? (Green Infrastructure and/or Wetland Adaptation Areas)

8. **Clear all selections and identify shoreline protection priorities:** Filter for Tier 1 Shorelines by County (Example: "Shoreline Priority Area" is "Tier 1" AND "County" is "Dorchester").

9. **Select an area to investigate based on forest or wildlife priorities (pictured below).** These are internal datasets and thus are not available on iMap or the Coastal Atlas. For a more fine-toothed analysis, download the Coastal Resiliency service and conduct a Desktop Analysis.

   Forest Legacy Easements must occur within Forest Legacy Areas, which are geographically defined areas that contain some of the highest economic and environmental values to benefit Maryland's wildlife, wood products industry, water quality, and residents.
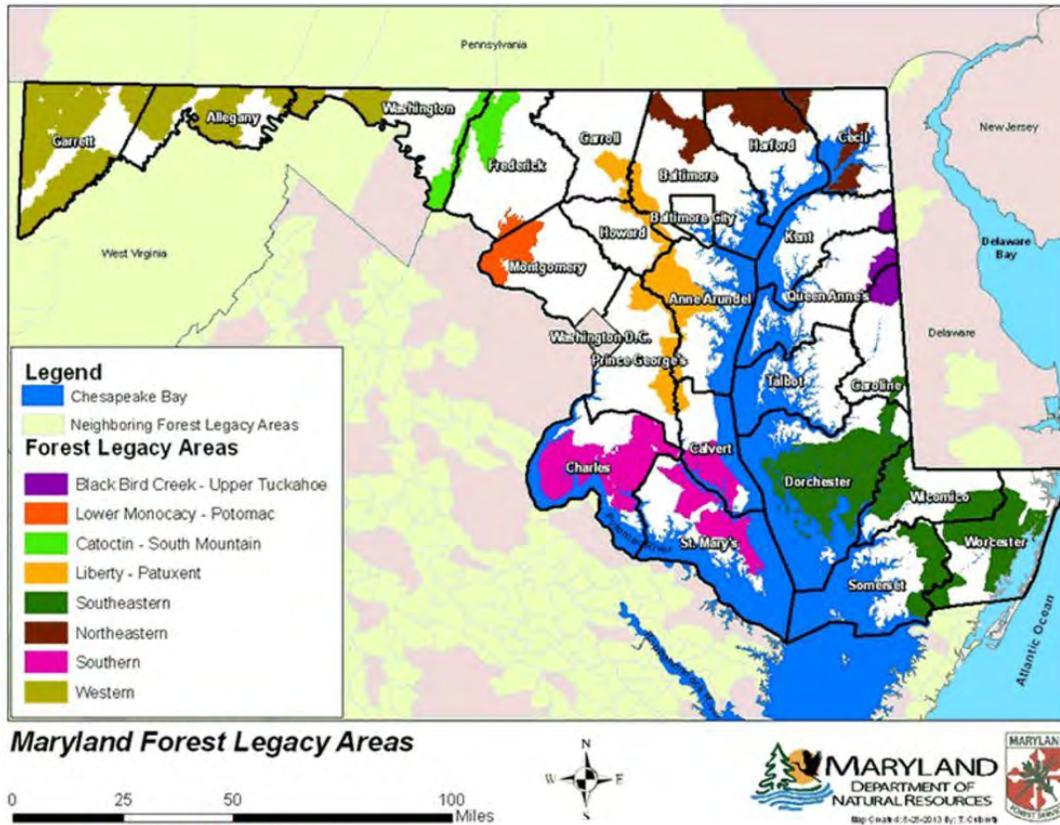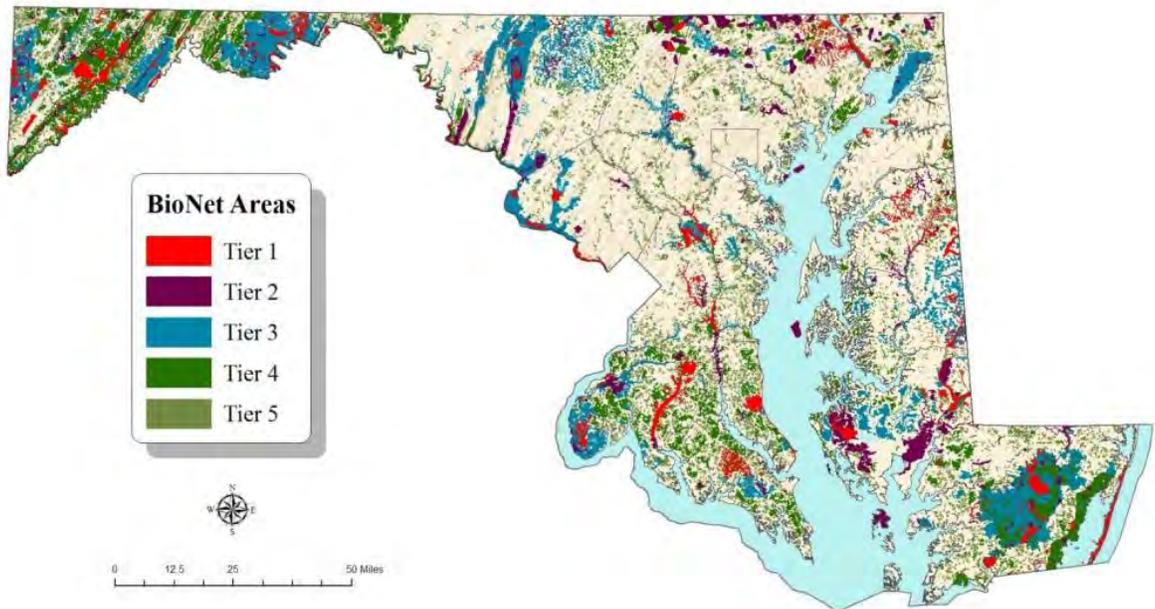
Figure 1: Maryland's Forest Legacy Areas

BioNet Priority Tiers identify conservation priorities based on rarity, diversity and quality, with Tier 1 representing the highest or most critically significant for biodiversity conservation.

Question: Do any of the selected areas correspond to your identified parcels for resilience easements?

Question: What other steps can you take to further narrow priority shorelines?

Question: Is there another method of initiating these analyses? Where would you start?

For more information, see:

- Forest Legacy Program
  http://dnr.maryland.gov/forests/Pages/programapps/forestlegacy.aspx
- Coastal Resilience Easements
  http://dnr.maryland.gov/ccs/Pages/habitats_slr.aspx
- State Wildlife Action Plan
  http://dnr.maryland.gov/wildlife/Pages/plants_wildlife/SWAP_home.aspx
- Wildlife & Heritage Data
  http://dnr.maryland.gov/wildlife/Pages/plants_wildlife/digitaldata.aspx

III. Water Quality/TMDL Analysis

Situation: Anne Arundel County is trying to reduce nutrient runoff into the Bay and meet their County Watershed Implementation Plan (WIP) goals. At the same time, coastal communities are reporting an increase in coastal flooding due to tidal and storm events. County planners must leverage water quality funds to address both run-off and coastal flooding.

Required Data:

- Coastal Resiliency Assessment
- Storm Surge
- Trust Fund Priority boundaries
- Parcel Boundaries or County Protected Lands

Analysis Steps:

1. **Identify areas prioritized for Best Management Practice funding**: Turn on Trust Fund Priority zones (HINT: Navigate toad Data / Environment / MD_TrustFund) and zoom to an area of interest in Anne Arundel County, such as Annapolis.

   Question: Why are these watersheds significant?

2. **Narrow by storm surge impacts:** Overlay the Hurricane Storm Surge data layer to identify coastal areas impacted by storm surge and water quality concerns. Use the transparency function if necessary.

3. **Narrow by coastal protection benefits**: Turn on the Coastal Resiliency Assessment Priority Shorelines and identify Tier 1 or 2 shorelines that fall within Trust Fund priority watersheds and are impacted by storm surge.

4. **Identify property parcels or county owned lands for implementation:** Turn on the Parcel Boundaries data layer (Navigate to Add Data / PlanningCadastre / MD_ParcelBoundaries) and/or the Protected Lands data layer (Add Data / Environment / MD_ProtectedLands). Identify parcels or lands of interest that overlay with the above analysis.

   Question: Identify 2-3 parcels of interest that align with coastal protection and water quality priorities. Create Bookmarks for each location.

5. **Conduct a Query**: Remember that a query exists to identify Trust Fund Water Quality Priorities. This query highlights the highest priority watersheds for non-point source pollution control. A query also exists to identify Creation Opportunities. These queries can be used to identify areas where green infrastructure may promote water quality and coastal protection benefits.

IV. County Download Example – For GIS Users

This exercise provides a Desktop example for applying coastal resiliency data to a targeted area of interest. This approach allows the user to create tailored data products. The analysis is not conducted within the Coastal Atlas, but within ArcGIS.

Situation: A regional Coalition wants to evaluate coastal exposure to hazards across their study area, which includes multiple counties and municipalities. Because the Coastal Resiliency Assessment evaluates coastal exposure across the entire state, some data analysis is required. This evaluation will be used to target coastal green/blue infrastructure to protect communities and natural areas in the region.

Required Data:

- Coastal Resiliency Assessment
- Study Area Shapefile

Analysis Steps:

- **Download Coastal Resiliency Assessment**: Open the description webpage for the Priority Shoreline Areas, navigate to **MDiMapDataDownload**, and download a zip file. Downloaded data will have full metadata.

- **Prepare Study Area Shapefile:** Buffer your study area by 1 kilometer to ensure adequate shoreline data will be captured (Buffer Tool).

- **Clip Resiliency Data**: Clip the Coastal Resiliency Assessment shoreline points to your study area (Clip Tool).

- **Explore the Attribute Table**: The downloaded version of the Resiliency Assessment shoreline data will display additional columns that are not automatically viewable on the Coastal Atlas (although they can be viewed when using the identify tool).

  Notice the EI_wHAB, EI_woHAB, and hab_role columns. These are the columns you will be working with to create your own hazard and habitat rankings. Definitions are provided below:

  - **EI_wHAB:** These numeric values were used to create Low/Moderate/High hazard rankings for the Hazard_with_Habitats column.

  - **EI_woHAB:** These numeric values were used to create Low/Moderate/High hazard rankings for the Hazard_without_Habitats column. This column is displayed on the Atlas as the Shoreline Hazard Index.

  - **Hab_role:** These numeric values were used to create None/Low/Moderate/High habitat role rankings for the Hazard_Reduction_by_Habitats column.

- **Determine Low/Moderate/High Breakpoints:** Breakpoints must be defined to determine how to reclassify these data into Low/Moderate/High rankings. Reclassify the Exposure Index and Habitat Role values using the methodology below to determine relative hazard exposure and relative habitat role within your study area.

  - **Exposure Rankings:** Determine the 25 and 75 percentile quantile breakpoints for the Low/Moderate/High rankings:

    Bring the EI_wHAB and EI_woHAB values into an excel spreadsheet and combine both columns into one column. Perform the following:

    PERCENTILE(X:Y, 0.25)
    PERCENTILE(X:Y, 0.75)

    Where X = first cell in EI list
    Where Y = last cell in EI list

    The resulting values represent breakpoints for determining Low/Moderate/High hazard rankings along the shoreline of your study area. The 25th percentile value identifies the transition from low to moderate. The 75th percentile value identifies the transition from moderate to high.

    Habitat Rankings: Determine the 25 and 75 percentile quantile breakpoints for the Low/Moderate/High rankings:

    Bring the hab_role values into excel and deleting all rows where "hab_role = 0." Perform the following:

PERCENTILE(X:Y, 0.25)
PERCENTILE(X:Y, 0.75)

Where X = first cell in hab_role list
Where Y = last cell in hab_role list

The resulting values represent breakpoints for determining Low/Moderate/High rankings along the shoreline of your study area. The 25th percentile value identifies the transition from low to moderate. The 75th percentile value identifies the transition from moderate to high. All areas where hab_role = 0 have no role in hazard reduction.

- **Populate Hazard Rankings:** Create your own "Hazard_with_Habitats" column. Select for rows where EI_wHAB ≤ the 25th percentile exposure value. Use Field Calculator to designate these rows as "Low" for the Hazard_with_Habitats column. Select for rows where EI_wHAB > the 25th percentile exposure value and ≤ the 75th percentile exposure value. Use Field Calculator to designate these rows as "Moderate" for the Hazard_with_Habitats column. Select for rows where EI_wHAB > the 75th percentile exposure value. Use Field Calculator to designate these rows as "High" for the Hazard_with_Habitats column

  Create your own "Hazard_without_Habitats" column. Select for rows where EI_woHAB ≤ the 25th percentile exposure value. Use Field Calculator to designate these rows as "Low" for the Hazard_without_Habitats column. Select for rows where EI_woHAB > the 25th percentile exposure value and ≤ the 75th percentile exposure value. Use Field Calculator to designate these rows as "Moderate" for the Hazard_without_Habitats column. Select for rows where EI_woHAB > the 75th percentile exposure value. Use Field Calculator to designate these rows as "High" for the Hazard_without_Habitats column.

  You have just used the breakpoints created for your study area to designate Low, Moderate, and High hazard shorelines. Compare these two newly created columns to determine where habitats are playing a significant role in hazard reduction. Tier 1 shorelines are represented by a transition from Low or Moderate Hazard with habitats to High Hazard without habitats. Tier 2 priority shorelines are represented by a transition from Low Hazard with habitats to Moderate Hazard without habitats.

- **Populate Habitat Rankings:** Create your own "Hazard_Reduction_by_Habitats" column. Select for rows where Hab_role > 0 and ≤ the 25th percentile habitat value. Use Field Calculator to designate these rows as "Low" for the Hazard_Reduction_by_Habitats column. Select for rows where Hab_role > the 25th percentile habitat value and ≤ the 75th percentile habitat value. Use Field Calculator to designate these rows as "Moderate" for the Hazard_Reduction_by_Habitats column. Select for rows where Hab_role > the 75th percentile exposure value. Use Field Calculator to designate these rows as "High" for the Hazard_Reduction_by_Habitats column. Select for rows where Hab_role is 0. Use Field Calculator to designate these rows as "None" for the Hazard_Reduction_by_Habitats column.

You have just used the breakpoints created for your study area to designate shorelines where habitat plays a Low, Moderate, or High or nonexistent role in risk reduction. Tier 1 shorelines are represented by shorelines with a high role. Tier 2 priority shorelines are represented by shorelines with a moderate role.

- Use the above information within your study area to determine your own conservation and restoration priorities. Focus on shorelines adjacent to coastal communities or infrastructure at risk to flooding.

Visual Example:
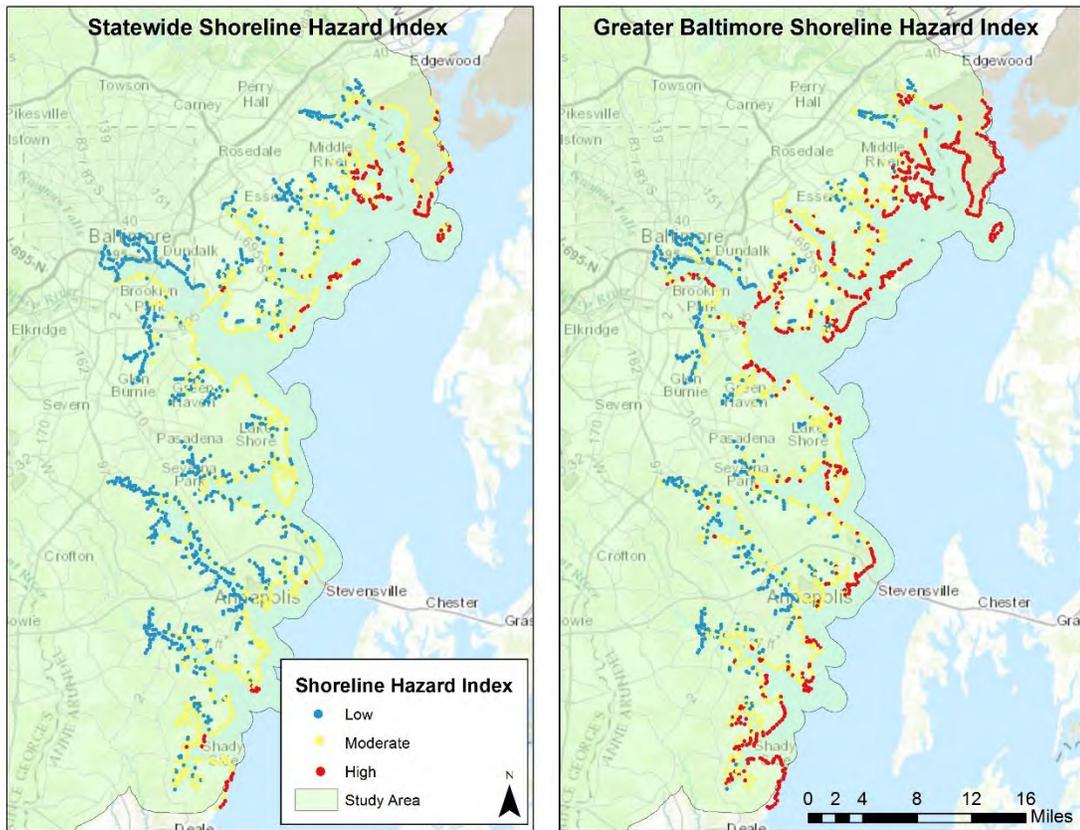
Statewide priorities will differ from priorities within a smaller region. The left panel displays the statewide Shoreline Hazard Index, which identifies low, moderate, high hazard shorelines relative to the entire state. The right panel displays a newly created Shoreline Hazard Index for a specified study area.

Appendix

Helpful Resources

- Maryland Department of Natural Resources Coastal Resiliency Assessment Webpage: http://dnr.maryland.gov/ccs/Pages/CoastalResiliencyAssessment.aspx

- Maryland Department of Natural Resources Coastal Atlas Link: http://dnr.maryland.gov/ccs/Pages/coastalatlas.aspx

- The Nature Conservancy Coastal Resilience Tools: http://coastalresilience.org/

- US Army Corps of Engineers, Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience: http://el.erdc.usace.army.mil/elpubs/pdf/sr-15-1.pdf

- US Army Corps of Engineers, North Atlantic Coast Comprehensive Study: http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf

- The Natural Capital Project, InVEST Coastal Vulnerability Model: http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/coastal_vulnerability.html

Presentation Slides - Overview

Slide 1

Statewide Coastal Resiliency Assessment:
Mapping Natural Solutions for Resilient Maryland Communities

Nicole Carlozo, Maryland Department of Natural Resources

Coastal Resiliency Assessment & Tool Training
June 15, 2016

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Slide 2

Overview

I. Agenda & Logistics
II. Current Events – Why a Resiliency Assessment?
III. Resiliency Basics – Definitions
IV. Project - Goals and Partnerships

I. Data Development
II. Coastal Atlas
III. Guided & Independent Exercises

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Slide 3

Why a Resiliency Assessment?

Source: Boesch et al., 2013

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Slide 4

Building Resilience to Climate Change Policy

"It is the policy of the Maryland Department of Natural Resources to make sound investments in land and facilities and to manage its assets and natural resources so as to better understand, mitigate and adapt to climate change."

MARYLAND
DEPARTMENT OF NATURAL RESOURCES

Slide 5

Supporting Regional Resilience

MARYLAND
DEPARTMENT OF NATURAL RESOURCES

Goal: Increase the resiliency of the Chesapeake Bay watershed, including its **living resources, habitats, public infrastructure and communities**, to withstand adverse impacts from changing environmental and climate conditions.

Adaptation Outcome: Continually **pursue, design, and construct restoration and protection projects** to enhance the resiliency of bay and aquatic ecosystems from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.

Slide 6

Coastal Resiliency
Terms & Definitions

MARYLAND
DEPARTMENT OF NATURAL RESOURCES

Resiliency – The ability of a community to prepare for, respond to, and recover from a coastal hazard event.

- **Where are the people?**
  - Are there demographic/social metrics or community characteristics that limit community resiliency?
- **Where are the hazards?**
  - Identify physical parameters that contribute to erosion and inundation risk.
- **Where are the habitats?**
  - Identify natural features that provide risk-reduction benefits.

Slide 7

Slide 8
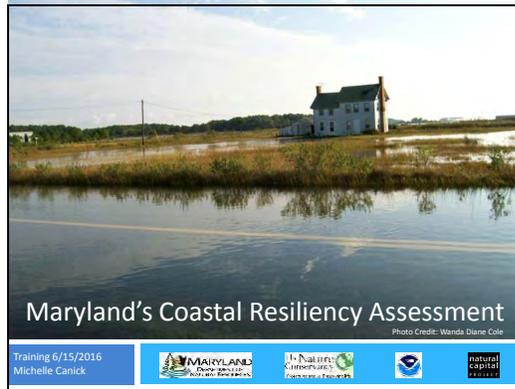
Slide 9

Slide 10

Slide 11

Slide 12
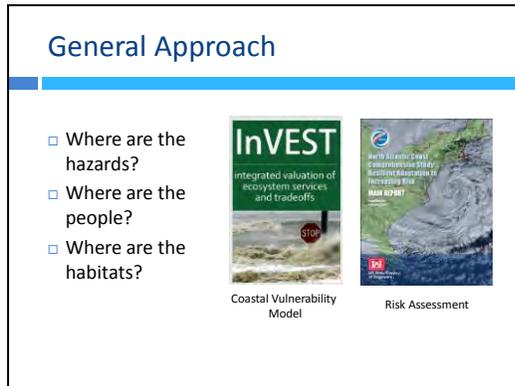
Slide 13

Community Flood Risk Analysis

Category 4 Storm Surge
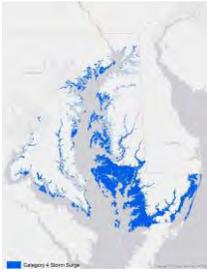
Coastal Communities
- □ Population Density
- □ Social Vulnerability -
  demographic parameters or
  community characteristics limit
  a community's ability to prepare
  for, respond to, and recover
  from coastal hazard events.

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Slide 14

Community Flood Risk Analysis

Risk = Exposure x Probability

Exposure: Who (or what) is exposed?
- □ Population Density (PDI)
- □ Social Vulnerability (SVI)

Probability: How likely is exposure in a given year?
- □ Floodplains (10%, 2%, 1%, 0.2%)
- □ Storm surge (Category 4 storm surge)

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Slide 15

Community Flood Risk Analysis

- ❑ US Census data: American Community Survey
  - □ 2009-2013 5-year estimate
  - □ Block Group Scale
- ❑ 2010 MD Department of Planning Land Use
  - □ Low Density Residential
  - □ Medium Density Residential
  - □ High Density Residential
- ❑ USGS Dasymetric Mapping Toolbox
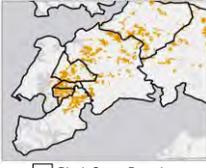
☐ Block Group Boundary
■ Residential Land Use

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Slide 16

Community Flood Risk Analysis

Risk = Exposure x Probability

Exposure =
Population Density (PDI)
+ Social Vulnerability (SVI)

Population Density
Very High
High
Moderate
Low
Very Low

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Slide 17

Community Flood Risk Analysis

Risk = Exposure x Probability

Exposure =
Population Density (PDI)
+ Social Vulnerability (SVI)

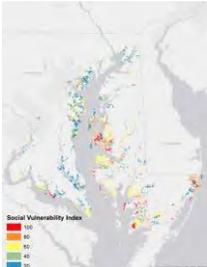Social Vulnerability Index
100
80
60
40
20

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Slide 18

Community Flood Risk Analysis

Social Vulnerability =
% pop. <=17 or >=65 +
% pop. below poverty +
% pop. with limited English

Characteristics that limit the
ability to prepare for, respond
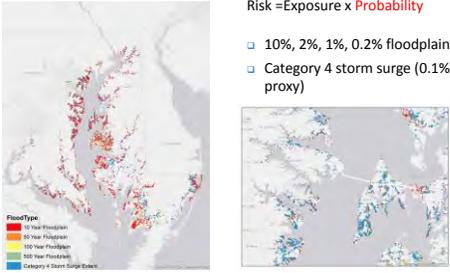to, and recover from coastal
hazard events.

Social Vulnerability Index
100
80
60
40
20

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Slide 19

Community Flood Risk Analysis

Risk = Exposure x Probability

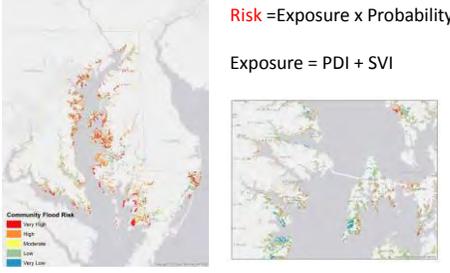- 10%, 2%, 1%, 0.2% floodplains
- Category 4 storm surge (0.1% proxy)

FloodType
- 10 Year Floodplain
- 50 Year Floodplain
- 100 Year Floodplain
- 500 Year Floodplain
- Category 4 Storm Surge Extent

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Slide 20

Community Flood Risk Analysis

Risk = Exposure x Probability

Exposure = PDI + SVI

Community Flood Risk
- Very High
- High
- Moderate
- Low
- Very Low

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Slide 21

Natural Features Analysis

Where are the hazards?
- Erosion
- Flooding

Where are the habitats?
- Forest
- Marshes
- Dunes
- Underwater grass
- Oyster reefs

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Slide 22

Natural Features Analysis

Variable	Very Low Hazard Rank (1)	Low Hazard Rank (2)	Moderate Hazard Rank (3)	High Hazard Rank (4)	Very High Hazard Rank (5)
Geomorphology	Bulkhead	Rip-rap	Groin, breakwater, jetty, unconventional structure, living shoreline	Coarse-grained sand to gravel beaches	Other natural shoreline, dilapidated bulkhead
Elevation (meters)	14.7 - 81.6	5.9 - 14.7	2.3 - 5.9	0.5 - 2.3	0 - 0.5
Natural Habitats	Forest	Marsh	Dune	Oyster reef, Underwater grass (dense = 4, less dense = 4.5)	No habitat
Sea Level Rise (meters)	None	1.32 – 1.42	1.46 – 1.48	1.49 - 1.67	2.05 – 2.35
Wave Power (kW/m)	0 - 0.02	0.02 - 0.05	0.05 - 0.16	0.16 - 0.78	Atlantic Shoreline
Storm Surge Height (feet)	0	0.1 - 2.2	2.3 - 3.5	3.6 - 4.6	4.7 - 8.9
Erosion Rate (feet/year)	Accretion or Protected	0 - 2, no change or unknown	2 - 4	4 - 8	>8

Slide 23

Natural Features Analysis

Model Parameters
- Geomorphology
- Elevation
- Sea level rise
- Wave power
- Storm surge height
- Erosion rate
- *With Habitats*

Slide 24

Natural Features Analysis

Model Parameters
- Geomorphology
- Elevation
- Sea level rise
- Wave power
- Storm surge height
- Erosion rate
- *Without habitats*

Slide 25

Natural Features Analysis

Hazard Index *without Habitats*
- Hazard Index *with Habitats*
Habitat Role in Hazard Reduction

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Slide 26

Data Integration
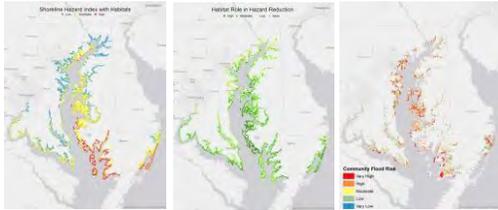
Hazards   Habitats   People

Natural Features Analysis   *Community Risk Analysis*

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Slide 27

Priority Shoreline Areas

Tier 1 (22% of Shoreline)
- Within 2km of Risk Area
- High Habitat Role or transitions to High Hazard if habitats are Lost

Tier 2 (40% of Shoreline)
- Within 2 km of Risk Area
- Moderate Habitat Role or transitions to Moderate Hazard if habitats are Lost

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Slide 28

Marsh Protection Potential

Components

- □ Protective capacity (marsh size)
- □ Proximity to people
- □ Proximity to hazards
- □ Proximity to other protective habitats
- □ Persistence in the face of SLR

Index Calculation

- □ A score of 0 or 1 (very low) to 5 (very high) for each component
- □ The Index is equals to the sum of the component scores, equally weighted

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Slide 29

Marsh Protection Potential

How much is the marsh able to attenuate waves and stabilize the shoreline?

Protective capacity

- □ Marsh area

Protection Service	Relevant Characteristics
Wave Attenuation	Marsh size (esp. width), stem height, stem density, stem stiffness
Shoreline Stabilization	Belowground biomass, species identity, density, height, biomass production, hydroperiod, distance to sediment supply

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Slide 30

Marsh Protection Potential

How much is the marsh able to attenuate waves and stabilize the shoreline?

Protective capacity

- □ Marsh area

Score	Area (acres)
5 (Very High)	>986
4 (High)	986-76
3 (Moderate)	76-6
2 (Low)	6-0.4
1 (Very Low)	<0.4

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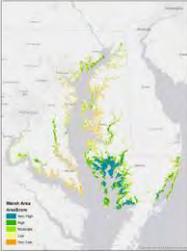
Slide 31

Marsh Protection Potential

Is the marsh located where coastal hazards are a threat?

Proximity to Hazards
- □ Shoreline Hazard (max w/in 250 m)
- □ Floodplain
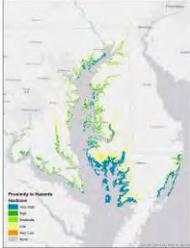
Slide 32

Marsh Protection Potential

Is the marsh located where there are people to protect?

Proximity to People
- □ Population Density + (max w/in 2km)
- □ Social Vulnerability (max w/in 2km)
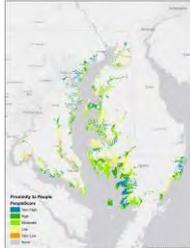
Slide 33

Marsh Protection Potential

Is the marsh located adjacent to other protective habitats?

Proximity to Habitats
- □ Non-marsh habitat (% w/in 250 buffer)
- □ Other marshes (% w/in 250 buffer)

Marsh Protection Potential

Is the marsh likely to survive in the face of rising sea levels?

Persistence
- % remaining in place to 2100
- % migration space in buffer
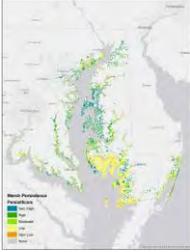
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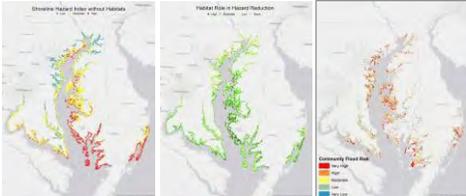## Marsh Protection Potential

Index = sum of all component scores, equally weighted
- Protective capacity (marsh area)
- Proximity to hazards
- Proximity to people
- Persistence
- Proximity to other protective habitats

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Coastal Atlas Layers

Shoreline Hazard Index

Habitat Role in Hazard Reduction

Coastal Community Flood Risk Areas

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Slide 37

Coastal Atlas Layers

Priority Shoreline Areas

Marsh Protection Potential

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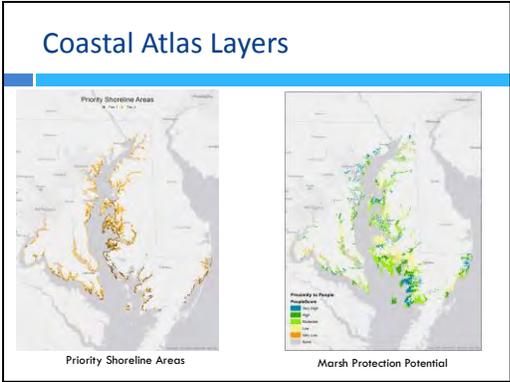
1. How do you best characterize yourself?

   ☐ State government

   ☐ Federal government

   ☐ NGO

   ☐ Other (please specify): _____

2. What agency/organization do you work for?

3. Participating in this training was a good use of my time:

   ☐ 5 – Strongly Agree

   ☐ 4 – Agree

   ☐ 3 – Neutral

   ☐ 2 – Disagree

   ☐ 1 – Strongly Disagree

   ☐ Prefer not to answer / Not applicable

4. If you chose 3, 2, or 1, please explain:

5. How much did this training increase your knowledge of the Coastal Resiliency Assessment and Coastal Atlas?

   ☐ 5 – A great deal

   ☐ 4 – A lot

   ☐ 3 – Some

   ☐ 2 – A little

☐   1 – Not at all

☐   Prefer not to answer / Not applicable

6. If you chose 3, 2, or 1, please explain:

7. Did you learn something that you will apply in your work or future decisions?

☐   Yes

☐   No

☐   Maybe

☐   Prefer not to answer

8. Please rank your satisfaction (1 – not satisfied – to 5 – very satisfied) for the following sections of the agenda.

	1 Not Satisfied	2	3 Satisfied	4	5 Very Satisfied
Resiliency Data Development (TNC)					
Guided Exercise: Using the Coastal Atlas (DNR)					
Guided Exercise: Understanding Resiliency Assessment Data Products (DNR)					
Guided Exercise: Identifying Relevant program Data (DNR)					
Independent Exercises & Data Exploration					
Materials (Binder)					

9. Please let us know any additional feedback that you have on the training or above sessions: