# Developing Wetland Restoration Priorities for Climate Risk Reduction and Resilience in the MARCO Region

**Analysis for the Mid-Atlantic Regional Council on the Ocean (MARCO) to support a Framework for prioritizing wetlands as Natural and Nature-Based Features for Climate Risk Reduction and Resilience**

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***The Mid-Atlantic Regional Council on the Ocean (MARCO) and MARCO's Climate Change Action Team (CCAT) recognize that information on sustaining wetlands, nature-based shoreline management, and climate change is rapidly evolving; continued research is important to understand the systems affected by the environment and by management efforts. The information in this report will inform MARCO activities, but nothing in this document should be construed as a MARCO endorsement or MARCO policy. We hope that others find the information in this report useful to their climate adaptation efforts.*** ***Funding for this project was provided by the U.S. Department of Interior (DOI) through the North Atlantic LCC, but this material does not represent official DOI or NALCC policy.***

# Executive Summary

This report examines the current state of practice for identifying and prioritizing wetlands for their usefulness in climate risk reduction and climate resilience. It is intended to identify promising paths to advance current practice and to improve implementation of strategies across the coastal states of the Mid-Atlantic Region in order to achieve regional protection of human communities and maintenance of ecological functions over the coming century of climate change impacts.

New York, New Jersey, Delaware, Maryland, and Virginia are the states of the Mid-Atlantic Regional Council on the Ocean (MARCO). Together with their federal, local, and nongovernmental partners, they face the science-driven task of tailoring investments and regulatory attention toward conservation and restoration of those wetlands that can provide:

- ***climate risk reduction*** – protecting coastal communities and infrastructure from flooding, storms, erosion, salt-water intrusion, and direct injury; and
- ***climate resilience*** – conserving or restoring sufficient natural assets to allow ecological systems to function and adapt under continuing climate impacts.

This project identifies where, and to what extent, risk reduction and resilience goals are articulated and implemented in programs affecting wetlands in the MARCO states, a rapidly changing policy environment. Based on an inventory and examination of climate adaptation plans, wetland management plans, and other priority-setting schemes in the region, this project develops a proposed framework that will support a cohesive regional approach to risk reduction and resilience while also allowing for improvement in individual states (or areas) as opportunities permit. The proposed framework is intended to meet the following objectives:

- A simple set of defined program elements for attention by the MARCO states as they seek to improve wetland prioritization for risk reduction and resilience.
- Opportunity for continuous improvement by states and federal programs and other cooperating actors in the region – recognizing that such improvements are likely to occur at discontinuous rates because of political, scientific, and funding differences, and because opportunities will arise at different times as resource management plans are updated or as legislatures and agencies respond to public needs.
- Opportunities for learning among states and for adoption of successful methods from others as they show results.

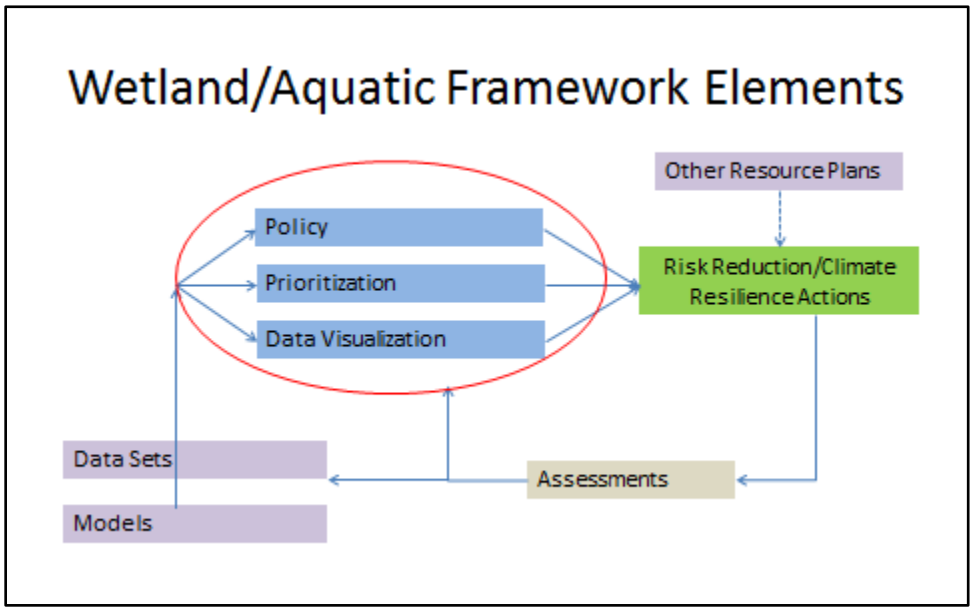
Three **key elements** provide a basis for a common framework:

1) **Policy**. Policy makers should state one or more policies concerning the use of wetlands as natural or nature-based features (NNBFs) in achieving climate risk reduction and

resilience. Policies should drive toward greater specificity and greater prescriptiveness as experience is gained.

2) **Prioritization**. Priority-setting should be systematic. Many priority-setting schemes are embodied in resource management plans. Some of these provide detailed scoring systems; many others simply identify habitats or landscape types of particular interest or concern. The important question is whether, and to what extent, priority setting schemes include climate risk reduction and resilience objectives, and can make distinctions among potential choices for expenditures, acquisitions, and staff – among geographies, wetland types, and shoreline goals, and over definable time horizons. Priority schemes are most useful where they can generate a reproducible outcome.

3) **Data Visualization**. Commitment to data visualization is an essential element to ensure implementation and program continuity in the complex area of climate risk reduction and resilience. Data visualization is critical to public communication and outreach. It also makes spatially explicit decisions clear to other government agencies, legislators, local officials, and others responsible for constructing prioritization schemes or considering new policies.




This report includes an inventory and discussion of policies, priority-setting schemes, and data visualization tools in place across the region. Links to the tools are provided within the text as well as in the Tools Reviewed section at the end of the document. This serves as a snapshot of current practice and provides examples of how these elements can evolve and be expanded and improved upon. The inventory also helps to document collaboration and exchange among MARCO states.

MARCO can work toward improving the alignment of these tools and their effectiveness. Better and more responsive decision systems rely on well-articulated policies with increasing levels of specificity and prescription, priority-setting that leads to reproducible results aimed at mitigating identified threats, and consistent use of visualization tools.

Best practices for the framework include **process improvements** to better communicate goals and drive priorities, and **harmonization** of goals and methodologies across the region and among agencies within states:

**Process Improvements**

- **Policies to use wetlands as NNBFs should be clearly stated by each MARCO state to support risk reduction and resilience across all programs.** Adopted policies should specifically address: conserving identified existing wetland complexes, conserving/restoring marsh migration corridors and areas for future wetlands, and targeting support for living shorelines in the right places.

- **All prioritization schemes for wetland conservation, restoration, and management for risk reduction and resilience should articulate what goals they seek to achieve and what threats they seek to offset or mitigate.** The ability to harmonize use of data and models across the region is most relevant where the outputs are aimed at communicating the "why" as well as the "where" and "when."

- **MARCO states should mandate wetland NNBF priority setting in all updates of related resource planning programs.** Each required update of a resource management plan offers an opportunity to advance risk reduction and resilience using the funds and planning resources then available to the program that is updating the plan.

- **Build a data visualization component into each priority-setting action.** A well-thought-out data visualization tool supports policy and priority-setting approaches and makes the tradeoffs and choices apparent.

**Harmonization**

- **Develop a vision for the entire region with respect to what future wetland NNBF conditions are desired.** Policies and plans should be improved, working toward a converging regional vision with attention to regional, local, and parcel-level spatial scales.

- **MARCO states and their collaborators should adopt time-scales for goal setting and measuring that are consistent across the region.** In standardizing time horizons, it is important to address near-term risk reduction, middle-term climate adaptation, and long-term resilience.

- **Support the continuing harmonization of data and information analysis methods.** Cooperative exchanges, events and science webinars should be supported to address the needs of managers for actionable information. Common data sets and tools should focus on *vulnerabilities*, and on developing regionally consistent analytic methods to define and measure risk reduction and resilience *opportunities* and performance measures.

- **MARCO and regional partners should develop technical best practices to assist marsh migration**. Targeting and priority setting that has a marsh migration focus must be supported by research supporting enhanced technical capacity to support acquisition, planning, and managing expectations for wetland adaptation areas including addressing design and decision challenges.

- **Establish monitoring protocols to evaluate progress in achieving NNBF goals with wetlands.** Accountability and learning can occur across at least four measures: measuring progress by each state as to its fulfillment of the goals it has set for itself, making data available to independent researchers, determining performance using the dates applied for targeting and vulnerability assessments, and determining whether technical specifications need to be adjusted in light of measured experience.

# Developing Wetland Restoration Priorities for Climate Risk Reduction and Resilience in the MARCO Region

## Overview

This report is intended to determine the current state of practice for identifying and prioritizing wetlands for their usefulness in climate risk reduction and climate resilience. It is intended to identify promising paths forward to advance those practices and to improve implementation of strategies across the coastal states of the Mid-Atlantic Region to achieve regional protection of human communities and ecological functions over the coming century of projected climate change impacts.

The states of the Mid-Atlantic Regional Council on the Ocean (MARCO) -- New York, New Jersey, Delaware, Maryland, and Virginia – use science-based tools to prioritize wetlands sites for conservation and restoration. Many of these tools address multiple objectives, including wildlife habitat, open space and recreation, water quality improvement, erosion control, and coastal conservation. Targeted conservation and restoration of wetlands also provide natural and nature-based features (NNBFs) in various locations that can reduce risks from climate change and improve coastal and ecological resilience.[1] As used in this report:

> *Climate risk reduction* specifically includes protecting coastal communities and infrastructure from flooding, storms, erosion, salt-water intrusion, and direct injury.
>
> *Climate resilience* includes conserving or restoring sufficient natural assets to allow ecological systems to function and adapt under continuing climate impacts that change the physical profiles and biological complements of coastal and inshore environments.

This project examines where, and to what extent, risk reduction and resilience goals are articulated and implemented in the many programs affecting wetlands in the MARCO states, a rapidly changing policy environment. It examines climate adaptation plans to determine where these affect wetland priorities in the region. And it examines wetlands plans and other resource plans to determine the extent to which climate impacts are addressed. It also examines how

[1] NNBFs are defined in Bridges, et al. (2015). While these include a variety of features (dunes, beaches, reefs, underwater vegetation), this analysis is focused on wetlands of various types and on sites associated with living shoreline treatments that may include wetland vegetation.

goals for risk reduction and climate resilience have been included in conservation priority-setting schemes. Building upon existing prioritization tools, this report develops the framework for a regional approach that can be used consistently and reliably to identify regional wetland restoration priorities for federal and state programs to achieve risk reduction and climate resilience outcomes.

This project also serves the North Atlantic Landscape Conservation Cooperative (NALCC) mission to address regional threats by focusing on common goals and jointly developing the "scientific information and tools needed to prioritize and guide more effective conservation actions by partners toward those goals." This report takes into account variability among the participating MARCO states, both as to geography and as to their legal and policy portfolios, recognizing that effective approaches will necessarily be built cooperatively upon existing foundations rather than created entirely anew.

The project was assisted by an Expert Panel of advisors, who convened in January and May 2016 to identify prioritization tools and plans, data sources, and issues for evaluation. The project has also benefited from oversight by the members of the MARCO Climate Change Action Team (CCAT) and MARCO staff. The Environmental Law Institute (ELI) reviewed the plans, policies, laws, regulations, and data sources identified in the Appendix, and conducted interviews with climate and wetland managers in the region. ELI is solely responsible for the content of this report.

## Framework for Continuous Improvement in Priority Setting

The Mid-Atlantic States are currently addressing climate risk and resilience in a multitude of ways. Our review of climate adaptation and wetland management policies, plans, and tools, assisted by a panel of expert advisors (see Appendix), shows a dynamic and evolving policy environment, with new efforts being launched continually by states, federal agencies, local governments, and non-governmental organizations.

An important function of this project is to provide a way to understand this richness of activity, and to create a framework that will advance practice. Specifically, the framework can help to identify key factors that will support a cohesive regional approach to climate risk reduction and resilience while also allowing for improvement in individual states (or areas) as opportunities permit. The proposed framework is intended to meet the following objectives:

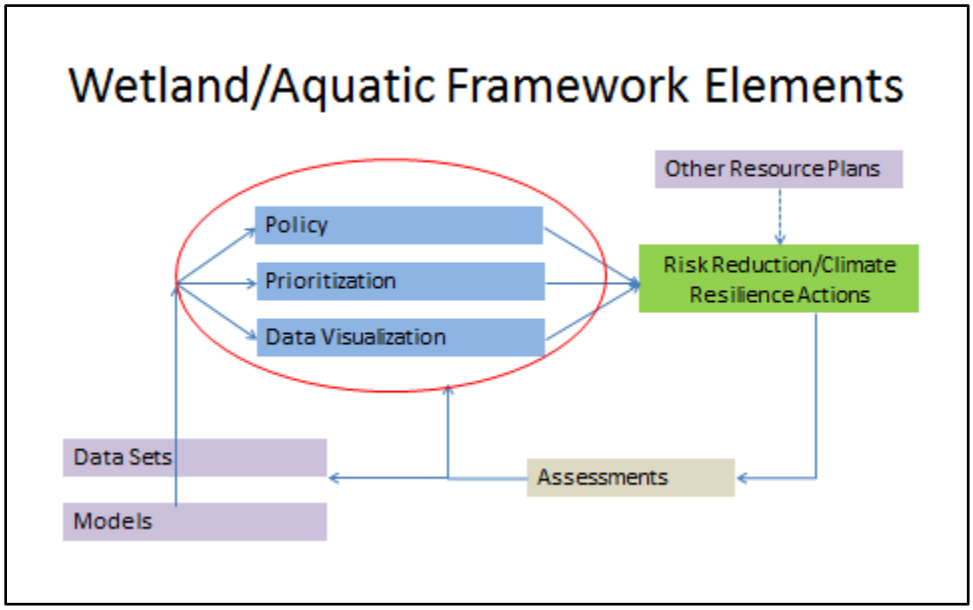
- A simple set of defined program elements for attention by the MARCO states as they seek to improve wetland prioritization for risk reduction and resilience.
- Opportunity for continuous improvement by states and federal programs and other cooperating actors in the region – recognizing that such improvements are likely to occur at discontinuous rates because of political, scientific, and funding differences, and because opportunities will arise at different times as resource management plans are updated or as legislatures and agencies respond to storm events or other public needs.
- Opportunities for learning among states and for adoption of successful methods from others as they show results.

The framework also recognizes the wide variety of tools and activities that interact with decisions about wetland conservation and restoration in the climate context. Because all of these are present in different forms across the region, the framework is intended to prompt functional integration of approaches rather than formal uniformity across MARCO.

| **Tools influencing wetland priorities** | |
|---|---|
| • Statewide policies<br>• Regulations<br>• Statewide vulnerability assessments<br>• Local vulnerability assessments<br>• Habitat classification systems<br>• Wetland plans<br>• Climate action plans<br>• Open space plans<br>• Wildlife action plans<br>• Storm recovery plans | • Forest plans<br>• Coastal and Estuarine Land Conservation Program plans<br>• Infrastructure plans<br>• Research agendas<br>• Models<br>• Data repositories<br>• Data visualizations<br>• Monitoring/Assessment<br>• Communications tools |

## Framework Elements

The elements of the framework are shown on the following chart. These elements should be part of most state, federal, or local activities that identify wetland and related aquatic sites as NNBFs for climate risk reduction and resilience.




Three **key elements** provide a basis for development in the MARCO region of a common framework that can adapt over time. These key elements are: Policy, Prioritization, and Data Visualization.

1) **Policy**. Policy makers should state one or more policies concerning use of wetlands NNBFs in climate risk reduction and resilience if these features are to play such a role. This element is needed for programs to advance beyond general statements that climate change should be taken into account when making conservation decisions or general statements that wetlands have adaptation benefits. Articulated policies can be very detailed or broad. They can be procedural (such as requiring findings before approving structural shoreline measures), or they can declare objectives for landscape management (such as an expressed policy to preserve tidal marsh migration corridors). Some policies are articulated ahead of clear implementation mechanisms, but recognize that these mechanisms will be developed separately through various programs. Others are clearly intended to drive decision-making in specific governmental programs. Policies should drive toward greater specificity and greater prescriptiveness as experience is gained.

2) **Prioritization**. Priority-setting should be systematic. Many priority-setting schemes are embodied in wetland plans, land conservation acquisition plans, state wildlife action

plans, climate action plans, open space plans, and other vehicles. Some of these provide detailed scoring systems; many others simply identify habitats or landscape types of particular interest or concern. The important question for managers is whether, and to what extent, priority setting schemes actually include climate risk reduction and resilience objectives. Furthermore, these schemes should be able to make distinctions among potential choices for expenditures, acquisitions, and staff – among geographies, wetland types, and shoreline goals, and over definable time horizons—in the interests of risk reduction and resilience. Priority schemes are most useful where they can generate a reproducible outcome in guiding decisions.

3) **Data Visualization**. While data are key inputs to any natural resource planning or management program, commitment to data visualization is an essential element to ensure implementation and program continuity in the complex area of climate risk reduction and resilience. Data visualization is critical to public communication and outreach. It also makes spatially explicit decisions clear to other government agencies, legislators, local officials, and others responsible for constructing prioritization schemes or considering new policies.

These three key elements can be adopted and improved at different times. Whether adopted by an entire state, a particular state or federal agency, or other entity, they drive targeting activity. Many existing climate risk reduction and resilience efforts in the MARCO region have begun with simple or incomplete policies or prioritization schemes that provided a basis for future addition, evolution, and improvement.

In the context of any program design, program evaluation, or planning opportunity, program managers should determine whether *each* of these elements exists, and how each can be advanced. The chapters of this report address these key elements in turn.

The policies, prioritization, and visualization elements should drive effective **risk reduction and resilience actions**. Commitments to these implementation actions may be embodied in specific climate adaptation or wetland management plans or in **other resource plans** prepared to support specific programs such as state wildlife action plans, comprehensive state wetland plans, coastal and estuarine land conservation plans, outdoor recreation plans and conservation land plans, and others that affect targeting of conservation actions.

**Data sets** and **models** are inputs to the priority-setting strategy. These often include models of sea level rise and storm surge, bathymetry using LIDAR, wetland condition assessments and mapping, guidelines on the performance of various shoreline treatments in various settings, and indices of performance.

Performance **assessments** are important to evaluate the outputs of a risk reduction and resilience program and to make adjustments, including determining new data needs, monitoring outcomes, and updating or adjusting models.

Members of the Expert Panel advising this project emphasize the importance of integrating communication. We include communication within and among governmental agencies and their funders and collaborators, with governors and legislators, as well as with members of the public, landowners, businesses, and local officials. However, communication is not best understood as a separate element in the Framework. Rather, it is fundamental to the three **key elements** shown in the circle. Effective communication must be founded on a policy or policies, identification of priorities, and especially the use of data visualization—critical in this complex area of science where we are considering *physical and biological changes* over *large geographies* over *time frames ranging from a few decades to a century or more*. A clear policy, a replicable prioritization scheme, and data visualization tools provide the content for communication.

Progress on use of wetlands as NNBFs can be made if decision makers engaging with climate risk reduction and resilience keep in mind the following three key questions:

- Have we articulated a policy?
- Have we set one or more priorities?
- Have we communicated visually?

When managers can find ways to improve each of these elements, the result will be better performance and communication. Recognition of this framework across MARCO could also improve opportunities for the partner states to adopt and adapt operating approaches from one another.

## Which Wetlands?

The framework must operate to define actions that can be made spatially explicit. These are generally driven by goals of risk reduction for human communities and for the maintenance and continuation of functioning wetlands and shoreline systems over time.

Based on the current state of the science, governments and nongovernmental conservation partners in the MARCO region have identified and pursued several goals that relate to use of wetland NNBFs. These include five general areas of activity:

- *Conservation and restoration of natural features in place* -- Conservation of specific natural shorelines and marshes where these are currently intact and can provide risk reduction benefits over several time horizons. Meeting this need may include not only passive conservation, but also nourishing, stabilizing, or changing the vertical profile of the natural feature.
- *Marsh migration planning* -- Facilitating the migration of marshes to be affected by sea level rise and storm surge. Variously referred to as "advancement" or "retreat," this activity requires careful identification of undeveloped adjacent uplands and wetlands or impoundments, conservation of these lands, restoration of hydrological connections where needed, and other restoration activities to support migration of coastal and tidally-influenced wetlands over several time horizons.
- *Living shorelines* -- Promoting or requiring "living shoreline" techniques where landowners or public entities seek construction to forestall shoreline erosion. Further, this activity may include determining in advance where to install or require these features proactively to meet a regional or area goal.
- *Coastal infrastructure and structures* -- Requiring siting, design, and building practices that incorporate provisions for hydrology and natural systems. These activities include prescribing coast smart protection of infrastructure and communities using NNBFs where feasible; and responses to storm events that include targeted buyouts and related ecological restoration.
- *Habitat diversity* -- Creating and supporting habitat mosaics that will provide ecological resilience to the effects of climate change, including sustaining species complexes.

As discussed later in this report, these goals underlie many of the policies and prioritization schemes that are evolving. For example, The Nature Conservancy's online *Coastal Resilience Toolkit* suggests focusing on: protecting or restoring salt marshes to serve as buffers; developing hybrid approaches that link natural and built defense structures; and removing incentives to build in high-risk areas.

Documenting risk and vulnerability of both natural features and human communities is a necessary predicate to effective action. Equally important is the ability to project desired future conditions on the relevant landscapes – defining spatially explicit goals for the relevant time horizons. Understanding which NNBFs are needed and where they may be effective informs both policy and priority-setting schemes as these are developed and refined. This will help determine how to set conservation and restoration priorities harmoniously within the region. Ideally, decision makers will want to identify:

1. Regionally important areas and systems,
2. Locally important priorities (e.g., county-by-county, or within National Estuarine Research Reserves (NERRs), or shoreline planning areas), and
3. Parcel-level selections, either where opportunities arise because of landowner applications or proactively within the context of the first two priorities.

The Nature Conservancy and the consulting firm CH2M, in *Coastal Risk Reduction: Integrating Natural Defenses into a Sustainable Coastal Risk Management Framework* (2015), define key considerations:

- covering "a large coastal area to take account of alongshore connectivity and regional influences" on coastal processes;
- considering a long time period to take into account changes in coastline resulting from both development and climate change drivers, changes in risk, and time for communities to plan for adaptation;
- considering a full range of options including non-structural, structural, and NNBFs, and promoting NNBFs where appropriate "to realize multiple benefits" they can provide; and
- engaging the attention of the full range of stakeholders.

In many cases the preferred long-term management approach may differ from present practices, and consequently any risk reduction effort will need to provide a map to move toward different answers over the longer time scale. Important inputs are up-to-date data and clear identification of risks. Public outputs should include nontechnical information on plans, a high level overview of risk and management solutions, and detailed management statements for specific areas where "natural and nature-based solutions are considered."

Many assessments and approaches are used in the MARCO region to project future climate impacts, predict vulnerabilities, and to set priorities. These frequently rely on common models, datasets, or recommendations. Among the commonly used tools referenced often in this report, are:

- Sea Level Affecting Marshes Model (SLAMM). Many state, local, and nongovernmental vulnerability assessments are based on some version of SLAMM. SLAMM incorporates inundation, erosion, overwash, saturation, and accretion factors, and in later versions salinity, to simulate the dominant processes in wetland conversion and shoreline changes from sea-level rise.
- NOAA Digital Coast Tools, such as the Habitat Priority Planner. Datasets include LiDAR, socio-economic, and land cover data, and include viewers and visualization tools.
- Chesapeake Bay Habitat Tool, developed by The Nature Conservancy,
- InVEST Coastal Vulnerability Model and InVEST Coastal Protection Model
- North Atlantic Coast Comprehensive Study (NACCS), including data on exposure analysis, risk analysis, inundation mapping, coastal features, federal and state shore protection projects, NNBF suitability classification, and others.
- NOAA National Climatic Data Center. Available climate and historical weather data for use with other tools and assessments.

At the site level, there are also many tools, including on-the-ground assessment methods for selecting among living shorelines and other techniques. Guidelines for engineering living shorelines to address differing shoreline conditions have been developed for the region, including technical resources developed by the Stevens Institute of Technology, Maryland Department of the Environment, Virginia Institute of Marine Science, and others (discussed *infra*).

Because we can expect new datasets, models, compilations, and assessments to continue to be developed, it is important to apply a systems approach to policy design, prioritization, and data visualization.

## Policy Design

Experience shows that it is very difficult for wetland conservation and restoration activities to gain traction, either for climate adaptation or for other purposes, without clearly articulated policies. Consequently, general policies to "take climate into account" or to "use natural and nature-based features" are not likely to be as effective as policies that clearly prescribe *how* risk reduction and resilience considerations are to be integrated into government decisions or that identify *which* wetland areas are the ones toward which to direct restoration and conservation activities.

Policies can be adopted and improved incrementally. Some policies may set goals for an entire state or coastal region, others for a single agency. Some may establish standards for administration of specific resource management programs or funds. They may guide a large set of government activities, or they may be adopted in connection with narrowly targeted programs governing specific types of activities.

Climate risk reduction and resilience policies using wetlands are best understood across two analytic dimensions.

- **Specificity**. This dimension addresses the detail with which the policy articulates a program goal. For example, a policy that says "preserve corridors for tidal marsh migration" is more specific than a policy that says "consider wetlands when designing a coastal resilience strategy."

- **Prescription**. This dimension addresses how the policy directly drives actions, such as the expenditure of funds or making regulatory decisions. For example, a policy that says "permits for hardened shorelines shall be denied, unless a living shoreline is infeasible" is more prescriptive in comparison with a policy that says "the agency should encourage landowners to install living shorelines." Similarly, a policy that prioritizes expenditure of acquisition funds on marsh migration corridors is more prescriptive than one that includes climate factors generally in funding decisions.

Whenever a state legislature, governor, agency, local government, or partnership adopts a new policy or modifies an existing policy, an opportunity arises to move toward a higher level of specificity and greater prescription.

## Policies for Wetlands in Climate Adaptation

While data-driven vulnerability assessments are essential to priority setting, it is critical for states and others to articulate policy objectives for wetlands in order to drive action and align state, federal, local, and nongovernmental programs.

***Policy Objectives Driving Actions***

- A policy objective to identify and protect intact wetland complexes providing NNBF functions can support effective targeting of conservation dollars across multiple resource management programs.
- A policy to support marsh migration makes it possible to identify corridors, protect future wetland sites, and invest in management and restoration activities.
- A policy preference for living shorelines can drive permitting activities, can determine where living shorelines are needed, and can identify when public funding or technical support might be targeted to ensure their timely and sequential installation.

Specificity in wetlands NNBF policies is evident in a number of places across MARCO. For example, New York City's targeting strategy for risk reduction using wetlands and Maryland's mapping of wetland adaptation areas for future acquisition to support marsh migration both support actions. Each MARCO state provides some amount of policy preference (or permitting simplification) for living shorelines. Coast smart construction and siting requirements vary in specificity and prescriptiveness, but it is helpful if policies indicate not simply survival of the sited infrastructure itself, but also use of NNBFs to support the system of resilient NNBFs along the coast, or to support future migration of habitats.

## State and Local Policies

The policies described below have some specificity and/or prescriptive effect in the MARCO region. These include both explicit policies that guide decisions, and those that are implicit but reasonably specific in identifying goals for use of wetlands as NNBFs. *This "policy overview" box briefly summarizes the specific state policy tools and laws discussed and hyperlinked throughout this chapter.*

| ***Policy Overview*** | |
|---|---|
| **State** | **Overview of Wetland NNBF Policies** |
| New York | • Consider climate risk in state permitting<br>• Use of statewide sea-level rise projections<br>• Open Space plan including resiliency and prioritization goals<br>• Promote reliance on natural resiliency, |

| | |
|---|---|
| | including living shorelines, in local government planning and decisions<br>• Protect/restore wetland NNBFs for risk reduction based on detailed vulnerability assessments and modeling |
| New Jersey | • Use state vulnerability assessments to target state actions<br>• Promote living shorelines<br>• Identify marsh migration opportunities in Delaware estuary |
| Delaware | • Integrate sea level rise in all planning scenarios<br>• Promote living shorelines<br>• Identify wetland conservation opportunities |
| Maryland | • Screen all acquisitions for climate change/sea level rise and resilience<br>• Inventory state-owned lands for resilience<br>• Map marsh migration corridors for conservation acquisition<br>• Map and prioritize NNBFs that provide high levels of risk reduction<br>• Require living shorelines unless infeasible or mapped for structural defenses<br>• Coast Smart construction guidelines including NNBFs in siting/design criteria<br>• Local government assistance |
| Virginia | • Map vulnerability of coastal resources<br>• No net loss goal of natural carbon sink for wetlands, forests, farmlands<br>• Living shorelines preferred and requirements<br>• Comprehensive coastal resource management guidance for local governments including preferred options<br>• Mapped wildlife action priorities, including climate adaptation wetlands |

**New York**

In general, New York's policies at each level of governance – state, regional, local – endorse use of NNBFs, including wetlands. State policies tend to be broad, and targeting of wetlands for risk reduction and resilience is based chiefly on vulnerability assessments, screening of proposed governmental and permitting actions, and on site-specific risk reduction needs as well as regional habitat goals.

New York's policies that influence priority setting for wetland NNBFs derive in substantial part from the *Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure*, developed by the state's 2100 Commission in 2013. The Commission advised New York to:

> safeguard our coastline through a comprehensive package of short- and long-term solutions to address baseline sea-level rise and tidal changes and extreme storm surges. This includes protecting urban shorelines with carefully designed measures, such as surge barriers, levees, bulkheads, natural defenses, and green infrastructure to better manage stormwater.

The Commission recommended that the state "assess changes to the Environmental Conservation Law to encourage green infrastructure as part of mitigation actions taken to promote resilience; provide incentives for creation of soft shorelines and wetlands; and require consideration of sea level rise scenarios. Identify revisions to existing laws and programs to streamline soft infrastructure projects, particularly where such infrastructure will provide additional defenses against future storms." The Commission recommended development of policies:

- to "restore tidal wetlands along the coasts in coordination with federal, local, and private entities,"
- to update state wetlands maps, and to conduct a feasibility study addressing how to expand and protect barrier islands, beaches, and dunes;
- to determine how and where to protect existing tidal wetlands and come up with a strategy to create new ones;
- to expand creation of living shorelines; use existing mapping resources to identify vulnerable areas that can use natural buffers; use soft infrastructure on a pilot basis; and protect and restore coastal wetlands; and
- to incorporate projections of future sea level rise in the Tidal Wetland Act and "determine where protection of additional upland buffer areas would be appropriate."

New York's *Community Risk and Resiliency Act (CRRA)*, signed in September 2014, advanced these recommendations, putting some policies into law. The Act directed the Department of Environmental Conservation (DEC) to adopt official sea level rise projections by January 1, 2016

and to update them at least every five years. As for policies, it requires certain New York programs to consider future climate risk due to sea level rise, storm surges, and flooding in connection with permitting, funding, and regulatory decisions. Decisions subject to this screen include, among others, projects related to protection of waters, freshwater wetlands, tidal wetlands, and coastal erosion hazard areas; wetlands permits and facility siting permits; and New York's Open Space Conservation Plan. The Act requires DEC and the Department of State (DOS) to develop guidance on the use of natural resiliency measures. The Act also requires DOS to develop model local laws to help local governments incorporate climate risk and resilience measures into local bylaws, including resiliency measures that use natural resources to reduce risk.

As a complementary effort to help implement the CRRA, the Hudson River National Estuarine Research Reserve (HRNERR) and New York state agencies are working on *Guidance for the Use of "Natural Resiliency Measures*." The Guidance document is expected to be completed in January 2017 and will include information on risk reduction and community resilience practices, the benefits of NNBFs, and a framework for state use of these tools. Updated policy preferences for living shorelines will provide an opportunity to guide wetland NNBF choices. An existing 2007 interpretive guidance on Shoreline Protection for DEC's Division of Fish, Wildlife and Marine Resources recommended that where a new or replacement shoreline erosion project is being proposed, the project sponsor should be required to take the "least structural or softest approach" that will address the problem at the site, and that "wherever possible the character of the natural shoreline and riparian zones should be retained or restored," and the footprint of hardened structures minimized.

Ecological policy objectives also influence decisions in New York. New York's Draft *Open Space Conservation Plan* (2014) governs most state land acquisition decisions. It now includes a policy to "incorporate vulnerability to sea-level rise and enhanced storm surge and protection of critical habitats into land acquisition and conservation programs." It also calls for use of best available science to protect coastlines and watersheds and make them more resilient to climate change impacts, as well as efforts to facilitate the development of "hybrid engineering approaches that link 'soft' ecosystem based approaches (green) with 'hard' infrastructure (grey) to provide holistic solutions to enhance resiliency." It calls for a "long-term statewide program to prioritize high-risk floodplain areas for conservation through acquisition and easement … [including] plans to facilitate tidal wetland migration in response to sea-level rise."

The *Long Island Sound Comprehensive Conservation and Management Plan* articulates policies to increase and maintain resiliency of coastal habitats. It includes a goal to prioritize habitats that are vulnerable to climate change for restoration and adaptation, including the use of living shorelines.

Specific counties and municipalities also have policies relevant to use of NNBFs. Among these are plans developed by *New York Rising Communities*. These plans identify policies to utilize green infrastructure, restore coasts and floodplains, and improve environmental stewardship.

Policies aimed at using natural buffers and green shoreline techniques in advance of potential sea level rise effects are also embodied in some locally-focused plans prepared for the Hudson estuary communities of Piermont, Catskill, and Kingston with governmental and nongovernmental (Scenic Hudson) support. Some of these articulate or recommend policies, or present alternatives for consideration which would allow tidal wetland habitat to expand.

New York City has developed its own policy frameworks to guide risk reduction and resilience. *PlaNYC – A Stronger, More Resilient New York* calls for minimizing upland wave zones through use of dunes, offshore breakwaters, wetland, reefs and living shorelines in specific areas, and for improving coastal design and inspection procedures. The New York City Department of Parks and Recreation's *Wetlands Strategy* (2012) expresses a policy to strengthen protection of vulnerable wetland parcels, to increase wetland acquisition and restoration efforts, and to assess the potential impacts of sea-level rise on tidal wetlands. The City's Office of Recovery and Resiliency, established in 2014, has articulated four policy goals: increase coastal edge elevations; minimize upland wave zones; protect against storm surge; and improve coastal design and governance.

**New Jersey**

New Jersey's current policy mix is driven primarily by vulnerability assessments and its commitment to advance the use of living shorelines.

*Preparing New Jersey for Climate Change*, prepared by the New Jersey Climate Adaptation Alliance in 2013, recommended that the state conduct an "assessment to determine the vulnerability of tidal wetlands, forests, and other natural areas" to climate change, and the value of these areas to reduce and adapt to the effects of climate change. It also recommended use of a risk management approach to identify people, places, and assets (including natural capital) most at risk to climate stressors and identify potential direct investments in risk reduction. New Jersey's *Vulnerability Assessment* and *Vulnerability Index* support this approach by determining where areas are vulnerable, and where actions may be warranted. However, these do not themselves define management priorities.

New Jersey has a policy to remove obstacles to the use of living shorelines. It created a living shoreline program in the New Jersey Department of Environmental Protection (NJDEP) with a coordinator to assist in project identification. NJDEP adopted regulations in 2013 to provide a general permit for some living shorelines that are under appropriate governmental sponsorship or oversight. The regulations articulate a policy to support government-backed living shorelines. The general permit applies to "habitat creation, restoration, enhancement, and living shoreline

activities necessary to implement a plan" sponsored by a federal or state agency or by a nonprofit conservancy acting for such programs; or for research by a college or university (NJAC 7:7-6.24). The living shoreline must disturb only the minimum amount of "special areas" defined by state law and may not decrease the total acres of special areas on a site. The project must be one acre or less below mean high water unless a larger area can be justified to meet project goals. Where the project is to restore existing shoreline to a previous condition, it cannot exceed the footprint of the shoreline as it appeared on the applicable Tidelands Map (from the 1970s) except for structural components intended to reduce wave energy. The Stevens Institute of Technology has published *Living Shorelines Engineering Guidelines* to assist in assessing site conditions, defining parameters, and identifying design guidance to address these and technical parameters.

New Jersey's *Wetland Program Plan 2014-2018* states a policy to protect coastal wetlands, and articulates the state's intention to develop more definable coastal wetland protection standards, study effectiveness of living shorelines, and provide technical assistance for coastal resiliency projects.

Several policies are associated with the Partnership for the Delaware Estuary. *Climate Change and the Delaware Estuary (2010)* recommends identifying vulnerable wetland areas "that could benefit from restoration or adaptation to increase the acreage that is sustainable." It also calls for managing lands that are landward of tidal marshes that have suitable elevations, slope, or other traits that can facilitate marsh migration. *Weathering Change (2012)*, a guide for local communities, advises that they should "work with nature to protect and create wetlands" and living shorelines. The *Delaware Estuary Comprehensive Conservation and Management Plan* (1996) is being updated during 2016-2018. The plan includes goals related to sea level rise and wetlands; specifically Goals H-7 include developing measures to protect shoreline and littoral habitats, and identifying techniques to prevent loss of both tidal wetlands and emergent tidal wetlands that can mitigate for sea level rise.

**Delaware**

In general, Delaware's policies have focused on sea level rise implications and responses, including a particular focus on infrastructure. Wetlands mapping, targeting, and policy commitments for investments in these activities are under development.

Delaware's policies derive substantially from implementation by state agencies of an Executive Order which recommended: incorporating sea-level rise into public and private sector regional planning efforts; updating the state tidal wetlands map; developing a comprehensive wetlands restoration, protection, and retreat strategy; and designating shoreline zones for adaptation action. *Delaware Executive Order 41 "Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities from Reducing Emissions" (2013):*

- Directs the Cabinet "Committee on Climate and Resiliency" to develop "agency specific actionable recommendations for improving Delaware's preparedness and resiliency to climate impacts" on a variety of interests and systems (including natural ecosystems); and specifies that "The recommendations shall prioritize the use of natural systems or green infrastructure as the preferred means to improve resiliency."
- Directs all state agencies to "incorporate measures for adapting to increased flood heights and sea level rise in the siting and design of projects" for construction and reconstruction. "Construction projects shall also incorporate measures to improve resiliency to flood heights, erosion, and sea level rise using natural systems or green infrastructure to improve resiliency wherever practical and effective."
- All state agencies must "consider and incorporate sea level rise scenarios into appropriate long-range plans for infrastructure, facilities, land management, land-use, and capital spending. DNREC [Department of Natural Resources and Environmental Control] shall periodically update the scenarios with the best scientific data available and distribute new guidance to state agencies."

These policies are being methodically pursued. The *Climate Framework for Delaware: Summary of Recommendations (2014)* has 50 climate adaptation recommendations for DNREC, including: designing and implementing restoration activities to "slow the current loss of coastal beach, marsh, and forest habitats"; restoring adequate riparian buffers and buffers around unique ephemeral wetlands, including coastal plain seasonal ponds and vernal pools; developing climate change adaptation plans for two DNERR properties; incorporating Executive Order 41 into coastal zone federal consistency enforceable policies; adapting coastal impoundments and ponds with levees, water control structures, water level management and restoration; and continuing to pilot "climate-smart coastal impoundments" to create impoundments that shift habitat inland with sea level rise.

*Preparing for Tomorrow's High Tide (2014)* identifies actions to implement recommendations of the multi-stakeholder Sea Level Rise Advisory Committee. Actions recommended by the Wetlands, Shorelines & Habitat group included the creation of a database for communication and the coordination of planning and analysis; development of a coastal resiliency toolkit (based on TNC toolkit developed in New Jersey); developing a post-storm retreat strategy; updating wetland maps to include migration corridors, and assessing marsh transition zones to develop a retreat strategy, with pilot projects; living shoreline demonstrations; and designating shoreline zones for adaptation actions.

In Delaware, hardening of shorelines is generally discouraged by state policies. For living shorelines, DNREC has adopted a Statewide Activity Approval (SAA), simplified permitting under Delaware's Subaqueous Lands Act, to authorize construction of several types of living shorelines not exceeding 500 linear feet.

The *Delaware Wildlife Action Plan 2015-2025* (2015) adds a section on climate change impacts. The plan uses a model of Conservation Opportunity Areas (COAs), relying on information from and access to geographic focus areas and planning models including the Delaware Watershed Resources Registry (now under development). Geographic focus areas include various initiatives (Bayshore, Inland Bays, Great Cypress Swamp, Nanticoke, Brandywine-Christina watershed, White Clay Creek, Forest Legacy areas, and Delaware River Basin Conservation Initiative). The adaptation policy is to address salinity, forest fragmentation, and adapt coastal impoundments and ponds. Actions include designing and implementing restoration activities to slow loss of coastal habitats, promoting living shorelines, and preparing to restore ecological integrity of unique ephemeral wetlands.

The *Delaware Wetland Management Plan (2015)* updates the 2008 Delaware Wetland Conservation Strategy. The Plan adds a climate adaptation goal: To "use available science and research to better understand and plan for the effects of climate change and sea level rise on wetland habitats." The vision statement for that goal calls for "research to investigate and model wetland responses to sea level rise in terms of elevation, subsidence rates, shifts in vegetation communities, and conversion to open water." Areas that are identified as migration pathways "can be protected or acquired." Seven action items are listed for the climate goal. Relevant ones include research on the mechanisms and potential migration paths of wetlands and habitat conversion; identifying preservation areas for potential migration; investigating risk of flooding and saltwater intrusion to state wildlife impoundments, and considering how to support important wetland communities of related species; studying sediment rates, wetland elevation and open water conversions; and evaluating use of dredged material to restore tidal wetlands.

The *Delaware National Estuarine Research Reserve (DNERR) Management Plan (2013)* identifies core and buffer areas. The current plan calls for fee simple (outright real property) acquisitions within the NERR boundaries where property is needed to allow wetlands to migrate with sea level rise.

Delaware's Open Space Council drafted conservation criteria under the *Delaware Land Protection Act* to include climate change adaptation criteria. The open space conservation ranking criteria award additional points to properties *adjacent* to lands that are projected to be under water at 1.5 meters of Sea Level Rise, but no additional points for lands predicted to be underwater at 0.5, 1.0, or 1.5 meters SLR. These criteria apply for conservation choices. Note that in August 2016 the legislature eliminated the previous State Resource Area (SRA) program. The "open space" section of the new Act specifically adds as an allowed criterion for eligibility for state permanent protection a land area that "allows natural systems or plants and animals to accommodate or adapt to climate change or other large-scale changes in ecosystem processes." 7 Del. Code 7507A(a)(10).

**Maryland**

Maryland has several very specific policies, many of which are also high on the prescription scale. Maryland has mapped "Wetland Adaptation Areas" as Targeted Ecological Areas (TEAs) for conservation using state conservation and land acquisition programs. Maryland has triaged lands 0-2 feet above sea level as not suitable for state acquisition, although eligible for restoration activities in some cases where warranted. Maryland has required that climate resilience be built into all natural resource planning documents as these are updated. State development actions in the coastal critical area must undergo climate resilience review, and all state-funded construction must identify and maintain NNBFs as part of coast smart construction. Living shorelines are required by law, unless MDE has determined and mapped that structural means are needed, or unless the landowner can prove living shorelines are infeasible.

In general, Maryland's policies relevant to wetland NNBFs derive from a sequence of responses to recommendations made in Maryland's *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase 1 & 2: Sea-Level Rise and Coastal Storms/Building Societal, Economic, and Ecological Resilience* (2008).

Chapter 5 on Adaptation recommended retaining and expanding "forests, wetlands, and beaches to protect us from coastal flooding" and recommended using existing GIS assessment tools (Green and Blue Infrastructure Assessments) to identify high-priority areas for conservation, as well as developing and implementing a package of appropriate regulations, financial incentives, and educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival. It recommended establishing priorities to allow for horizontal marsh migration or vertical accretion; managing habitats to enhance ecological services; and identifying and developing programs to enhance and protect wildlife corridors and maintain connectivity of green forest core areas across the landscape. Further recommendations included promoting and supporting sustainable shoreline and buffer area management practices, using techniques to promote the installation of innovative shore protection techniques that maximize habitat restoration and enhancement and accommodate for projected sea-level rise; developing a general permit that streamlines the rebuilding process of storm-damaged tidal marshes; and standardizing design and construction methods and protocols employed for new, retrofitted, or replacement shore erosion control structures that consider climate adaptive strategies for coastal environments subject to sea-level rise, erosion, and storm hazards. The strategy recommended integration of "coastal erosion, coastal storm, and sea level rise (SLR) adaptation and response planning strategies into existing state and local policies and programs" together with pursuing "opportunities to enhance and protect Maryland's 'green infrastructure."

Each of these recommendations has been subsequently embodied in policies that provide both specificity and prescription.

In 2010, Maryland's Department of Natural Resources (MDNR) issued an official climate resilience policy that has influenced many MDNR activities affecting wetlands as NNBFs. MDNR's Policy Directive 2010:11, *Building Resilience to Climate Change*, directed MDNR's Land Acquisition and Planning Unit to review "all proposed land acquisitions and conservation easements to:

(1) assess potential impacts of climate change and sea level rise, and

(2) identify landscape or site-level characteristic that support ecosystem resilience."

MDNR was directed to develop "specific land conservation-climate change evaluation criteria within 12 months." These criteria now include a state policy that does not allow use of state Program Open Space funds for purchase of lands or for acquisition of conservation easements on lands that are 2 feet or less above current sea level, based on sea level rise and inundation models. However, some restoration activities may be approved in these areas (without acquisition), where low-elevation restoration projects "may enhance wetland and species migration while increasing coastal resilience over the short and long-term." (Also see discussion of "coastal resilience easements," *infra* at p. 33). MDNR also developed a scorecard that it uses for every parcel or easement under consideration for acquisition to evaluate the potential impacts of sea level rise. It includes consideration of extent of likely inundation by 2050 and 2100, land cover, restoration potential, storm surge protection function, and identification of potential barriers to habitat migration.

The *Building Resilience to Climate Change* policy required MDNR to conduct a GIS-based audit of its own lands and to develop specific habitat restoration potential assessments for resilience. MDNR now maintains and continuously updates a "living" document entitled *Building Resilience through Habitat Restoration* (current edition March 2015), which identifies its restoration objectives, defines best management practices, and summarizes project implementation approaches. General restoration guidance includes building coastal resilience, employing a landscape approach, creating habitat mosaics, reconnecting streams with their floodplains, understanding interactions with other stressors, incorporating uncertainties into project planning and design, targeting areas sustainable under future conditions, considering slope and site elevation to aid in migration of vegetation, and monitoring and adapting projects as needed. The document identifies dozens of data sets and models to use in carrying out objectives. These include Maryland's Coastal Atlas, MDNR Climate Change Impact Area mapping tool, SLR vulnerability assessment, SLAMM, erosion vulnerability assessment, storm surge risk (SLOSH model), and National Oceanographic and Atmospheric Administration (NOAA) and U.S. Army Corps of Engineers (USACE) models and assessment tools.

*Building Resilience to Climate Change* also required MDNR to integrate "consideration of climate change during the development of new or updated resource management assessment and strategic planning documents." These specifically include the state's Green Infrastructure Assessment, Wildlife Action Plan, Coastal Zone Management Program, CELCP, Forest Resource Assessment and Strategy, forest stewardship lands, fisheries management plans, land-unit plans, tributary strategies, watershed implementation plans and capital improvement budget programming. As these plans have been updated, climate resiliency goals and tools have been incorporated in each plan.

Based on these policies, Maryland has added marsh migration corridors and future wetlands as key conservation and acquisition areas for state conservation programs by updating Maryland's primary conservation planning data tool. *GreenPrint* serves as Maryland's statewide set of spatial georeferenced databases used for open space protection and many other conservation purposes. When lands are identified in *GreenPrint* as Targeted Ecological Areas (TEAs), they are conservation priorities. In 2012, MDNR's Chesapeake and Coastal Service undertook a robust analytic process documented in *Coastal Land Conservation in Maryland: Targeting Tools and Techniques for Sea Level Rise Adaptation and Response* to implement an MDNR/NOAA policy goal to "facilitate landward movement of coastal wetlands subject to dislocation by sea level rise." (Papiez, 2012). MDNR calculated scores for marsh migration corridors and future wetlands parcels for each of Maryland's 16 coastal counties and Baltimore City. The two top tiers (medium and high priority) were added to *GreenPrint* as "Maryland's Wetland Adaptation Areas" a new category of TEA.

Risk reduction is the latest portion of Maryland's priority-setting activities. Building on experience from other MARCO states, in 2016 The Nature Conservancy (for MDNR) completed a *Coastal Resiliency Assessment* which provides geospatial information and rankings identifying which Maryland NNBFs can serve coastal risk reduction goals if they are prioritized for conservation and restoration (Canick, 2016). The mapped areas are included in Maryland's online Coastal Atlas.

Maryland has also adopted a statutory policy to require use of living shorelines in most circumstances. The Maryland *Living Shoreline Protection Act* (2008), Md. Code Ann, Envt., § 16-201, and implementing regulations provide that "improvements to protect a person's property against erosion shall consist of nonstructural shoreline stabilization measures that preserve the natural environment, such as marsh creation," excepting only areas previously mapped by MDE as appropriate for structural measures, and areas where the landowner can demonstrate to MDE that nonstructural methods are "not feasible." The MDE's Tidal Wetlands Division uses a unified approach to shoreline management to address impacts on the natural environment of shore erosion influenced by sea level rise. The 2008 Act established a rebuttable presumption that every project site is capable of supporting a living shoreline, and an applicant is required to prove that a structural technique is necessary in order to use such a technique in place of a

living shoreline. The waiver process is the initial and primary mechanism used by MDE to consider sea level rise during review of an application, as the Act presumes that a living shoreline is the best method to offer long-term resiliency to sea level rise. If a waiver is granted to construct a structural erosion control project, the MDE must work to minimize impacts and require that the applicant ensure the resiliency of the project to sea level rise.

In addition, the state may not authorize an erosion control project if existing state or private wetlands are effectively preventing erosion, or if the proposed project may adversely affect an adjacent property, or navigation, threatened or endangered species, species of conservation need, significant historic or archeological resources, or oysters. Moreover, a person proposing a shoreline stabilization measure that requires a wetlands license or permit must first consider taking no action, and "relocation of structures threatened by erosion." COMAR 26.24.04.01. Prior to the 2008 act, living shorelines were recommended but not required as the default choice. MDE has published shore erosion control guidelines.

The state's Critical Areas Commission adopts regulations that affect land use and development activities in the "critical area"– lands within 1000 feet of all tidal waters and tidal wetlands. In 2015, the regulations were amended to require that all proposed development activities by a state agency on state lands within the critical area must undergo evaluation to address: preservation and protection of potential wetland migration areas; likelihood of inundation by sea level rise over the course of the design life of the project; climate resilient practices that may avoid or minimize structural damage associated with coastal hazards, extreme weather events, sea level rise, and other climate impacts; detrimental impacts on potential wetland migration areas; and coastal hazard and sea level rise impacts to public access.

A 2012 *Climate Change and "Coast Smart" Construction* Executive Order (E.O. 01.01.2012.29) requires state agencies to consider risk from coastal flooding and climate change in the construction or reconstruction of state-funded structures, and the siting and design of these structures to minimize associated impacts. Maryland's *Coast Smart Construction Program* was further advanced by a 2014 law establishing a public-private Coast Smart Council in MDNR, and a 2015 law, Md. Ann. Code, State Fin. & Pro. §3-602.3 that requires that state capital projects that include construction of a new structure or reconstruction of a structure with substantial damage be done in compliance with coast smart siting and design criteria. From the point of view of wetlands as NNBFs, Maryland's criteria include avoidance of areas likely to be inundated within next 50 years. In addition, "natural and nature based features that may serve to buffer the project from the impacts of future sea level rise, coastal flooding or storm surge (e.g., vegetated or forested buffers, dunes, wetland adaptation areas) or that support general climate adaptation practices (e.g., habitat adaptation areas), shall be identified and should be protected and maintained to the maximum extent practicable." *Climate Change and Coast Smart Construction: Infrastructure Siting and Design Guidelines* (2014) define policies that specify identifying, protecting, and maintaining "ecological features" that may buffer projects

from the impacts of sea level rise, coastal flooding or storm surge, or that support adaptation of habitats. They direct that "whenever possible, onsite mitigation measures should be directed towards enhancing, restoring or creating ecological features to provide additional protection against future sea level rise and coastal storm impacts." They also includes requirements relating to structures, that specify a minimum of two feet of freeboard above the 100-year base flood elevation, unless a waiver is granted after review by MDE, MDNR and the Dept. of General Services.

*Executive Order 01.01.2014.14 Strengthening Climate Action in Maryland (2014)* includes a further directive to deliver "tools and assistance to local governments to support community-scale climate vulnerability assessments and the development and integration of specific strategies for enhancing resilience to the impacts of climate change into local plans and ordinances." The order directs state agencies to review planning, regulatory, and fiscal programs to integrate consideration of climate goals including impacts of sea level rise, increased precipitation and temperature, and extreme weather." MDNR must issue guidelines to require consideration of climate change factors, including both mitigation and adaptation, under Maryland environmental impact reviews. And the order requires the Department of Information Technology to create an online climate data and information portal (see data visualization section below).

**Virginia**

Virginia's wetland NNBF policies are aimed at improving local shoreline protection, increasing knowledge, and identifying wetlands that provide habitat resiliency benefits.

Virginia's policies relating to wetlands as NNBFs are derived in part from the Commonwealth's *Climate Action Plan (2008)*. The plan articulated a policy that "To allow for the potential migration of tidal wetlands inland and increase coastal resiliency, the Virginia Marine Resources Commission (VMRC) should adopt shoreline protection policies that emphasize the use of living shorelines and seek to avoid shoreline hardening (bulk heads, sea walls, rip rap) wherever possible." The Plan also recommended a state effort to map and assess the vulnerability of coastal resources including wetlands to sea level rise and climate impacts (subsequently implemented by the Virginia Institute of Marine Science (VIMS). In addition, the Climate Action Plan recommended that the Commonwealth implement a "no net loss goal" for carbon sequestration areas by protecting, in separate categories, forests, wetlands, and farmland as natural carbon sinks.

Subsequently, Virginia's 2011 *Living Shorelines Act* directed VMRC, in cooperation with the Department of Conservation and Recreation (DCR) and with technical assistance from VIMS, to adopt and implement a general permit "that authorizes and encourages the use of living shorelines as the preferred alternative for stabilizing tidal shorelines in the Commonwealth." (Va. Code §28.2-104.1). VMRC's first such general permit, effective Sept. 1, 2015, provides a

streamlined permitting process for living shorelines; it provides limits on maximum fetch, specifies coarse sand for required fill, and use of fiber logs, mats and shell bags as needed, and provides that appropriate wetland vegetation shall be planted, and maintenance and monitoring conducted. (4 Va. Admin. Code 20-1300-10 et seq.) An additional general permit is under development, which will allow for some marsh toe revetments with planting and sand placement. In order to provide a simplified single-permit process, living shoreline permits are exempt from other tidal wetlands and coastal primary sand dune permit requirements if all general permit conditions are met. To further support the living shoreline policy, further legislation provides additional incentives. Low interest loans are available to support living shoreline construction under a 2015 amendment to the Virginia Clean Water revolving loan fund; and 2016 legislation created a Virginia Shoreline Resiliency Fund to help residents and businesses subject to recurrent flooding, which may be used to mitigate future flood damage. (2016 Ch. 0762, Va. Code 10.1-603.14-.27). Other recent legislation allows local governments at their discretion to exempt approved "living shorelines" from local property taxes. (2016 HB 526).

The Living Shorelines Act also directed VIMS to "develop comprehensive coastal resource management guidance for local governments to foster the sustainability of shoreline resources" by December 30, 2012. The guidance "shall identify preferred options for shoreline management and taking into consideration the resource condition, priority planning, and forecasting of the condition of the Commonwealth's shoreline with respect to projected sea-level rise" (Va. Code §28.2-1100.9). Comprehensive coastal resource management guidance was prepared by VIMS's Center for Coastal Resources Management, and tools are available as locally-tailored web portals for each local governmental unit. Information includes local conditions, risks to natural and built environments, preferred shoreline strategies, and opportunities for future shoreline resources, as well as model language. It suggests that local governments consider a policy for shoreline best management practices as the recommended adaptation strategy unless an applicant can justify a departure, and further suggests that local governments consider "preserving available open spaces adjacent to marsh land to allow for inland retreat of the marshes under rising sea level."

Virginia's 2015 *Wildlife Action Plan* builds its NNBF recommendations upon a Virginia Conservation Lands and Climate Assessment. This was, in turn, built on Virginia's *Climate Modeling and Species Vulnerability Assessment* (2013) conducted by Virginia Tech's Conservation Management Institute for the Department of Game and Inland Fisheries and the National Wildlife Federation, as well as upon a 2009 strategy document on protecting species of greatest conservation need from climate change. The 2015 Wildlife Action Plan says:

> Climate-related wetlands conservation actions include restoring and enhancing vegetation within the wetlands to support changing conditions (e.g., using vegetation species that can withstand a broader array of conditions like more frequent inundation

and higher salinity levels), restoration of wetlands to increase their elevation along the coast where feasible or needed, and enhancement of wetland migration by targeted restoration or acquisition in areas where wetlands may migrate (both inland and upstream).

Policies are elucidated for each planning region, such as "priority areas for wetlands protection and restoration…include those wetlands that may provide some opportunity for adaptation and resiliency as sea levels rise."

Virginia's *Wetlands Program Plan 2015-2020* identifies "loss of tidal wetlands due to sea level rise and adverse ecosystems on all wetlands" as priority issues for the Commonwealth, and sets objectives to develop studies and data.

State policies also can affect local government actions. In addition to the comprehensive coastal resource management guidance provided by VIMS for local governments, some local governments in the Hampton Roads area are addressing sea level rise and flooding issues. State legislation in 2015 (Va. Code 15.2-2223.2) requires local governments in the Hampton Roads Planning District Commission area to include a coastal resource management plan in the next revision of their comprehensive land use plans "to combat projected sea-level rise and recurrent flooding." The Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project is a prior (and ongoing) voluntary effort to organize inter-governmentally. Norfolk's recent vision plan, *plaNorfolk2030* (2015), includes goals to "implement wetland design changes, such as the use of living shorelines that allow for the landward migration of wetlands to sea level rise." In 2016 the legislature established the Commonwealth Center for Recurrent Flooding Resiliency at Old Dominion University, William & Mary, and VIMS.

## Policy Characteristics

Policy definitions often begin with broad statements recognizing the need for planning for risk reduction and resilience. They then evolve into more specific and prescriptive commitments that focus on specific wetland types, or that define risk reduction objectives for wetlands; that define and require planning for protection of marsh migration corridors; that apply climate change screens to natural resource management decisions; or that require the update of resource plans so that they pursue a consistent set of objectives for wetlands NNBFs. Understanding climate vulnerabilities is a necessary, but not sufficient, predicate for effective priority setting. Clear policies are needed – both to organize activities and to provide accountability for results.

In the MARCO region, the rapid course of policy evolution has been from broad to specific and from general to prescriptive. Policies may include very broad statements supporting the idea of

marsh migration, or they may direct the organization of resources to identify and support marsh migration in particular ways. They may generally acknowledge that “living shorelines” are a good choice that should be easy to permit; or they may require the use of living shorelines unless living shorelines will have adverse consequences or are infeasible.

In considering their frameworks and goal setting going forward, MARCO states (and their partners) should seek greater specificity over time with respect to the types of wetland NNBF goals they have identified: conservation and restoration in place, support of wetland migration, promotion and siting of living shorelines, coastal smart development with NNBF components, and habitat diversity in support of resilience.

Specificity includes the kind of policies that require coast smart construction to incorporate NNBF features. It includes requirements to identify NNBF wetlands currently in public ownership and to identify their function in resilience and risk reduction.

Prescriptiveness includes policies that require living shorelines except where infeasible or where structural solutions have been previously identified as desirable. Prescriptiveness includes mapping marsh migration corridors on acquisition maps. Prescriptiveness includes requiring use of official state sea level rise maps in all construction and permitting decisions. Prescriptiveness includes requirements that climate adaptation be explicitly included in every update of a resource management plan for any natural resource program.

Over time, the move to greater specificity in policies should drive more performance. And where there are clear objectives linked to official programs and expenditures, the likelihood of persistence and follow-through is increased. This is critical if an effective sequence of actions is to be maintained over a multi-decade period.

## Prioritization

Priority setting is important in several respects, particularly geographically and temporally.

- **Geographically**. This dimension identifies the areas in need of attention for conservation and restoration. Geographically, priority setting can be understood in terms of the relative importance of NNBF protections for the Mid-Atlantic coast understood as a whole, regionally (Long Island Sound, Hudson River Estuary, Delaware Estuary, Chesapeake Bay and tributaries, Atlantic shore and coastal bays), in smaller regions within states such as habitat areas or ecological areas, in protection of particular human communities and/or wetland complexes, and finally very locally to determine parcel-level priorities within targeted restoration areas.

- **Timing.** Priority-setting also should be understood in terms of timing – designating which conservation and restoration actions need to be taken first in order to provide ongoing benefits in the near term, and to preserve the opportunity for actions to be taken in future decades and still be effective.

Prioritization approaches appear in a variety of plans and programs. Priority setting for wetland NNBFs can either be stand-alone priority setting to meet climate objectives, or integrated as the addition of climate objectives to existing priority-setting schemes for natural resources. For example, many existing state and federally-supported plans define priorities for acquisition of lands and easements for open space programs, for wetland conservation, or for conservation actions focused on species of special conservation need. Where these plans also include climate-related factors, they can contribute to an overall risk reduction and resilience strategy.

***Example: Coastal and Estuarine Land Conservation Program Plans***

Each state's CELCP plan includes a priority scheme for conservation and restoration projects seeking NOAA support. But only some CELCP plans expressly include priorities relating to the climate adaptation functions of wetlands. For example, Virginia's plan includes low lying and coastal wetlands as potential protection areas if they are connected to undeveloped uplands. Although these do not get extra priority points, they support a Virginia policy to "conserve shoreline and low-lying lands connected to sufficiently large undeveloped uplands so that wetlands can migrate inland." Delaware's plan includes additional points for sea level rise adaptation features, such as properties that support habitat migration.

Prioritization schemes within resource programs should integrate factors for climate risk reduction and resilience. Useful prioritizations always amount to more than provisos that say "take climate into account." Based on recent developments, wetlands conservation and

restoration opportunities related to climate risk reduction and resilience should be identified in a way that determines how much priority they get. Some plans include geographic areas of interest or lists of relevant factors, but don't set a hierarchy, while others are more specific. The key advancement in priority-setting is increasing **reproducibility** of results – *viz.,* is the method sufficiently clear that different decision makers using the scheme would likely reach similar results?

## State Priority Schemes

Priority-setting at a regional scale larger than states is still a work in progress. For example, the North Atlantic Landscape Conservation Cooperative is supporting a planning process with The Nature Conservancy to identify resilient sites for conservation that can provide natural "strongholds" for resiliency and habitat diversity in response to sea level rise, working to identify suitable metrics and methods for identification of these sites.

This section examines priority-setting schemes currently in effect that advance the use of wetlands NNBFs to reduce climate risk and improve resilience in the MARCO region. We include those that are currently most likely to influence funding decisions, whether or not they have high levels of reproducibility. *This "prioritization overview" box briefly summarizes the specific state tools discussed and hyperlinked throughout this chapter.*

| ***Prioritization Overview*** | |
|---|---|
| **State** | **Overview of Wetland NNBF Prioritization** |
| New York | • New York priority setting relies on data-driven simulations and modeling to identify specific responses in specific locations for planning |
| New Jersey | • New Jersey uses vulnerability assessments to identify areas for future targeting<br>• Partnership for Delaware Estuary assesses candidate areas for living shorelines |
| Delaware | • Delaware has focused primarily on sea level rise vulnerability but has not yet developed a prioritization approach for wetlands<br>• Partnership for Delaware Estuary assesses candidate areas for living shorelines<br>• Delaware incorporates sea level rise in long-term planning for funding, infrastructure, and land use |
| Maryland | • Maryland has identified marsh migration |

| | |
|---|---|
| | corridors and future wetlands as "Wetland Adaptation Areas" and mapped them as Targeted Ecological Areas for conservation<br>• Maryland has conducted risk reduction assessment to identify NNBFs most important for communities and mapped them<br>• Maryland applies a climate change screen to all acquisition and funding decisions |
| Virginia | • Virginia has produced data useful for priority setting<br>• Virginia has identified priority aquatic conservation areas for the Eastern Shore, and regional priorities for wildlife habitat threatened by climate change |

**New York**

New York's priority setting is often done with detailed simulations to identify particular wetlands or sites for future prioritization.

Detailed studies have been conducted from 2012-2015 for key counties using the Sea-Level Affecting Marshes Model (SLAMM). These simulations show the effects of climate change on 1.4 million acres of wetlands and associated shore lands of New York. Warren Pinnacle Consulting was funded by the New York State Energy Research and Development Authority (NYSERDA) to support such work for New York City, NYC Parks, and Long Island, and by the New England Interstate Water Pollution Control Commission (NEIWPCC) for Westchester County. Scenarios used the most up-to-date wetland layers and LIDAR. New York State is also supporting a decision-support tool that would allow users to account for environmental and socio-economic factors, and protection of developed areas. SLAMM simulations allow users to select and prioritize resources and scenarios in the tool. Thus the data are available to set priorities based on future conditions and timing, while decisions about setting priorities are left to the users.

New York City's 2012 *Wetlands Strategy* identifies necessary wetlands restoration projects; wetlands that should be transferred into public ownership; and research, mapping, and priority setting needs. The implementation of the study's priority-setting recommendations includes the results of research noted above, as well as some efforts below.

The Nature Conservancy developed a NYC Tidal Marsh Systems Analysis (Maher, 2016) to enable the City's Department of Parks and Recreation to set priorities based on conditions and vulnerability, for use in identifying options for restoration. This approach calculates index

scores for conditions (9 variables) and vulnerability (6 variables) to determine areas for use of appropriate techniques. The approach identifies appropriate locations for use of four restoration and protection strategies: acquisition of lands adjacent to marshes, removal of hard surfaces from future flooded areas to facilitate marsh migration, increasing the elevation of certain low marshes where there is the highest likelihood future marsh losses by 2085, and areas where marsh edges of currently eroded marshes can be rebuilt.

PlaNYC and OneNYC lay out the approach to coastal defense noting the City's 520 miles of coastline; and the 2016 update report identifies the status of specific coastal defense projects around the city including marsh restoration, shoreline restoration, and wetland and watershed restoration projects. This amounts to a priority scheme for the City as it implements the plan goals to increase coastal edge elevations, minimize upland wave zones, protect against storm surge, and improve coastal design and governance.

HRNERR in cooperation with the City of New York is also researching "coastal green infrastructure" features that can protect coastal areas of the City from flooding and erosion. New York City's Economic Development Corporation and the Office of Recovery and Resiliency are supporting the analysis of 43 miles of at-risk shoreline, and evaluating where to target conservation actions that may provide resiliency.

In the tidally-influenced Hudson River, the HRNERR and others are engaged in planning with various riverfront communities to develop waterfront resiliency plans. These include spatially-defined options for protection or restoration of wetlands and marsh migration corridors. The New York Department of State's (DOS's) *Coastal Risk Assessment* is available to waterfront communities, but they must do their own priority setting. In addition, communities can apply to DOS for funds through the Environmental Protection Fund Local Waterfront Revitalization Program to incorporate resilience to climate risks into local waterfront plans, and to reduce vulnerability to sea level rise and climate impacts.

The HRNERR is also collaborating with state agencies on a *Sustainable Shorelines Project*. Initially launched in 2008 and subsequently expanded, the project is determining the effects of climate change on shorelines, assessing the ecology of engineered shoreline treatments, and developing tools for decisions. As part of the project, HRNERR is developing a *priority shoreline inventory,* building on a prior 2005 inventory of hard shorelines in the tidal waters of the Hudson to identify candidate locations for sustainable living shoreline demonstration projects.

Nongovernmental efforts also have undertaken priority setting. Modeling the tidally influenced freshwater wetlands in the upper Hudson River, the nonprofit organization Scenic Hudson recently released research projecting a net increase in wetland area under climate change scenarios (Tabak, 2016). However, just three wetlands areas would account for over 50% of all these projected future wetlands by 2100. Scenic Hudson has used this information to develop maps of ownership parcels of undeveloped public and private open space that can support the

migration pathways. In effect, it can use this information for priority setting and for planning assistance; but it is holding the mapping results close at the current time.

New York's Draft 2014 *Open Space Conservation Plan* calls for climate-related resilience and risk reduction priorities, including support of tidal marsh migration, but does not itself establish a methodology for setting and implementing such priorities. New York's CELCP is incorporated into the Open Space Plan.

Another targeting tool is the Long Island Sound habitat restoration study, conducted with the support of the NEIWPCC. The study supports a comprehensive conservation management plan and identifies 12 habitat types of importance, followed by sites for conservation focus, ranking by habitat condition. The study identified and mapped 33 areas for focus of restoration efforts. This is used for funding by the HRNERR and cooperators including DEC, and feeds into the New York Open Space Plan. Unlike some other states in the MARCO region, New York does not prepare a comprehensive wetland program plan.

**New Jersey**

New Jersey uses a *Coastal Vulnerability Index* and *Coastal Vulnerability Assessment* which gives ranks of low, medium, high risk. The index identifies where development is constricting the natural dynamics of coastal migration, using GIS-based analysis to determine where marsh retreat potential has been constricted, and drawing conclusions about resiliency. State programs use these in decisions, but these are not expressly incorporated into a ranking or priority matrix or scoring mechanism.

New Jersey's *Wetland Program Plan 2014-2018* identifies objectives and action items, some of which relate to resiliency. These include developing more clearly definable coastal wetland protection standards, studying the effectiveness of living shorelines, and providing technical assistance for coastal resiliency projects. But the plan does not itself specify priorities.

In 2012 the Partnership for the Delaware Estuary prepared a report on *New Jersey Living Shoreline Possibilities*, which includes a preliminary GIS analysis of areas of interest (AOIs) for installation of living shorelines in the estuary. The candidate sites were assessed within three shoreline categories: potentially suitable for bio-based stabilization; potentially suitable for hybrid options; and potentially unsuitable for living shorelines. These areas were scored and sites mapped, and conceptual plans prepared.

Several groups of living shoreline projects have been identified, targeted, and are under construction or completed under the Delaware Estuary Living Shorelines Initiative. Including Matts Landing and Money Island, these are areas where living shorelines are targeted and installed rather than simply reactively permitted at the request of landowners. In order to assist in targeting within restoration areas, the Partnership for the Delaware Estuary prepared *Marsh*

*Futures* (2015) as part of the South Jersey Bayshore Sustainable Infrastructure Project. It uses scientific survey tools to assess local salt marsh vulnerability and chart best management practices and interventions. The pilot approach identifies specific salt marsh tracts deemed by local managers to be "marshes of interest" or "areas of interest" in Fortescue, Money Island, and the Maurice River, New Jersey. This assists in prioritizing and selecting among alternative actions at the tract level within an area already targeted as important for risk reduction and resilience. The field data were used to construct detailed visual presentations and tables "useful for providing discrete guidance for strategic local planning" about techniques to sustain marshes and determine where sediment addition would be beneficial.

New Jersey has also developed a *Getting to Resilience* tool to assist local decision-makers in identifying planning, mitigation, and adaptation opportunities to reduce vulnerability to coastal storms and sea level rise and build capacity for coastal community resilience. This is not itself a priority-setting tool. But it provides a roadmap for the elements needed to develop procedures, plans, information, or regulations needed to move to resilience.

**Delaware**

Delaware has focused primarily on sea level rise vulnerability. It has not yet developed a comprehensive ranking or priority approach for wetlands, but development of restoration prioritization layers is identified as an action item in the 2015 Delaware Wetland Management Plan. Delaware's *Sea Level Rise Vulnerability Assessment* (2012) assigns values to impacts. High concern resources identified by the assessment include tidal and freshwater tidal wetlands; beaches and dunes; other protected lands statewide; habitats of conservation concern. Delaware is currently working on a suitability analysis for areas of potential marsh migration. In developing possible prioritization approaches, Delaware's Wetlands Assessment evaluates wetlands of various types across the state in specific watersheds; these provide valuable data for future prioritization endeavors. Delaware is also working on developing a Water Resources Registry that can rank potential restoration and preservation opportunities for wetlands, riparian lands and uplands, and stormwater management.

Delaware's CELCP Plan assigns high conservation value points for ability of sites to adapt to sea level rise and provide connectivity to existing preserved land.

In 2012 the Partnership for the Delaware Estuary prepared a report on *Delaware Living Shoreline Possibilities*. As with the corresponding New Jersey report, this includes a preliminary GIS analysis of areas of interest (AOIs) for installation of living shorelines. The candidate sites were assessed within three shoreline categories: potentially suitable for bio-based stabilization; potentially suitable for hybrid options; and potentially unsuitable for living shorelines. These areas were scored and sites mapped, and conceptual plans prepared.

Many living shoreline projects are under construction or in operation under the auspices of the Delaware Estuary Living Shorelines Initiative, including Lewes-Rehoboth Canal, Indian River Marina, Mispillion Harbor Reserve, Blackbird Creek Reserve, and the Bethany Loop Canal.

**Maryland**

Maryland has devoted substantial attention to priority setting approaches aimed at climate risk reduction and resilience focused on wetlands and NNBFs. It has incorporated priorities into its statewide data management and mapping programs and into certain of its funding and operational programs.

Maryland first undertook an effort to identify and prioritize marsh migration needs and opportunities for future marshes under climate change conditions for the entire Maryland coastline, *Coastal Land Conservation in Maryland: Targeting Tools and Techniques for Sea Level Rise Adaptation and Response* (Papiez, 2012). The targeting strategy assigned scores to 9 objectives and aggregated the scores to determine the rank of opportunity areas:

1. Wetland classes projected in the year 2100
2. Uplands that will be converted to wetlands by 2100 (corridors)
3. Diversity of wetland types
4. Largest intact and continuous wetland areas of one acre or greater
5. Reduced ranking if wetlands are vulnerable to sea level rise of 0-2 feet
6. Breeding bird habitats – two specific wetland types/sizes
7. Existing nearshore priority habitat areas in Blue Infrastructure watersheds
8. High priority inland wetlands associated with high quality forest tracts
9. SLAMM-projected wetlands with hydric soils, not currently wetlands.

The High and Medium Priority areas determined using this scoring methodology were added to Maryland's Targeted Ecological Area (TEA) maps for each of the coastal counties and Baltimore City, as "Wetland Adaptation Areas." These are shown on *GreenPrint* and in Maryland's *Coastal Atlas*. These maps are used by Program Open Space and other Maryland programs to guide conservation acquisitions. The ranking and mapping of Wetland Adaptation Areas does not guarantee that these lands will be conserved before any other lands on the maps, but puts them on the universal system used to guide state and local conservation decisions.

Maryland's state *Land Preservation and Recreation Plan* confirms the effect of the priority. It focuses plans for land acquisition on "high priority" wetland adaptation areas that have been identified as future wetland locations to provide for landward migration, and it removes prior TEA lands in the 0-2 foot zone above sea level from the prior plans for acquisition. Maryland also has acquired "coastal resilience easements" in support of these priority actions.

*Coastal resilience easements*

Under state policy these may include development setbacks in areas subject to sea-level rise inundation by 2050, buffer lands to support "high priority" Wetland Adaptation Areas, limits on impervious surfaces to reduce effects of increased storm events, and requirements for additional review of shoreline stabilization projects. Maryland in 2013 acquired a "Coastal Resilience Easement" on 221 acres in Dorchester County under Program Open Space in cooperation with the Eastern Shore Lands Conservancy.

The Conservation Fund, working with MDNR, developed a prioritization strategy for Blackwater National Wildlife Refuge, much of which is projected to be inundated by sea level rise in the near term, *Blackwater 2100: A Strategy for Salt Marsh Persistence in an Era of Climate Change*. The strategy uses SLAMM and available datasets to develop selection criteria for land conservation and management. These criteria are: greatest predicted longevity under sea-level rise scenarios; most intact current conditions (as evidenced by lack of interior ponding); highest abundance of seven focal salt marsh bird species; and extensive area of contiguous interior.

*Maryland's State Wildlife Action Plan (2015)* includes a new chapter on Climate Change and assigns climate change vulnerability scores for species and habitat assessments for coastal, selected terrestrial, and coldwater riverine habitats. Chapter 6 identifies impacts of climate change at regional and state scales, assigns risk and vulnerability scores to Maryland species of greatest conservation need (SCGN) and their associated habitats, and then examines impacts from climate change for all taxa groups. Vulnerability of species and habitats is composed of three components: Exposure; sensitivity; and adaptive capacity. The Plan notes that "There is no standard method or framework to assess vulnerability to climate change…The three most commonly used methods are correlative or empirical models, mechanistic or process-based models, and trait-based assessments." The Plan uses NatureServe's Climate Change Vulnerability Index (a trait-based assessment tool) for most species. Coastal habitat vulnerability is based on a 2008 Maryland SLAMM study applied to 12 sites in different areas. The Plan observes that freshwater aquatic and coastal habitats are "highly vulnerable" to sea level rise. There are different results in different parts of the coastal zone.

Chapter 7 of the Plan lays out conservation actions and uses a matrix assigning values for: Urgency (High – within 2 years, Medium 2-5 years, Low 5-10 years); cost; chance of success (High – 90-100%, Somewhat likely or uncertain 30-90%, Highly Uncertain, <30%); benefit: collateral species benefit: feasibility; and public support (High/Medium/Low) for each action.

***NNBF Data Sets/Tools Identified in Maryland's State Wildlife Action Plan (2015)***

- Targeted Ecological Areas (GreenPrint)
- Maryland Watershed Resources Registry (containing TEAs and other data layers, as well as 8 "opportunity assessment" analyses
- BioNet (2012 biological GIS assessment – resulting in 5-tier system)
- Green Infrastructure (Maryland Department of Planning)
- Blue Infrastructure (MDNR Near shore assessment for coastal and tidal and aquatic), contained in Maryland's Coastal Atlas
- Stronghold Watersheds (MDNR Biological Stream Survey, for rare, threatened, endangered freshwater species, augmented by species richness data)

The section on "conservation actions to address climate change" emphasizes "multiple temporal and spatial scales to sustain fish and wildlife populations and their habitats." The decisional approach is derived from the National Fish, Wildlife and Plants Climate Adaptation Strategy (2012), and from Staudinger (2015): Prioritization and triage; flexible and adaptive management; "no regrets" actions; precautionary actions where vulnerability is high; addressing variability and uncertainty; integrating greenhouse gas mitigation into actions where complementary; and improved and coordinated monitoring systems.

More recently Maryland undertook a project to identify priority sites for climate risk reduction. Maryland's new *Statewide Coastal Resiliency Assessment* (2016) was prepared by The Nature Conservancy with the MDNR Chesapeake and Coastal Service, and supplements the habitat and resilience priority-setting efforts described above. It focuses on risk reduction provided by coastal forests, marshes, dunes, underwater grasses, and oyster reefs. It was conducted to enable Maryland to establish priorities for "natural infrastructure solutions within tidal regions of the coastal zone." The Assessment is "exclusively concerned with the ability of habitats to reduce risk for people," and does not address factors such as "biodiversity, ecosystem health, rare species, recreation value, and water quality services" that are addressed in other decision-making tools used to prioritize natural habitats. The Assessment is described as a screening-level tool that can be used in connection with other tools, such as Maryland's climate change scorecard used for acquisitions, and targeting with other programs.

The assessment results are available as five map layers on Maryland's Coastal Atlas: 1) the Shoreline Hazard Index indicates the relative exposure to hazards along the Maryland shoreline, and is calculated from six physical variables (geomorphology, elevation, sea level rise, wave power, storm surge height, and erosion rate); 2) Hazard Reduction by Habitats illustrates the relative degree to which existing coastal forests, marshes, dunes, underwater grasses and oyster reefs buffer the shoreline from coastal flooding and erosion; 3) Community Flood Risk Areas shows the location of near-shoreline residential communities and ranks their flood risk based on population density, the demographic factors of age, income, and language

proficiency, and the predicted frequency of flooding; 4)Priority Shoreline Areas are locations where protection and restoration of natural habitats "has the greatest potential to reduce the coastal hazard risk faced by residential communities" based on the integration of Shoreline Hazard Index, Hazard Reduction by Habitats, and Coastal Community Flood Risk Areas; and 5) the Marsh Protection Potential Index, which ranks the relative protective value of different coastal marshes including marshes inland of the shoreline, based on five characteristics: protective capacity (marsh area), proximity to hazards, proximity to human communities, persistence of the marsh until 2100, and proximity to other protective habitats.

Maryland's Program Open Space currently uses a scorecard to screen potential acquisitions that are already under consideration based on Maryland's other priority-setting programs, "Maryland's Criteria for Coastal Land Conservation in Response to Climate Change Impacts of Sea Level Rise." The scorecard indicates the risk of inundation over the 2050 and 2100 time periods, identifies land cover, restoration potential including reforestation opportunities, and the likelihood that the acquisition will provide storm surge protection, as well as whether there are impediments to habitat migration. This is not itself a priority-setting tool, but a parcel level screen to ensure that climate risk reduction and resilience factors are included in every acquisition.

MDNR is now working on a resilience master plan – statewide planning scale – trying to determine how much buffering wetlands, coastal forests, submerged aquatic vegetation, etc. can provide, and over what period of time. And as the Coastal Resiliency Assessment shows, risk reduction focusing on the potential of existing marshes is an aspect of policy, along with the future resiliency goals represented by such efforts as the Wetland Adaptation Area additions to the state's *GreenPrint*.

**Virginia**

Virginia has generated a great deal of valuable data that can support priority setting and targeting and made it available (see data visualization section).

In 2010, VIMS prepared *Estuarine Blue Infrastructure: Priority Conservation Areas for the Seaside of Virginia's Eastern Shore*. This analysis identified priority aquatic conservation areas based on habitat and ecosystem service values, and also identified proximity to upland priority conservation areas. However, climate factors were applied only to the Chesapeake Bay aquatic priority conservation areas deemed vulnerable to sea level rise, and used as indicators that these areas were unlikely to be sustained.

*Virginia's Conservation Lands and Climate Assessment* (2015) used datasets from the state's conservation lands database together with climate datasets and determined potential threats to parcels of conserved lands. Information from the Virginia Conservation Lands Database was combined with climate data from the WorldClim climate data portal, and modeled climate

scenarios at multiple spatial and time scales (Klopfer, 2015). This information was then integrated into Virginia's 2015 draft *Wildlife Action Plan* for each of the geographic subregions/counties used to set priorities, in order to determine "climate-smart" actions that would support the Commonwealth's habitat and species conservation objectives.

Using the Virginia CZM Program's Virginia Ecological Value Assessment (available at *Coastal GEMS*), a "Land Protection Tool for the Southern Tip Ecological Partnership" has been developed by The Nature Conservancy and the U.S. Fish & Wildlife Service to evaluate "individual parcels based on their potential for marsh retreat due to sea-level rise, habitat value for migratory land birds and raptors, and overall ecological integrity" in the counties of Accomack and Northampton on Virginia's Eastern Shore. This tool identifies key parcels affected by a 2 foot sea level rise by 2040. The Southern Tip Partnership (comprising U.S. Fish & Wildlife Service, TNC, the Virginia Department of Conservation and Recreation, the Department of Game and Inland Fisheries, and the CZM Program) has used this tool to prioritize land acquisition projects.

The *Virginia Wetlands Catalog* (Weber, 2014) determines the condition and status of wetlands throughout the Commonwealth and ranks them in terms of their priority for restoration or conservation. This update of the original 2006 catalog uses an expanded wetlands base map and stream data, with floodplain and hydric soils data. However the catalog and priority setting scheme does not include climate change risk and resilience factors, and so the conservation and restoration rankings do not now support MARCO climate objectives. Prioritizations for conservation include plant and animal biodiversity, significant natural communities, ecosystem services, natural corridors and stream buffers, proximity to conserved lands, relatively clean watersheds, and drinking water sources. Some of the same variables were used for restoration priorities, together with degraded watersheds, impaired waters, wetland mitigation banks, prior converted agricultural wetlands, and stream reaches with low biodiversity that could be restored. The Department of Conservation and Recreation is just beginning an effort to include sea level rise.

The programmatic 2015-2020 *Virginia State Wetlands Program Plan* identifies "loss of tidal wetlands due to sea level rise and adverse ecosystem effects on all wetlands due to climate change" as a priority "issue" to meet net resource gain and ecosystem services goals. It includes as an objective the development by VIMS of a protocol to use the mapped Tidal Marsh Inventory to assess effects of development and sea level rise. VIMS has begun work to assess climate-induced changes to wetlands on the York River, with an emphasis on headwater wetlands and connectivity to downstream wetland systems. The Plan also projects development by VMRC of guidance to "simplify and codify" the Commonwealth's preferences for shoreline management.

## Priority Setting Characteristics

Reproducibility matters if a priority scheme is intended to cover a substantial geographic area, such as an entire coastline or state, and to guide activities over a multi-year period. Simple inclusion of "risk reduction" or "climate resilience" in an unweighted list of factors does little to ensure that the right parcels or activities are pursued in a meaningful sequence.

Vulnerability-driven priority schemes are very useful, but they can be enhanced and improved if they are followed by geospatial targeting of areas linked to desired future outcomes. Assessment of vulnerabilities alone may not produce an ordered set of responses.

On a statewide basis or larger regional scale, it is very helpful to understand how scores and ranks are assigned. Transparency in methodology is very helpful, partly in order to make clear what policies are being pursued, and partly because it make it possible to improve methodologies and targeting as experience is gained. Moreover, without means to document how priorities were assigned, shifts in priorities may occur over time without acknowledgement or external accountability.

In general, timing issues for priority actions are less well understood. Certainly a triage approach can be one aspect of timing (e.g. Maryland's elimination of lands within 2 feet of sea level from acquisition eligibility). But additional work is helpful in order to get from current conditions to an intended or desired resilient wetland NNBF complex by 2050 or 2100. Without transparency on timing in priority setting, it will be difficult to determine what choices to make when funds or staffing are limited. This aspect of the problem is different from the steady-state priority setting of decades past, when open space plans or wildlife habitat plans focused on geographically stable targets. But it is key to current priority setting for NNBFs.

Finally, local prioritization is also important. Wherever possible, it should be coordinated with larger state or regional goals. At times, the funding source or legal authority to take action lies with a local government (e.g., New York City, or a Virginia county's wetlands board). Politically, it is also helpful to be clear where local opportunities lie even if larger-scale regional or statewide priorities lead in other directions. Thus, Maryland's decision to map high and medium wetland adaptation areas for each county as potential acquisition targets provides an opportunity for actors to build on local needs or interests, or for interested organizations to enlist funding from programs that are spread across multiple jurisdictions.

Site-level tools are also important. Bridges, et al. (2015) provides a tiered framework for analysis to determine what applications of NNBF may be appropriate in given sites. The Systems Approach for Geomorphic Engineering (SAGE) also provides a community of practice to draw upon for techniques and living shoreline alternatives suitable for various purposes. And work by the Stevens Institute of Engineering and the Partnership for the Delaware Estuary, among others, can help make finer-scale determinations within smaller areas.

## Data Visualization

Data visualization is a key element. It facilitates priority setting and helps to sustain priority schemes over time, important given the needed sequence of actions to address climate change impacts. Data visualization assists decision makers, funders, and implementers, and it enhances the possibilities for coordination across state and local government boundaries and region-wide.

Collecting data and conducting modeling simulations provide the foundation for visualization. Data visualization provides a link between things that scientists want to determine and what the public can understand. More public awareness of risks and vulnerabilities is a predicate for action. Mapping outputs are needed for elected officials and advocates who need to convince others to take action. They are critical for messaging to the public and outreach to property owners.

However, a trusted source is needed to produce or sponsor this information. Particularly where tasked to do so by legislation, a trusted institutional source enhances the understanding that an ongoing process is generating solid information, and that visuals are not generated to serve a one-time agenda. Sometimes a state agency or public university source has more credibility locally. Sometimes a nongovernmental organization such as Scenic Hudson or TNC, when working closely with local elected officials, can provide mapping and visual information that is seen as reliable and accessible.

Data visualization is essential to support any visioning exercise at the local scale. The expert panel pointed out that communities and community leaders can help determine what information and level of detail they want. Interviews with regulators, engineers, officials can make it possible to provide accessible action-oriented information visually.

### Current Use of Data Visualization

Many sources of visual data are available, often with viewers and mappers. Among these are NOAA's Digital Coast, including a Sea Level Rise Viewer and Coastal Flooding Impacts Viewer. SLAMM and SLAMM-View 2.0 are also available on Digital Coast. The U. S. Fish and Wildlife Service is supporting SLAMM-View's availability at slammview.org. The site notes that: "SLAMM-View is a web browser-based application that provides tools for improved understanding of results from research projects that employ the Sea Level Affecting Marshes Model (SLAMM). Version 3.0 of SLAMM-View was designed for (1) a user-friendly, workflow-based approach to assess impacts of sea-level rise (SLR) on coastal areas with both visualization and analysis functionality, and (2) to be mobile-friendly for use on your phone or tablet. SLAMM-View provides simultaneous comparison between both current and future conditions

out to the year 2100, and among different SLR scenarios (e.g., 0.4 meter vs. 1 meter), using interactive maps and tabular reporting capabilities. To date, SLAMM-View provides access to SLAMM simulation results for the entire coastlines of 9 states, and partial coverage of an additional 12 states and 2 U.S territories." In the MARCO region this includes work on New York and Long Island Sound, and the Chesapeake region; missing parts of the New Jersey coast.

InVEST models in the region use mapped information as inputs and produce maps as outputs for use by decision makers.

The Nature Conservancy's *Coastal Resiliency Toolkit* provides visualization tools usable throughout much of the region to relate diverse databases and modeling to map projected future conditions and vulnerabilities. TNC, working with the state of New York, developed the initial coastal resilience tools in 2007. The goal was to enable decision makers to incorporate sea-level rise into decisions; refinements included storm event data and SLAMM results. Current visualizations are available for New York, New Jersey, and Virginia's Eastern Shore.

The tools discussed below are primarily those state-specific data visualization sources and outputs that are widely used in decision making. *This "data visualization overview" box briefly summarizes specific tools discussed and hyperlinked throughout this chapter.*

| ***Data Visualization Overview*** | |
|---|---|
| **State** | **Overview of Visualizations in Use** |
| New York | • TNC Coastal Resilience Map<br>• Coastal Risk Areas |
| New Jersey | • TNC Coastal Resilience Map<br>• Coastal Vulnerability Index |
| Delaware | • Sea Level Rise Inundation Map<br>• Community Flood Visualization Index |
| Maryland | • iMAP, Maryland Coastal Atlas, Maryland GreenPrint, Blue Infrastructure, Critical Area Map, MERLIN Online<br>• Erosion Vulnerability Tool<br>• High Energy Shorelines |
| Virginia | • Coastal Resilience Map (eastern shore)<br>• Coastal GEMS<br>• Comprehensive Coastal Resources Management Portal<br>• Shoreline Assessment Mapper<br>• Blue Infrastructure |

**New York**

The Nature Conservancy's *Coastal Resilience Map-New York* is now updated regularly and includes data layers and sliders to show effects under various future climate impact scenarios. Information layers include sea level rise, risk, habitat loss, communities at risk and current habitats. The map is useful for decision makers because it allows them to identify neighborhoods and populations that are most at risk. For instance, the tool has sliders that show the risk score for senior citizens as well as for families in poverty. The future habitat loss and degradation folder lets users view how habitats, including tidal marshes and forested wetlands, would be affected by various sea level rise projections. In addition, the tool lets users see where habitat management and restoration tactics would be most effective at reducing risk. It includes marsh migration projections for 2020, 2050, and 2080.

Other visualization tools and maps are produced by state and local governments and research programs. For example, New York has mapping visualizations for Long Island Sound and New York City areas.

The New York DOS has developed Coastal Risk Areas for New York City, and Nassau, Suffolk and Westchester Counties to be used in determining a risk assessment score for critical community assets, and which are factored into the resilience planning process. They use FEMA regulatory flood maps and various flood and inundation models to identify coastal areas subject to Extreme, High, and Moderate risk. In addition to 100 and 500-year floodplains, the Risk Areas were derived using NOAA's Sea, Land and Overland Surges from Hurricanes (SLOSH) model for Category 3 hurricanes, NOAA NWS's Shallow Coastal Flooding and Inundation model, susceptible natural shoreline protection features and sea level rise projections. The Risk Areas may be viewed and downloaded from DOS's Office of Planning and Development's Geographic Information Gateway. The Gateway also has map layers simulating various levels of sea level rise.

**New Jersey**

New Jersey's *Coastal Resilience Map* is also updated through the coastal resilience toolkit. It allows coastal communities to visualize risks to the built and natural environments, and to identify opportunities for investments. As with New York, the map uses a geographic information system overlaid with information layers and sliders to show how rising sea levels could affect New Jersey. There are information layers that let the user observe: sea level rise, potential risk, current restoration efforts, and demographic and infrastructure distribution. The map uses models developed by the IPCC and NASA Goddard that predict how human activity will affect sea level in the future to show how best and worst case scenarios would affect New Jersey. The tool also lets users look at key infrastructure that is threatened by storm surge

today and in the future. One of the layers isolates tidal marshes and allows users to view which tidal marshes would be affected or destroyed, and likely tidal marsh retreat zones, given different sea level rise scenarios over a 50-year period developed by Rutgers. In addition, the map lets users see where restoration projects are under way, and the model incorporates those programs into its projections.

Indices can be used to produce maps. New Jersey's *Coastal Vulnerability Index* identifies where development is constricting the natural dynamics of coastal mitigation, using GIS-based analysis to determine where tidal marsh retreat potential has been constricted and drawing conclusions about resiliency.

**Delaware**

Delaware's *Sea Level Rise Inundation Map* provides a scenario-based "bathtub" model map for use by the public in understanding vulnerabilities to sea level rise in the state. While a simple satellite photo with sliders for inundation levels, it communicates information that supports public discussion, outreach, and planning.

Delaware's *Community Flood Visualization Index* has assisted in communication on flooding.

Delaware's *Open Space Plan* has provided a useful visualization tool for other conservation purposes, but state resource area (SRA) maps have not been available for local governments in recent years, initially because of litigation. Subsequent 2016 legislation eliminated SRAs altogether and authorized published open space mapping of protected lands only for government-owned lands and lands held by private land preservation organizations.

Delaware's Watershed Resources Registry is currently under development; following the Maryland model, this may be a GIS-based analysis and mapping tool to rate the best areas for resource protection and restoration.

**Maryland**

Maryland has a large portfolio of mapped data online, available through the state's *IMAP*, the state's data portal for geospatial information. It includes numerous datasets, maps, and mappers available to users inside and outside government. Environmental datasets relevant to this study include especially the *Maryland Coastal Atlas*, *Maryland GreenPrint*, *Maryland Critical Area Map*, *MERLIN Online* **(**Maryland's Environmental Resources and Land Information Network), the *Maryland Bay Trust Fund Mapper/Restoration Print* (nonpoint source projects), structural shoreline stabilization maps, and many others. *GreenPrint* includes numerous data layers, including separate layers that can be added to any interactive conservation map to address "Climate Impacts." These climate impacts layers include: Sea-Level Rise Affecting Marshes Model (SLAMM)(with results projected for 2050 and 2100 for different wetland types), Sea Level Rise Vulnerability (LiDAR results at 0-2 ft., 2-5 ft., and 5-10 ft. of sea level rise),

Wetland Adaptation Areas (High, Medium, and Low priorities added to the TEAs for conservation of wetland migration corridors and future wetland parcels), Storm Surge Risk Areas, and Drought and Fire Vulnerability layers. Maryland's Coastal Atlas also includes this information. Maryland also has a Water Resources Registry, which allows it to integrate issues related to habitat, water quality, sea level rise, critical areas, and other uses, in an online, interactive mapping tool, which enables users to get to site selection and impact and mitigation factors. MDNR maintained a *Climate Change Impact Area* tool.

The *Maryland Coastal Atlas* includes climate resilience and risk reduction data layers described earlier. Maryland relies heavily on making these spatially explicit data broadly available and easy to use. If everyone is working from the same maps, it becomes possible to design approaches or justify conservation and restoration strategies. Interviewees say that sea level rise maps are the most persuasive to local communities/landowners.

The *Erosion Vulnerability Assessment Tool* (EVA) has been developed by the Virginia Institute of Marine Science (VIMS) with funding from the Baltimore District Army Corps of Engineers in partnership with the MDNR. VIMS says EVA is intended to "identify areas alongshore that have demonstrated historic patterns of instability, and currently support valued natural, social, or economic resources." EVA projects future shoreline position in 50 years, it identifies where resources will be vulnerable, and identifies where the opportunity for shoreline stabilization or restoration may have the greatest benefits. VIMS notes that "EVA was designed as an online interactive map interface to illustrate the output of a highly integrated spatial data model that uses multiple data sets generated by various developers across the Chesapeake Bay region. The map outputs, which can be generated on the fly, will inform local planners where community infrastructure, cultural resources, and habitat are potentially at risk in the future."

MDE also has created a web tool that creates county maps depicting mapped segments of certain high energy shorelines designated by MDE as appropriate for structural shoreline stabilization measures. These maps are maintained and updated by MDE.

**Virginia**

TNC created a *Coastal Resilience Map* for Virginia's Eastern Shore (Atlantic Coast and the Eastern Shore of the Chesapeake Bay). As with the other TNC resilience maps described above, the tool uses a geographic information system overlaid with information layers and sliders to give users a detailed look at how habitats and human population groups will be affected given different climate impact scenarios. The future habitat layer allows users to view how different sea level rise projections would affect natural environments, including salt marshes and other wetlands.

Virginia's *Coastal GEMS* provides a very user-friendly portal for geospatial information and mapping on a wide variety of issues related to coastal habitats in the Commonwealth. Coastal GEMs provides extensive information on coastal resources in Virginia in the form of detailed descriptions and interactive spatial data. Coastal GEMs utilizes the following data layers: coastal water, coastal wildlife, coastal land, conservation planning, shellfish management, coastal access, Atlantic Coast recreational use, and reference layers. Within these data layers are sub-layers that enable users to view data about the condition of various coastal resources, habitat types, and existing environmental protections. Within the Conservation Planning layer, there are data sets that show potential wetland restoration sites, ecological core areas, and results from the Virginia Ecological Value Assessment. Coastal GEMs offers users limited ability to view the impacts of climate change, represented by sea-level rise. Virginia's Coastal Zone Management Program in spring 2016 noted the desirability of creating a "coastal resiliency atlas" that could "serve as a repository for information on current resiliency-related features as well as opportunities for additional features" that could be added to GEMS.

Virginia has compiled data using the Wetlands Condition Assessment Tool (WetCAT) for all wetlands in the Commonwealth, and beginning with coastal plan wetlands is conducting level II and III assessments, with the data compiled into a "wetland data viewer" to support decision making. Virginia's separate wetland mitigation targeting tool is a mapper, but is based on 2002 data as updated in 2007.

VIMS's Center for Coastal Resources Management's data portal for local governments includes, among other things wetland maps for coastal jurisdictions, with digital shoreline inventory reports with a map viewer for use by local wetland boards and planners. VIMS is producing a Comprehensive Coastal Resources Management Portal tailored to each coastal locality, and has completed 22 of these. Included in the portal is a map viewer for the Shoreline Management Model; the model output identifies the preferred shoreline management technique, reflective of Virginia's state policy to prefer living shorelines to address erosion issues. Additionally, VIMS has a Shoreline Assessment Mapper and Blue Infrastructure (BI) online mapping tool.

VIMS provides a great deal of additional information in visual formats. For each Chesapeake Bay segment, individual maps were created depicting potential shifts in key coastal habitats with climate change. VIMS has also identified databases relevant to climate change and sea level rise and cataloged them.

VIMS has identified vulnerable tidal shallow water habitats in Virginia's waters. To enhance possible model applications, in addition to maps illustrating potential "Marsh Preservation Opportunities," VIMS created a webpage with an interactive web-based map interface that "allows the user to view current habitat distribution, modeled climate change output, as well as all base layers used in the analyses" (Bilkovic, 2009).

## Data Visualization Characteristics

Data visualization tools can be highly informative. In the MARCO region, the availability of many mappers and tools (Maryland GreenPrint, NOAA's Digital Coast, TNC's Coastal Resilience sites, VIMS data portals, Coastal GEMS), allows the general public, consultants, nongovernmental organizations, local government planners, academics, journalists, and others, to choose the data layers they are interested in, and to customize outputs to serve specific needs. This is a very powerful use of information that can engage the larger community.

A convergence of data sets, models, and displays will help lead to more consistent understandings across the region. Part of this convergence is happening naturally because of the reliance on the same datasets in many cases, and the same or similar modeling tools.

In some ways the availability of increasing power and availability of more datasets can, paradoxically, make policy choices less transparent as the number of factors and alternative scenarios multiplies. While building robust, publicly facing data visualization tools with multiple layers (as with GreenPrint or the VIMS viewers) is extremely valuable, MARCO state programs can also make available simplified data visualization tools and maps that address some of the choices and tradeoffs that are being made (or proposed) in their preferred solutions.

Many people have trouble thinking spatially or over long periods of time, and handling multiple variables only makes the challenge greater. Data visualizations make it possible to overcome these concerns, while assuring accountability by "showing the work" that underlies a policy outcome or prioritization approach.

Some visuals will be helpful for managers and scientists handling multiple scenarios and data layers, and testing alternatives. Others will be publicly facing mappers that can range in complexity from a simple sea level rise slider like Delaware's, to a multi-layer mapper with alternative conditions, such as Maryland's GreenPrint. Managers have found it highly useful in dealing with local officials, the public, and legislatures to have some relative simple versions of visualizations to show trade-offs and consequences. These will need to be supported in order to ensure they address the actual as well as perceived needs of the audiences.

# Targeting Conservation and Restoration Actions in the MARCO Region

## Current Limitations

Technical capacity in the MARCO region is very strong. There is great awareness and use of climate change datasets, models, and techniques for constructing living shorelines, for example. Nevertheless, the connections between general climate goals and wetlands priority-setting schemes are for the most part incomplete.

> The Chesapeake Bay Program's *Climate Resiliency Outcomes Management Strategy, 2015-2025* (2016) identifies several gaps that affect decision making on climate resiliency. These include challenges in coordinating modeling in order to differentiate climate change impacts from other impacts. The strategy also identifies the need for standardized assessment to identify key vulnerabilities and tradeoffs, and the need for adequately downscaled climate impact data to support watershed or shoreline decisions. The strategy identifies a gap in institutional capacity among agencies to coordinate across boundaries on data, tool development, and communication; and the need for improving indicator development and creation of a "broad assessment framework" which links "scientific and social-scientific activities" for adaptation.

Climate vulnerability assessments have been conducted in many instances in the MARCO region – on a statewide or sub-state regional basis. However, translating these assessments into prioritized opportunities for conservation and restoration has been more sporadic.

In part this may be because of the lack of an institutionalized framework for ongoing, continuous, integrated priority-setting – which focuses on ***desired outcomes in addition to vulnerabilities.***

In most circumstances, identification of locations for wetland NNBF actions has relied on a) a locally targeted resilience plan (as in New York City, or certain living shoreline projects in New Jersey), b) availability of specific funding (such as targeted storm recovery) or c) update of a resource conservation plan (for wildlife, or wetlands, or open space) onto which resilience and risk reduction priorities can be engrafted.

In contrast, a systematic approach is suggested by Maryland's sequence of priority setting actions that implement the policy directive on climate change adaptation that governs all MDNR activities. The sequence includes:

1) the inventory of publicly owned lands,
2) the intentional and required updating of other MDNR resource plans to include climate adaptation,
3) priority setting for wetland adaptation areas, and
4) priority setting for risk reduction areas.

Gaps in wetland prioritization opportunities and follow-through are likely to occur whenever there is less specificity in policy statements. Translating general or vague goals into reproducible priorities is challenging, and particularly so when many resource programs are potentially involved. Also, where each restoration project in a state does its own modeling to support one-off plans, it is more difficult to derive a coast-wide or regional approach.

However, ongoing efforts across the region are converging gradually on similar methodologies – using the same data sets, SLAMM outputs, and time horizons. With more fully articulated policy objectives, it is possible to create a regionally compatible approach. This will help not only to support continuous advances in technical proficiency, but it will also make it possible for federal, state, and nongovernmental actors across the entire MARCO region to communicate consistently across the region with the general public, with state legislators, and with Congress.

## Best Practices

This review is aimed at determining how MARCO can improve the ability of federal and state practitioners to target wetland NNBF efforts. Recognizing that the current system functions through incremental and discontinuous improvements, two areas of focus are important:

(1) State policy frameworks should be designed to better communicate goals and drive priorities; and

(2) Harmonization of goals and methodologies will improve results across the region and among agencies within states.

Better and more responsive decision systems rely on well-articulated policies with increasing levels of specificity and prescription, priority-setting that leads to reproducible results aimed at mitigating identified threats, and consistent use of visualization tools. As for harmonization, the Corps of Engineers has observed that "regional coordination is needed to identify the vulnerabilities, flood risk issues, and challenges within [the] region at a system scale" and to improve information exchange and transfer of best practices in order to encourage better targeting and innovative solutions (Bridges, 2015).

## Process Improvements

***Policies to use wetlands as NNBFs should be clearly stated by each MARCO state to support risk reduction and resilience across all programs.***

Both climate resilience and wetlands programs should focus on setting specific, actionable (prescriptive) policies leading to management strategies. Policies with clearly stated goals and targets are necessary to organize and sustain priority-setting, communication, funding, and alignment of actions of governmental and nongovernmental actors. This is particularly critical over the extended period of time that will be needed to address and manage climate adaptation activities, which will affect generations of policy makers, opinion leaders, and implementers.

Policy commitments should be specific and should provide support for *wetland priority goals* and identification of a *time sequence* for implementation. Elements of this goal setting include:

- Spatial identification of the existing wetland complexes that serve climate risk reduction and resilience purposes, and a commitment to conserve and restore these areas.
- Spatial identification of future wetland areas and wetland migration paths, and a commitment to conserve these areas and conduct activities needed to facilitate migration.
- Spatial identification of optimum locations for living shorelines, and a commitment to support their construction and maintenance actively where warranted, as well as in response to permit applications.

Related policies that address location of infrastructure and coastal development would then support these goals.

***All prioritization schemes for wetland conservation, restoration, and management for risk reduction and resilience should articulate what goals they seek to achieve and what threats they seek to offset or mitigate.***

Replicability is highly important to the design of effective priority-setting schemes, and to launching and maintaining the conservation and restoration actions that rely on those schemes. Identifying the threats being addressed enhances the replicability feature of priority setting. It makes priority-setting more credible in addressing conflicting choices. It also helps identify where attention may still be needed, and why. For example if most restoration actions have been focused on immediate risk reduction, clarity about these goals will make clear that future (and perhaps different) actions will be needed to support long term resilience – such as the preservation of marsh migration corridors.

Communication and consistency are grounded on specificity. The ability to harmonize use of data and models across the region is most relevant where the outputs are aimed at communicating the "why" as well as the "where" and "when."

Defining the criteria being used is also highly relevant to the use of data visualization products in explaining what is being accomplished. Current data visualizations are very strong in scenario-based vulnerability assessment. Further development can occur in modeling and visualizing the impact of NNBF project activity – which will be essential to maintaining public, legislative, and local government support.

***MARCO states should mandate wetland NNBF priority setting in all updates of related resource planning programs.***

Numerous separate resource planning efforts are driven by state and federal programs that affect open space, wildlife, coastal zones, wetlands, forests, agricultural preservation, and other resources. Each MARCO state should adopt requirements that with each plan update, wetland climate risk reduction and resilience must be built into the plan – using the policies, spatial goals, and time horizons that are then available.

Each required periodic plan update offers an opportunity to advance risk reduction and resilience using the funds and planning resources then available to the program that is updating the plan. A firm policy requirement attached to each update means that planning can be more efficient and consistent, and that it will benefit from continuous learning from prior planning efforts in other resource programs. As these plans are implemented by the program areas, they provide actions that support this commitment to a long sequence of actions that will be necessary if climate adaptation is to succeed at all.

Adopting such a requirement will avoid inconsistencies within states where, for example, wetlands conservation programs pursue habitat conservation without using sea level rise and climate change impacts data available in other programs. It will prevent investments that are inconsistent with climate adaptation goals – such as preservation of inundated lands with scarce dollars. It will also identify mutually sustaining opportunities, such as actions where, for example, a no net loss goal linked to climate mitigation (carbon sequestration) can also advance climate adaptation if properly targeted. Continuous improvement and integration of current science becomes possible when each related plan update is governed by the same update requirement, and often, using the same government-designated data set.

Such requirements, when authorized by state legislation, can also be mandated for updates of local land use comprehensive plans and coastal development plans.

***Build a data visualization component into each priority-setting action.***

In general, managers should make it a rule never roll out a policy or priority-setting scheme without a well-thought-out data visualization tool that supports the approach and makes the tradeoffs and choices apparent. These should be constructed along with policy communications so that they can explain in clear terms what the consequences of future climate change impacts may be, and what priority-setting efforts are intended to accomplish.

Priorities can be set in many ways, including descriptions of many wetland types, or identification of priority infrastructure or human populations that will need protection. But in order to be effective in communicating the relevant policy and the priority choice, visual tools are needed.

### Harmonization

***Develop a vision for the entire region with respect to what future wetland NNBF conditions are desired.***

Where it is possible to coordinate policies across the MARCO region (including states' publicly taking note of and cross-referencing one another's policies), policy makers should do so in order to improve communication, the likelihood of funding, and political acceptance. While a single region-wide policy is not essential if policies can be harmonized, use of agreed information to measure risk reduction and defined desired future conditions should support the converging policy goals that MARCO participants will have articulated.

Converging data practices could allow development of even more detailed or customized information, which could generate a mapped future vision for the entire region with future wetland NNBF scenarios keyed to time frames. Along with data convergence, policies and plans should be improved, working toward a regional vision with attention to the following spatial scales:

- Regional – A larger scale approach is needed for salt marshes, tidal marshes, and coast lines. The vulnerabilities to sea level rise and storm surges and other impacts occur at a large scale and each NNBF solution implicates other portions of the shorelines. Some of this is happening in the Delaware Estuary, the Hudson River Estuary, the Chesapeake Bay, and the NALCC region's coastal wetlands. But attention to the larger region can improve overall coordination and performance, including performance at statewide levels.
- Local – It is possible to scale up from local projects as well as scale down from statewide or regional plans. Local planning is often helpful because of legal and political opportunities and constraints; yet these investments and plans can influence a regional vision significantly.

- Parcel – Techniques for integrating parcel-by-parcel actions are needed to serve local as well as state-wide objectives. Parcel-by-parcel actions can be assisted where appropriate state policy is in place. Improvement of local targeting techniques can facilitate improved performance across the region.

***MARCO states and their collaborators should adopt time-scales for goal setting and measuring that are consistent across the region.***

Creating policies, plans, and spatial identification schemes with consistent time horizons will more easily facilitate a future multiple state or region-wide vision. It will allow the development of a schematic of what wetland NNBFs we are targeting, and who (what users) we are targeting to engage for action across the MARCO region.

Current projects and programs we reviewed in the region have used (variously) 2020, 2035, 2050, 2080, 2100, "in twenty years", in "a hundred years" and other time horizons for vulnerability assessments, decision-support tools, and other activities. Agreement on a few standard projections that are used across the region for projecting future desired conditions will help with consistent goal setting and will improve funding and political support, especially for larger-scale activities. Even if particular programs want to add additional or custom horizons to serve particular objectives, standard projections should be used as a matter of course. We recommend that MARCO and other participating entities determine the suitable time horizons for these purposes. Use of consistent time horizons and analytic methods can then be used to support region-wide understanding and the pursuit of policy goals that can sustain funding.

In standardizing time horizons, it is important to address the following distinct (but potentially interlocking) objectives:

- Near term risk reduction – preventing loss of life and loss of human communities and destruction of existing infrastructure which still has a useful life, while providing time for longer term climate responses may include moving of communities and infrastructure.
- Middle term climate adaptation – serving risk reduction and climate resilience goals.
- Long term resilience – self-sustaining and robust wetland complexes in future conditions that maintain habitat diversity and provide ecosystem services.

***Support the continuing harmonization of data and information analysis methods.***

Because of the use of common data sets and analytic models by organizations in the MARCO region, there is increasing consistency of understanding vulnerabilities and in the use of information for modeling and risk assessment. Data portals and data visualization tools are proliferating. This inventory helps to document the level of collaboration and exchange.

However, more support from MARCO and federal partners can advance this work in key areas. Cooperative exchanges, events and science webinars should be supported to address the needs of managers for actionable information. Common data sets and tools should focus not just on defining *vulnerabilities*, but also on developing regionally consistent analytic methods to define and measure risk reduction and resilience *opportunities* and ways to measure performance.

Even if delivery varies among regulatory, non-regulatory, and technical users, common data and methods can enable priority-setters to support effective identification and delivery of wetland NNBF projects by programs and groups that have differing primary objectives (such as hazard mitigation, wildlife habitat, infrastructure, open space). Watershed registries, vulnerability assessments, and mapped wetland adaptation areas all offer examples of multi-state information or cross-program information built on the same or similar data.

***MARCO and regional partners should develop technical best practices to assist marsh migration***.

While a great deal of work has been done to advance the technical understanding and engineering of living shorelines, and while wetland restoration (even in coastal settings) is a maturing field, there is, in contrast, not a great deal of experience with determining how technically to provide for effective marsh migration over decadal time periods. Targeting and priority setting that has a marsh migration focus must be supported by technical capacity in order to support acquisition, planning, and managing expectations for wetland adaptation areas.

Among the technical challenges are determining:

- how and when to move or to retrofit infrastructure to allow migration through and under structures,
- how to assist accretion and where to use dredged material,
- where to provide or manage swales or impoundments in the wetland migration path,
- management of when freshwater wetlands should be allowed to convert, and/or providing for planting or enhancing vegetation to support changes in function,
- needed actions to support water quality, and
- when and when not to reconstruct storm-breached areas to facilitate gradual adaptation.

This research area will be essential if wetland NNBFs are to play a role in climate risk reduction and resilience.

***Establish monitoring protocols to evaluate progress in achieving NNBF goals with wetlands.***

Effective operation of any priority-setting system or systems requires rigorous feedback to determine whether objectives are being accomplished. This is particularly important in a

dynamic environment such as the effects of climate change (sea level rise, storm surge, temperature, salinity, etc.) on natural systems or engineered nature-based features. Thus, MARCO should determine how best to evaluate and report on the performance of these systems. Accountability and learning can occur across at least four measures:

- Measuring progress by each state as to its fulfillment of the goals it has set for itself (first best practice, above). In effect, over the relevant period, have federal, state, local, and nongovernmental efforts been directed at the objects of policy priorities, and how much has been conserved, restored, installed. Such measures also provide regional accountability among the MARCO states (in some respects like the mutual reporting of states under the voluntary Chesapeake Bay agreement).
- Making data available so that independent groups (funders, NGOs, others) can become involved to help meet goals or to support areas of particularly success (or failure) as these become apparent.
- Determining performance using the dates applied for targeting and vulnerability assessments. Are the on-the-ground conditions as predicted, or are they outside the parameters that were used to install or conserve NNBFS? Are the NNBFs working as predicted to mitigate harm?
- Determining whether technical specifications need to be adjusted in light of measured experience. Specifically we will want to know if the relatively new and evolving specifications for living shorelines, or for design of marsh migration sequences, are succeeding or not. Using wetlands as NNBFs is a new and complex exercise.

Establishing a protocol across MARCO for future monitoring of conditions over a long period is critical, even though it may be difficult to fund absent federal research funding or a link to reporting pursuant to a state-driven target. Developing funding mechanisms for monitoring these features will only be possible if there is general regional agreement on goals, such that support for federal funding can be put forward and sustained as part of a national objective to advance adaptation progress and learning.

## Tools Reviewed


ARCADIS and Stevens Institute of Technology. 2014. Coastal Green Infrastructure Research Plan for New York City. http://www.dec.ny.gov/docs/remediation_hudson_pdf/cginyc.pdf. (Literature review on coastal green infrastructure strategies used to inform where future research is needed in order to understand how coastal green infrastructure can best benefit New York City.)

Boicourt, K., and Johnson, Z. P. (eds.). Maryland Commission on Climate Change, Adaptation and Response and Scientific and Technical Working Groups; University of Maryland Center for Environmental Science and Maryland Department of Natural Resources. 2010. Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic, and Ecological Resilience. http://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/12/ian_report_2991.pdf. (Identifies adaptation strategies for health, agricultural, and infrastructural benefits and for water resources. Encourages agencies to take advantage of opportunities to "enhance and protect" the state's green infrastructure and for MDNR to update the Green Infrastructure Assessment to include health-related climate impacts.)

Bosch, J., Foley, C., Lipinski, L., McCarthy, C., McNamara, Naimaster, A., Raphael, A., Yang, A., Baldwin, A. (P.I.) & Maryland Dept. of the Environment. 2006. Shore Erosion Control Guidelines: Marsh Creation. http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/Documents/www.mde.state.md.us/assets/document/wetlandswaterways/Shoreerosion.pdf (Marsh creation considerations for shoreline erosion control, and framework for activities relevant to use of NNBFs)

Bridges, T. S., Wagner, P. W., Burks-Copes, K. A., Bates, M. E., Collier, Z., Fischenich, C. J., Gailani, J. Z., Leuck, L. D., Piercy, C. D., Rosati, J. D., Russo, E. J., Shafer, D. J., Suedel, B. C., Vuxton, E. A., and Wamsley, T. V. U.S. Army Engineer and Research Development Center. 2015. Use of Natural and Nature-based Features (NNBF) for Coastal Resilience. https://s3.amazonaws.com/nyclimatescience.org/sr-15-1.pdf. (Report detailing how NNBFs can improve coastal resilience and develops a framework for activities relevant to the use of NNBFs.)

Campo, M., Kaplan, M., and Herb, J. (eds.). New Jersey Climate Adaptation Alliance. 2013. Resilience: Preparing New Jersey for Climate Change: A Gap Analysis from the New Jersey Climate Adaptation Alliance. http://njadapt.rutgers.edu/docman-lister/resource-pdfs/73-njcaa-gap-analysis-final-pdf/file. (Summary of stakeholder outreach that assessed stakeholder perspectives on gaps in climate policy and knowledge on climate impacts.)

Canick, M.R., Carlozo, N., and Foster, D. The Nature Conservancy. 2016. Maryland Coastal Resiliency Assessment. http://dnr.maryland.gov/ccs/Documents/MARCH-2016_MDCoastalResiliencyAssessment.pdf. (Methodology for prioritizing lands that provide the greatest risk reduction potential for communities. Intention is to add this measure to the GreenPrint database to add an additional criterion to DNR acquisitions and easements.)

Center for Sea Level Rise. 2014. The Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project. http://www.centerforsealevelrise.org/research-resources/pilot-project-resources/. (Project intended to promote collaboration across federal, state, and local government agencies in regions vulnerable to sea level rise, recurrent flooding, and coastal storms in order to produce a framework for intergovernmental strategic planning that can be used across the country.)

Chesapeake Bay Program. 2014. Watershed Agreement. http://www.chesapeakebay.net/documents/FINAL_Ches_Bay_Watershed_Agreement.withsignatures-HIres.pdf. (Updated agreement articulating the goals of the Chesapeake Bay Program, including setting a "wetlands outcome" that would increase wetlands capacity.)

Chesapeake Bay Program. 2015. Climate Resiliency Outcomes Management Strategy 2015-2025. http://www.chesapeakebay.net/documents/22073/0a_climate_6-30-15_ff_formatted_final_2.pdf. (Establishes approach for science and planning activities implementing two facets of Bay Agreement climate resilience goal: monitoring and assessment, and adaptation.)

Chesapeake Conservancy. 2014. Baltimore Wilderness. http://www.chesapeakeconservancy.org/images/Baltimore_Wilderness_Web_front.pdf. (Broad overview of the work the Greater Baltimore Wilderness Coalition is doing to improve Baltimore's network of protected areas.)

City of Kingston Tidal Waterfront Flooding Task Force. 2013. Planning for Rising Waters: Final Report of the City of Kingston Tidal Waterfront Flooding Task Force. http://www.kingston-ny.gov/filestorage/8463/10432/10440/10479/12782/10486/10490/Kingston_Tidal_Waterfront_Flooding_Task_Force_-_Final_Report.pdf. (Resiliency Plan for the City of Kingston. Objectives include evaluating the use of natural buffers and green infrastructure to reduce flood risk.)

City of New York. 2013. PlaNYC: A Stronger, More Resilient New York. http://www.nyc.gov/html/planyc/html/resiliency/coastal-protection.shtml. (New York City's plan to improve resiliency against storm surges. Includes policies to use natural features to minimize upland wave zone and promotes the improvement of coastal design features.)

City of Norfolk. 2013. plaNorfolk 2030. http://www.norfolk.gov/DocumentCenter/View/2483. (Document guiding planning decisions about physical and infrastructural development in Norfolk. Goals include using living shorelines that allow for landward wetlands migration.)

Delaware Coastal Programs. 2012. Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware. http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/AssesmentForWeb.pdf. (Methodology and results of a sea level rise Vulnerability Assessment conducted by the Sea Level rise Advisory Committee on 79 of the state's resources.)

Delaware Coastal Programs. 2013. Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware. http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/FinalAdaptationPlanasPublished.pdf. (Includes the initial set of recommendations developed by the Sea Level Rise Advisory Committee to help businesses, individuals, and government agencies respond to sea level rise.)

Delaware Coastal Programs. 2014. Coastal and Estuarine Land Conservation Program Plan. https://coast.noaa.gov/czm/landconservation/media/celcpplan-de-final.pdf. (Delaware's current CELCP

Plan. Assesses areas based on the state's Open Space criteria, including consideration for adaptability to sea level rise.)

Delaware Coastal Programs. 2014. Preparing for Tomorrow's High Tide: 2014 Sea Level Rise Workshop Proceedings and Interim Implementation Plan. http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/SLRImplementationWorkshopProceedingsComplete.pdf. (Specific implementation actions to expand upon the 2013 recommendations from the Sea Level Rise Advisory Committee. Most relevant actions were developed by the Wetlands, Shorelines and Habitat Workgroup.)

Delaware Department of Natural Resources and Environmental Control. N.d. Land Use Decision Making and Wetland Protection: A Guidebook for Public Participation. http://www.dnrec.delaware.gov/admin/delawarewetlands/documents/delaware%20wetlands%20public%20participation%20guidebook%20final.pdf. (A citizens guide on wetlands education and on how wetlands permits are issued in Delaware.)

Delaware Department of Natural Resources and Environmental Control. N.d. Open Space Program – Property Ranking Process. http://www.dnrec.delaware.gov/OpenSpaces/Documents/Open%20Space%20Program%20-%20Property%20Ranking%20Process%20-%20Final.pdf. (Open Space Council ranking criteria for use by DNREC.)

Delaware Department of Natural Resources and Environmental Control. N.d. Sea level Rise Inundation Map. http://firstmap.gis.delaware.gov/inundation/. (A "bathtub model" sea level rise scenario map for use by the public.)

Delaware Department of Natural Resources and Environmental Control. N.d. Statewide Activity Approval (SAA) for Shoreline Stabilization Projects in Tidal and Non-tidal Waters of the State of Delaware. http://www.dnrec.delaware.gov/wr/Documents/Shoreline_Stabilization_SAA.pdf. (Simplified permit authorizing the construction of several types of living shorelines not exceeding 500 linear feet.)

Delaware Department of Natural Resources and Environmental Control. 2008. Delaware Wetlands Conservation Strategy. http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/Delaware%20Wetlands%20Conservation%20Strategy%2008.29.08.pdf. (Guide that set 7 goals to improve coordination of wetlands management and data availability among state agencies.)

Delaware Department of Natural Resources and Environmental Control. 2014. Climate Framework for Delaware, Summary of Recommendations. http://www.dnrec.delaware.gov/energy/Documents/The%20Climate%20Framework%20for%20Delaware.pdf. (Both a summary of work already executed under Delaware E.O. 41 and a compilation of the recommendations from the Mitigation, Adaptations, and Flood Avoidance Workgroups.)

Delaware Department of Natural Resources and Environmental Control. 2015. Delaware Wetland Management Plan. http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/2015%20Delaware%20Wetlands%20Management%20Plan.pdf. (An update to the 2008 Delaware Wetland Conservation Strategy, this

document both summarizes progress and sets new action items to reach the 7 goals set to improve the health of the state's wetlands.)

Delaware Department of Natural Resources and Environmental Control. 2015. Delaware Wildlife Action Plan, 2015-2020. http://www.dnrec.delaware.gov/fw/dwap/Pages/WAP-Progress.aspx. (Strategy for protecting Delaware's wildlife and key habitats, including a detailed section on the impacts of climate change on key wildlife habitats.)

Delaware Department of Natural Resources and Environmental Control. 2015. Final Version of State Resource Area Standards and Criteria. http://www.dnrec.delaware.gov/openspaces/Pages/OpenSpaces.aspx. (Requirements for eligibility for land to be included in the State Resources Areas maps, which help inform funding decisions made by the state's Open Space Program.)

Delaware National Estuarine Research Reserve. 2013. Delaware National Estuarine Research Reserve Management Plan. https://coast.noaa.gov/data/docs/nerrs/Reserves_DEL_MgmtPlan.pdf. (Sets using a fee-simple acquisition policy to buy lands in the NERR boundary that will allow for wetland migration.)

Delaware Sea Grant. 2014. Community Flood Map Visualization Index. 2014. https://www.deseagrant.org/community-flood-map-visualization-index. (Before/after maps visualizing a 100-year flood in 10 communities in Delaware.)

Eastern Shore Land Conservancy. 2014-2015. Eastern Shore Coastal Resilience Assessment. http://www.eslc.org/wp-content/uploads/2015/02/Eastern-Shore-Coastal-Resiliency-Assessment-FINAL_rev.pdf. (Identifies vulnerabilities, mostly infrastructural, along the Eastern Shore to "long term coastal threats" from climate change.)

Eastern Shore Regional GIS Cooperative. N.d. Critical Area Interactive Map. http://webmaps.esrgc.org/cbca/desktop/Map. (Visual representation of the selected Critical Areas in each coastal jurisdiction.)

Executive Department of the State of Delaware. 2013. Executive Order Number Forty-One: Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities from Reducing Emissions. http://www.governor.delaware.gov/orders/EO041.pdf. (Executive Order directing the Governor's Committee on Climate and Resiliency to develop actionable recommendations for state agencies on improving resiliency and preparedness to climate change impacts.)

Executive Department of the State of Maryland. 2012. Executive Order 01.01.2012.29: Climate Change and "Coast Smart" Construction. http://wetlandswatch.org/Portals/3/WW%20documents/sea-level-rise/exec_order.pdf. (Policy to include consideration of climate impacts in future development projects.)

Executive Department of the State of Maryland. 2014. Executive Order 01.01.2014.14: Strengthening Climate Action in Maryland. http://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/12/climate_change_commission_final_eo_01_01_2014_141.pdf. (Directs state agencies to identify recommendations to implement Maryland's greenhouse gas reduction goals and direct the Commission on Climate Change to provide assistances to local governments in developing community-level vulnerability assessments.)

Executive Department of the State of New Jersey. 2007. Executive Order #54. http://nj.gov/infobank/circular/eojsc54.htm. (Executive Order setting greenhouse gas emissions targets and directing the Department of Environmental Protection to evaluation policies to reach those targets.)

Executive Department of the State of Virginia. 2014. Executive Order Number Thirty Five: Continuation of the Virginia Coastal Zone Management Program. https://governor.virginia.gov/media/3490/eo-35-continuation-of-the-virginia-coastal-zone-management-programada.pdf. (Executive Order establishing the Virginia Coastal Zone Management Program, focused on creating coastal communities and ecosystems and sets objectives to "protect and restore" wetlands and reduce the loss of coastal habitats.)

Governor's Commission on Climate Change. 2008. Final Report: A Climate Change Action Plan. http://www.sealevelrisevirginia.net/docs/homepage/CCC_Final_Report-Final_12152008.pdf. (Virginia's first climate action plan, which instructs state and local agencies to prepare for unavoidable climate impacts, including that the Virginia Marine Resources Commission to promote living shorelines, and establishes goals for reducing net greenhouse gas emissions through the protection of natural carbon sinks, including through creating a carbon crediting system using wetlands protection , restoration, and creation.)

Haaf, L., Moody, J., Reilly, E., Padeletti, A., Maxwell-Doyle, M., and Kreeger, D. Partnership for the Delaware Estuary and the Barnegat Bay Partnership. 2015. Factors Governing the Vulnerability of Coastal Marsh Platforms to Sea Level Rise (PDE Report No. 15-08). http://bbp.ocean.edu/Reports/Factors%20Governing%20the%20Vulnerability%20of%20Coastal%20Marsh%20Platform.pdf (Summary of science to aid coastal managers and practitioners in understanding the factors that affect vertical vulnerabilities of coastal wetlands in region.)

Hardaway, C.S., Milligan, D. & Duhring, K. Virginia Institute of Marine Science. 2010. Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments Version 1.2. http://web.vims.edu/physical/research/shoreline/docs/LS_Design_final_v1.2.pdf (Design guidelines for use in various settings for living shorelines).

Hudson River National Estuarine Research Reserve. 2008. Sustainable Shorelines Project. https://www.hrnerr.org/hudson-river-sustainable-shorelines/. (Project studying the impacts of climate change on shorelines, assessing the performance of "nature-based engineered shoreline structures," and a regulatory framework to guide shoreline development in the Hudson River Estuary, among other things.)

Hudson River National Estuarine Research Reserve. 2017 (*forthcoming*). Guidance on Natural Resiliency Measures in New York. https://www.hrnerr.org/naturalresiliencyguidance.html. (Guidance document on the benefits of using NNBFs for a variety of purposes, which will cumulate in a framework for use of these tools.)

Hudson River Sustainable Shorelines. 2015. Hudson River Sustainable Shorelines Project Overview. https://www.hrnerr.org/doc/?doc=260857495. (Project promoting the use of "best shoreline management options" for use in the Hudson River Estuary and summary of completed projects.)

Image Matters LLC & U.S. Fish & Wildlife Service. n.d. SLAMM-VIEW. http://www.slammview.org/ (Version 3.0 of SLAMM-View is a visualization tool to assess impacts of sea-level rise on coastal areas with both visualization and analysis functionality.)

Kane, A., Burkett, T. C., Kloper, S. and Sewall, J. 2013. Virginia's Climate Modeling and Species Vulnerability Assessment: How Climate Data Can Inform Management and Conservation. http://www.bewildvirginia.org/climate-change/virginias-climate-vulnerability-assessment.pdf. (A framework highlighting the importance of including climate impacts in wildlife conservation strategies.)

Klopfer, S.D., and McGuckin, K., Conservation Management Institute, Virginia Tech. 2015. Opportunities to Conserve Contemporary Climate Landscapes in Virginia: Final Report to the Virginia Department of Game and Inland Fisheries. (Analysis of existing data in order to assess how conserved lands are expected to be affected by climate change.)

Kreeger, D., Adkins, J., Cole, P., Najjar, R., Velinsky, D., Conolly, P., and Kraeuter, J. Partnership for the Delaware Estuary. 2010. Climate Change and the Delaware Estuary: Three Case Studies in Vulnerability Assessment and Adaptation Planning (PDE Report No. 10-01). http://delawareestuary.org/pdf/Climate/Climate%20Change%20and%20the%20Delaware%20Estuary_PDE-10-01.pdf. (Details three instances of climate adaptation planning in the Delaware Estuary. Recommends identifying vulnerable wetlands area that could benefit from restoration and managing the uplands of tidal marshes to facilitate marsh migration.)

Kreeger, D., Moody, J., Katkowski, M., Boatright, M., and Rosencrance, D. Partnership for the Delaware Estuary. 2015. Marsh Futures: Use of Scientific Survey Tools to Assess Local Salt Marsh Vulnerability and Chart Best Management Practices and Interventions (PDE Report No. 15-03). http://delawareestuary.s3.amazonaws.com/pdf/Summit15/PDE-Report-15-03_Marsh%20Futures.pdf. (Identifies tracts of salt marshes in three areas of New Jersey identified by local communities to be of interest for planning purposes.)

Lathrop, Jr., R. G., and Love, A. Grant F. Walton Center for Remote Sensing & Spatial Analysis, Rutgers University. 2007. Vulnerability of New Jersey's Coastal Habitats to Sea Level Rise. http://crssa.rutgers.edu/projects/coastal/sealevel/report/Vulnerability_of_New_Jersey_coastal_habitats_v4.pdf. (Geospatial analysis of already available data to create a comprehensive map of the potential impacts of sea level rise on New Jersey's coastal habitats.)

Legislature of the State of New Jersey. 2007. Global Warming Response Act. http://www.njleg.state.nj.us/2006/Bills/A3500/3301_R2.HTM. (Legislative Act that complements E.O. 54, enforcing meeting greenhouse gas emissions targets and sets reporting and implementation requirements.)

Lerner, J.A., Curson, D.R., Whitbeck, M., and Meyers, E.J. The Conservation Fund. 2013. Blackwater 2100: A Strategy for Salt Marsh Persistence in an Era of Climate Change. http://www.conservationfund.org/images/projects/files/Blackwater-2100-report_email.pdf. (Models marsh migration out to year 2100 in Blackwater National Wildlife Refuge in order to identify priority areas for wetlands conservation and climate adaptation.)

Long Island Sound Study. 2015. Long Island Sound Comprehensive Conservation and Management Plan 2015. http://longislandsoundstudy.net/wp-

content/uploads/2015/09/CCMP_LowRes_Hyperlink_singles.pdf. (Plan outlining policy objectives to improve the health of waters and coastal habitats and the resilience of communities along the Long Island Sound. Promotes both mitigating the impacts to vulnerable wetlands and uplands, including removing barriers to habitat migration and the use of living shorelines.)

Long Island Sound Study. 2016. Stewardship Area Atlas. http://longislandsoundstudy.net/issues-actions/stewardship/stewardship-areas-atlas/. (Areas along the coastal of long island sound that represent "exceptional ecological and recreational value. Atlas feeds into the New York Open Space Plan.)

Maher, N., Lloyd, S., and Alleman, L. The Nature Conservancy. 2016. New York City Tidal Marsh Systems Analysis: Conditions, Vulnerability, and Opportunities for Restoration. To be posted in 2017 at http://naturalareasnyc.org/in-print. (Assessment of 25 NYC marsh complexes and their adjacent potential marsh migration zones, and identifying vulnerabilities and setting priorities based on opportunities for use of protection, rehabilitation and restoration strategies.)

Maryland Commission on Climate Change. 2008. Climate Action Plan. http://www.mde.maryland.gov/programs/air/climatechange/pages/air/climatechange/legislation/index.aspx. (Document outlining the impacts of climate change on Maryland and outlining a carbon footprint and adaption strategy.)

Maryland Commission on Climate Change. 2008. Chapter Four: Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy. http://www.mde.maryland.gov/programs/Air/ClimateChange/Documents/www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter4.pdf. (Summarizes climate impacts in Maryland and sets policies to assess and promote restoration of wetlands, particularly in regard to carbon sequestration potential, and to acquire lands that allow for inland migration.)

Maryland Commission on Climate Change, Adaptation and Response and Scientific and Technical Working Groups; Maryland Department of Natural Resources. 2008. Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea-Level Rise and Coastal Storms. http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf. (Creates more actionable policies for the use of NNBFs as coastal flood buffers, including the identification of priority areas and promotion of sustainable shorelines. It also requires the integration of climate impacts and response planning strategies into "existing state and local policies and programs.")

Maryland Commission on Climate Change. 2014. Climate Change and *Coast Smart* Construction Infrastructure Siting and Design Guide. http://dnr2.maryland.gov/climateresilience/Documents/ClimateChange_CoastSmartReport013114.pdf. (Siting guidelines for identifying, protecting, and maintaining "ecological features" that will either buffer the state against climate impacts or support the adaptation of habitats.)

Maryland Department of the Environment. n.d. Structural Shoreline Stabilization Maps. http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/DocumentsandInformation/Pages/Programs/WaterPrograms/Wetlands_Waterways/documents_information/wetlandtidalshoremaps.aspx (county maps of high energy shorelines designated as appropriate for structural stabilization measures).

Maryland Department of the Environment. 2008. Shore Erosion Control Guidelines for Waterfront Property Owners, 2d ed. http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/Documents/www.mde.state.md.us/assets/document/wetlandswaterways/Shoreerostext.pdf (updated guidance on technical approaches and regulatory procedures to select erosion control measures.)

Maryland Department of the Environment. 2004. Priority Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays. http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/AboutWetlands/Documents/www.mde.state.md.us/assets/document/wetlandswaterways/CB_all.pdf. (Set of recommendations addressing wetlands protection, restoration, and mitigation and guide for identifying priority sites in the Coastal Bays area.)

Maryland Department of Natural Resources. N.d. Blue Infrastructure Near-shore Assessment. http://dnr2.maryland.gov/ccs/pages/bi.aspx. (Factsheet summarizing the methodology used to prioritize costal and estuarine habitats for inclusion in the Green Infrastructure network.)

Maryland Department of Natural Resources. 2003. Maryland's Green Infrastructure Assessment. http://conservationtools-production.s3.amazonaws.com/library_item_files/635/574/gia_doc.pdf?AWSAccessKeyId=AKIAIQFJLILYGVDR4AMQ&Expires=1475702162&Signature=iyO1T0c4gtoqXtlXz6r2oH2B48w%3D (Initial outline of prioritization tool used by MDNR to identify and rank areas of greatest ecological importance in order to guide conservation efforts. The initial draft did not incorporate climate impacts, but MDNR has later incorporated climate impacts into GreenPrint Map.)

Maryland Department of Natural Resources. 2008. Maryland's Coastal and Estuarine Land Conservation Plan (Revised Draft). https://coast.noaa.gov/czm/landconservation/media/celcpplanmddraft.pdf. (Policy identifying priority areas for land acquisition, largely based on the Green Infrastructure Assessment and Ecologically Significant Areas. It also promotes the protection of sustainable shorelines and conservation and expansion of NNBFs that protect against coastal flooding.)

Maryland Department of Natural Resources. 2010. Building Resilience to Climate Change. http://dnr2.maryland.gov/climateresilience/Documents/climate_change.pdf. (Policy directive for MDNR regarding land, resources, and assets management. Sets as a goal the protection of lands and construction of habitat that provide climate adaptation and carbon sequestration services.)

Maryland Department of Natural Resources. 2011. Maryland's Criteria for Coastal Land Conservation in Response to Climate Change Impacts of Sea Level Rise (Draft). http://dnr.maryland.gov/ccs/Documents/MDCCPEForm_July2011.pdf. (Questionnaire to help determine the capacity of a parcel of land to provide resiliency against sea level rise and storm surges through adaptation and/or mitigation. Has an entire section on wetland migration potential.)

Maryland Department of the Environment, Nontidal Wetlands and Waterways Division. 2011. Maryland Nontidal Wetland Mitigation Guidance. http://www.mde.state.md.us/programs/Water/WetlandsandWaterways/AboutWetlands/Documents/www.mde.state.md.us/assets/document/wetlandswaterways/MITGUIDEfeb72011.pdf. (A guide to help landowners comply with the Nontidal Wetlands Protection Act.)

Maryland Department of Natural Resources. 2011. GreenPrint. http://dnr.maryland.gov/land/Pages/Green-Infrastructure-Mapping.aspx. (Interactive map of Maryland's statewide set of spatial georeferenced databases used for open space protection, farmland protection, and many other purposes. Designates Targeted Ecological Areas. GreenPrint scores used to evaluate potential MDNR acquisitions and coastal resilience conservation easements.)

Maryland Department of Natural Resources. 2012. Ecological Scorecard. (Scorecard used to rank a parcel for acquisition.)

Maryland Department of Natural Resources. 2013. Greenhouse Gas Reduction Plan, Chapter 8: Adaptation-Update. http://ian.umces.edu/pdfs/ian_report_419.pdf. (Presents a set of policy recommendations that promote adaptation to climate impacts. Sets the retention and expansion of NNBFs, including wetlands, for protection against coastal flooding as a priority recommendation.)

Maryland Department of Natural Resources. 2013. Maryland Land Preservation and Recreation Plan 2014-2018. http://dnr2.maryland.gov/land/Documents/LPRP/LPRP_%202014-2018.pdf. (Five-year framework for planning and design of outdoor recreational areas. Provides a summary of how the state wetlands acquisition policies. Also details the how the Targeted Ecological Areas (TEAs) were identified.)

Maryland Department of Natural Resources. 2015. Maryland State Wildlife Action Plan. http://dnr2.maryland.gov/wildlife/Pages/plants_wildlife/SWAP_home.aspx. (Draft Plan sets actionable goals to improve adoption and implementation of adaptation strategies by government agencies and land managers and improve coordination of detecting impacts of climate change.)

Maryland Department of Natural Resources. 2016. Maryland's Coastal Atlas. http://dnr2.maryland.gov/ccs/Pages/coastalatlas.aspx. (Online mapping tool intended to help decision makers prepare for coastal and ocean activities. Includes data on sea level rise vulnerability, including vulnerable wetlands and wetland adaptation areas, and data from the Coastal Resiliency Assessment.)

Maryland Department of Natural Resources, Chesapeake and Coastal Services, 2015. Building Resilience Through Habitat Restoration. http://dnr2.maryland.gov/ccs/Documents/NF_CCS-HRC_Climate_2015.pdf. (Most recent restoration assessment for MDNR land, identifying restoration objectives, best management practices, and project implementation approaches.)

Maryland Department of Natural Resources. 2015. Coast Smart Construction Program. http://dnr2.maryland.gov/ccs/coastsmart/Documents/2015_CS_ConstructionProgram.pdf. (Law creating the Coast Smart Council. A primary responsibility of the Council is to design criteria to address climate impacts on construction or repair of capital projects.)

Maryland General Assembly, Department of Legislative Services. 2008. Living Shoreline Protection Act (Md. Code Ann, Envt., § 16-201). http://mlis.state.md.us/2008rs/fnotes/bil_0003/hb0973.pdf. (Statutory policy requiring use of living shorelines in most circumstances.)

Maryland iMAP. 2010. Maryland Blue Infrastructure—Blue Infrastructure Ranks. http://data.imap.maryland.gov/datasets/e96524e952a342b5936ed1c0ee3a7901_0. (Data layer showing spatial distribution of prioritized areas under the Blue Infrastructure Near-shore Assessment.)

Md. Code Ann., Envir. §§ 16-101 to 503: Maryland Tidal Wetlands Act. http://law.justia.com/codes/maryland/2005/gen/16-101.html. (Act restricting the construction and development in tidal wetlands.)

Md. Code Ann. Nat. Res. tit. 8, §18: Chesapeake and Atlantic Coastal Bays Critical Area Protection Program (Critical Area Act). http://dnr.maryland.gov/criticalarea/Pages/reg_act.aspx. (Act establishing a "Critical Area" buffer around tidal shorelines in order to minimize damage to water quality and wildlife habitats.)

Metropolitan Waterfront Alliance. 2015. Shape Your Waterfront: How to Promote Access, Resiliency, and Ecology at the Water's Edge. http://waterfrontalliance.org/wp-content/uploads/delightful-downloads/2015/06/WEDG_manual_jan_2015.pdf. (Three-part evaluation to help decision-makers and planners identify opportunities to improve "waterfront design.")

Miller, J.K., Rella, A., Williams, A., and Sproule, E. Stevens Institute of Technology. 2016. Living Shorelines Engineering Guidelines. http://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf. (Guidance document to help advance installation of living shoreline. Helps to assess site conditions and parameters and to identify design guidance to address these and technical parameters.)

National Oceanic and Atmospheric Administration. 2015. Guidance for Considering the Use of Living Shorelines. http://www.habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf. (Guiding principles for NOAA support of living shorelines, and conceptual framework for decisions).

National Oceanic and Atmospheric Administration, National Centers for Environmental Information. N.d. NOAA National Climatic Data Center. www.ncdc.noaa.gov. (Compilation of available climate and historical weather data for use with other tools and assessments.)

National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, and New York Department of State. 2015. Preliminary Coastal Hazards Composite Risk Map—New York State Coastal Zone. http://www.arcgis.com/home/item.html?id=82a2fa929168434dabb6a3970e1d38e0. (Coastal hazard risk map depicting vulnerability to coastal flooding, storm surges, and inundation. Complement to state coastal resilience planning guidance.)

National Oceanic and Atmospheric Administration, Habitat Blueprint. 2014. Habitat Focus Area: Delmarva/Choptank River Complex. http://www.chesapeakebay.noaa.gov/images/stories/hottopics/choptankhfafactsheet4.18.14.pdf. (Summary of restoration work on habitat and overview of work that NOAA will undertake in the area. Only Habitat Focus Area in the MARCO region.)

National Oceanic and Atmospheric Administration, Office for Coastal Management. 2016. Habitat Priority Planner. https://coast.noaa.gov/digitalcoast/tools/hpp. (Tool built to allow decision-makers to conduct geospatial analysis of coastal habitats in order to aid in conservation, restoration, and planning decisions.)

Natural Capital Project. n.d. Integrated Valuation of Ecosystem Services and Tradeoffs. http://naturalcapitalproject.org/invest (Coastal Vulnerability model uses geophysical and natural habitat characteristics of coastal landscapes to compare their exposure to erosion and flooding in severe weather; other models support nearshore waves and erosion modeling)

NatureServe. 2015. Climate Change Vulnerability Index. http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index. (Identifies and ranks plant and animal species most vulnerable to climate change.)

New Jersey Climate Adaptation Alliance. 2014. Resilience: Preparing New Jersey for Climate Change: Policy Considerations from the New Jersey Climate Adaptation Alliance. http://njadapt.rutgers.edu/docman-lister/resource-pdfs/120-resilience-preparing-new-jersey-for-climate-change-policy-considerations/file. (Set of recommendations for climate change preparedness, including assessing vulnerability of wetlands and other NNBFs and the value of those resources for adapting to climate change and assessing farmland purchases for the purposes of wetlands migration.)

New Jersey Department of Environmental Protection. 2009. Meeting New Jersey's 2020 Greenhouse Gas Limit: New Jersey's Global Warming Response Act Recommendations Report. http://www.climatestrategies.us/library/library/view/952. (Specific recommendations for meeting the state's greenhouse gas emission goals set by the Global Warming Response Act. The section on carbon sequestration mentions wetlands as carbon sinks, but do not set targets for wetlands conservation, restoration, or creation.)

New Jersey Department of Environmental Protection. 2009. New Jersey Coastal and Estuarine Land Conservation Program Plan (CELCP). https://coast.noaa.gov/czm/landconservation/media/celcpplannjdraft.pdf. (Assessment of priority conservation needs that creates a preference list for state land acquisitions. Wetland and other NNBFs are included as high conservation priority areas.)

New Jersey Department of Environmental Protection. 2013. New Jersey Wetland Program Plan 2014-2018. https://www.epa.gov/sites/production/files/2015-10/documents/njdep-wpp_2014-2018.pdf. (Framework for DEP's approach to its wetlands program. Sets policies for buffers and creation/restoration requirements and sets goals of analyzing coastal wetlands' response to sea level rise and of incorporating monitoring data into agency decision-making.)

New Jersey Department of Environmental Protection, Division of Fish and Wildlife. 2008. New Jersey Wildlife Action Plan. http://teaming.com/sites/default/files/New%20Jersey%20Wildlife%20Action%20Plan.pdf. (Plan focused on preserving species of greatest conservation need. Acknowledges sea level rise as one of the greatest long-term threats to coastal habitats, but does not set as a priority the creation of predictive models to better understand habitats that need protection against sea level rise. 2015 version not available online.)

New Jersey Department of Environmental Protection, Office of Coastal Management. 2009. Mitigating Shoreline Erosion along New Jersey's Sheltered Coast: Overcoming Regulatory Obstacles to Allow for Living Shorelines. http://www.nj.gov/dep/cmp/docs/living-shorelines2011.pdf. (Document promoting a "new shoreline management approach" in New Jersey that favors "more ecologically beneficial solutions" to coastal erosion.)

New Jersey Department of Environmental Protection, Office of Coastal Management. 2010. Getting to Resilience: A Coastal Community Resilience Evaluation Tool. http://www.state.nj.us/dep/cmp/docs/gtr-resilience.pdf. (A 5-part questionnaire designed as a decision-making tool to help municipal-levels

planners take advantage of opportunities that will help them adapt to and mitigate the impacts of climate change.)

New Jersey Department of Environmental Protection, Office of Coastal Management. 2011. New Jersey's Coastal Community Vulnerability Assessment and Mapping Protocol. http://www.state.nj.us/dep/cmp/docs/ccvamp-final.pdf. (Guide designed to help local decision makers create localized vulnerability assessments for coastal hazards.)

New Jersey Department of Environmental Protection, Land Use Management. 2016. Coastal Vulnerability Index Mapping. http://www.nj.gov/dep/cmp/czm_cvi.html. (Ranking assessment identifying where development is constricting the natural dynamics of coastal migration that uses GIS-based analysis to determine where marsh retreat potential has been constricted and draw conclusions about resiliency.)

N.J. Admin. Code tit. 7 §7-6.24: General Permit 24 – Habitat Creation, Restoration, Enhancement and Living Shoreline Activities. http://www.nj.gov/dep/rules/rules/njac7_7.pdf . (Legislation outlining conditions for the creation or enhancement of a living shoreline requires a General Permit.)

New York City Department of Parks and Recreation. 2012. New York City Wetlands Strategy. http://www.nyc.gov/html/planyc2030/downloads/pdf/nyc_wetlands_strategy.pdf. (Articulates NYC's goals of no net loss of wetlands, restoration, and maximizing the ecological function of remaining wetlands. The Plan strengthens protection of small wetland parcels, increases acquisition and restoration efforts, and sets goals for monitoring the impacts of sea level rise on tidal wetlands.)

New York Envtl. Conserv. §6-0101: State Smart Growth Public Infrastructure Policy Act. http://law.onecle.com/new-york/environmental-conservation/article6/index.html. (Articulation of state's infrastructure development policies that outlines criteria projects need to have to receive approval or state aid for construction. One criterion is focuses on mitigating sea level rise, storm surges, and flooding.)

New York State 2100 Commission. 2013. Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure. http://www.governor.ny.gov/sites/governor.ny.gov/files/archive/assets/documents/NYS2100.pdf. (Recommendations from the NYS2100 Commission to improve resiliency of the state's infrastructure against climate impacts. Recommendations include improving coastal barriers (both green and gray), identifying areas where coastal protection is most needed, and restoring tidal wetlands, among many others.)

New York State Assembly. 2014. Community Risk and Resiliency Act (Assembly Bill A6558B). https://www.nysenate.gov/legislation/bills/2013/a6558/amendment/b. (Act requiring New York state agencies to consider future climate risk due to sea level rise, storm surges, and flooding in connection with permitting, funding, and regulatory decisions.)

New York State Climate Smart Communities. 2014. New York State Climate Smart Communities, Climate Smart Resiliency Planning: A Planning Evaluation Tool for New York State Communities Version 2.0. http://www.dec.ny.gov/docs/administration_pdf/csrptool.pdf. (A self-assessment questionnaire tool "designed to stimulate ideas and collaboration" among local decision-makers on the issues of climate hazard planning.)

New York State Department of Environmental Conservation. 2007. Shoreline Protection: Interpretive Guidance to Staff. http://www.dec.ny.gov/docs/fish_marine_pdf/shoreprotect.pdf. (Internal recommendation for using the "least structural or softest approach" that will retain the natural shoreline to address new or replacement shoreline erosion projects.)

New York State Department of Environmental Conservation. 2009. NYS Coastal and Estuarine Land Conservation Program Plan. http://www.dec.ny.gov/docs/lands_forests_pdf/osp09eappd.pdf. (State CELCP was incorporated into the 2009 Open Space Conservation Plan in order to "highlight coastal resources areas" under the existing structure for land conservation and acquisition.)

New York State Department of Environmental Conservation. 2015. New York State Wildlife Action Plan. http://www.dec.ny.gov/docs/wildlife_pdf/swapfinaldraft2015.pdf. (State plan to protect species of greatest conservation need and their habitats. The strategies that address climate impacts focus on the reduction of greenhouse gas emissions.)

New York State Department of Environmental Conservation and the Office of Parks, Recreation, and Historic Preservation. 2014. Draft New York State Open Space Conservation Plan. http://www.dec.ny.gov/docs/lands_forests_pdf/osp14draftplan.pdf. (Currently New York's main document for guiding conservation and land acquisition efforts. The Plan sets a policy to incorporate climate impacts into land acquisition and conservation programs, promotes the implementation of living shorelines, and plans to facilitate tidal wetland migration.)

New York Department of State. N.d. Climate Change and Resilience Mapping. http://opdgig.dos.ny.gov/#/focus/resilience (Coastal Risk Areas mapped.)

New York Department of State. N.d. Risk Assessment Area Mapping—Datasets and Methodology. https://stormrecovery.ny.gov/sites/default/files/documents/Risk_Assessment_Area_Mapping.pdf. (Methodology used in developing coastal risk risk assessments for New York City, Long Island, and Westchester County.)

New York State Energy Research and Development Authority. 2016. NYSERDA Environmental Research Program Plan, Research Area 2: Climate Change Adaptation, Final Report, Version 2. https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Environmental/climate-change-adaptation-report.pdf. (Research agenda to address gaps in climate science and mapping relevant to adaptation and resilience.)

New York State Sea Level Rise Task Force. 2010. New York State Sea Level Rise Task Force: Report to the Legislature. http://www.dec.ny.gov/docs/administration_pdf/slrtffinalrep.pdf. (Recommendations targeting improving ecosystem and community resiliency to climate impacts. Recommendations include providing space for habitat migration and promoting the use of "non-structural and soft shoreline[s].")

New York Storm Recovery. 2014. NY Rising: Community Reconstruction Committee Plans: Executive Summaries. http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/executive_summaries_round_2lores.pdf. (Collection of 16 local-level climate adaptation planning documents that identify and prioritize opportunities for resilience and recovery. Most focus on mitigating flooding; 5 mention adaptation strategies using NNBFs and natural resources.)

North Atlantic Landscape Conservation Cooperative & The Nature Conservancy. Forthcoming 2017. Identifying Resilient Sites for Coastal Conservation. http://northatlanticlcc.org/projects/tnccoastal_resilient-sites/identifying-resilient-sites-for-coastal-conservation (Development of metrics, methods, and data sets to identify marshes and marsh migration sites to provide longterm resiliency.)

Northeast Climate Database (NExUS). N.d. NExUS. http://www.neclimateus.org/. (Searchable online database collating data, reports, and (mapping) tools related to climate information on the Atlantic Coast of the US and Canada.)

Northeast Regional Ocean Council. 2015. Make Way for Marshes: Guidance on Using Modals of Tidal Marsh Migration to Support Community Resilience to Sea Level Rise. http://northeastoceancouncil.org/marshmigration/. (Guidance document outlining how to model and communicate the impacts of sea level rise.)

Papiez, C. Maryland Department of Natural Resources. 2012. Coastal Land Conservation in Maryland: Targeting Tools and Techniques for Sea Level Rise Adaptation and Response. http://dnr2.maryland.gov/ccs/Publication/coastalland_conserv_md.pdf. (Methodology for identifying adaptation opportunities for coastal wetlands, namely inland migration, under a sea level rise scenario of 1.4 meters by 2100.)

Partnership for the Delaware Estuary. 1996. Comprehensive Conservation and Management Plan. http://www.delawareestuary.org/pdf/CCMP.pdf. (Sets goals for management of the Delaware Estuary, including one promoting protection of shoreline and littoral habitats and identify techniques to prevent the loss of wetlands that can mitigate the impacts of sea level rise.)

Partnership for the Delaware Estuary. 2012. Weathering Change. https://s3.amazonaws.com/delawareestuary/pdf/Climate/weathering_change.pdf. (A guide to encourage local communities to protect and create wetlands and living shorelines.)

Partnership for the Delaware Estuary and Rutgers' University Haskin Shellfish Research Laboratory. 2012. Final Report: Delaware Living Shoreline Possibilities (PDE Report No. 12-04). https://s3.amazonaws.com/delawareestuary/pdf/Living%20Shorelines/DCP%20Final%20Report_final2.pdf. (Preliminary geospatial analysis of potential areas for living shorelines in the Delaware Estuary.)

Partnership for the Delaware Estuary and Rutgers' University Haskin Shellfish Research Laboratory. 2012. Final Report: New Jersey Living Shoreline Possibilities (PDE Report No. 12-05). https://s3.amazonaws.com/delawareestuary/pdf/Living%20Shorelines/Dodge%20Final%20Report.pdf. (Preliminary geospatial analysis of potential areas for living shorelines in the Delaware Estuary.)

Scenic Hudson. 2016. Sea Level Rise Mapper. http://www.scenichudson.org/slr/mapper. (Interactive map demonstrating the impacts of different sea level rise scenarios along the Hudson River.)

Systems Approach to Geomorphic Engineering (SAGE). 2014. http://sagecoast.org/. (Searchable database and interactive map detailing projects from around the country that integrate green and gray solutions to coastal management challenges.)

Tabak, N. M., Laba, M., and Spector, S. 2016. Simulating the Effects of Sea Level Rise on the Resilience and Migration of Tidal Wetlands along the Hudson River. http://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0152437. (Adaptation of SLAMM for application along the Hudson River Estuary through 2100.)

The Nature Conservancy. 2015. Chesapeake Bay Habitat Tool. http://maps.tnc.org/chesapeakehabitat/. (A web map that provides spatial context for multi-habitat conservation and includes an interactive tool for prioritizing tidal wetland protection and restoration opportunities.)

The Nature Conservancy. 2016. Coastal Resilience. http://maps.coastalresilience.org/network/. (Visual tool to help decision-makers assess where to reduce risks of coastal hazards. Includes data on floods, sea level rise, and future (wetlands) habitat, among others. Available for New Jersey, New York, and the Eastern Shore of Virginia in the MARCO region.)

The Nature Conservancy. 2016. New York City Tidal Marsh Systems Analysis: Conditions, Vulnerability, and Opportunities for Restoration. (Prioritization scheme to help NYC's Department of Parks and Recreation identify marshlands for restoration and protection.)

The Nature Conservancy and CH2M. 2015. Coastal Risk Reduction: Integrating Natural Defenses into a Sustainable Coastal Risk Management Framework. http://www.ch2m.com/sites/default/files/content/article/attachments/CSR_Vsn%202_single%20pages_electronic.pdf. (Guidance document promoting the integration of nature-based solutions to "reduce the environmental and socio-economic risks" of coastal hazards and climate impacts.)

U.S. Army Corps of Engineers. 2015. North Atlantic Coast Comprehensive Study (NACCS). http://www.nad.usace.army.mil/CompStudy/. (Database including data on exposure analysis, risk analysis, inundation mapping, coastal features, federal and state shore protection projects, NNBF suitability classification, and others.)

VA. Code Ann. §15.2-2223.2: Comprehensive Plan to Include Coastal Resource Management Guidance. https://vacode.org/15.2-2223.2/. (Legislation requiring local governments in the Hampton Roads Planning District Commission area to include a coastal resource management plan in the next revision of their comprehensive land use plans "to combat projected sea-level rise and recurrent flooding.")

VA. Code Ann. §28.2-104.1: Living Shorelines; Development of General Permit; Guidance. http://law.lis.virginia.gov/vacode/title28.2/chapter1/section28.2-104.1/. (Directs the Department of Conservation and Recreation and VIMS to establish and implement permit regulations authorizing and encouraging the use of living shorelines as the preferred "alternative" for shoreline stabilization.)

VA. Code Ann. §28.2-1300-1320: Wetlands. http://law.lis.virginia.gov/vacode/title28.2/chapter13/. (Virginia's Tidal Wetlands Act. Regulations for activities in tidal wetlands requiring permits.)

Village of Catskill. 2014. Resilient Catskill: Report of the Catskill Waterfront Resilience Task Force. http://www.scenichudson.org/sites/default/files/images/Catskill%20Waterfront%20Resilience%20Task%20Force%20Final%20Report.pdf. (Community resiliency plan focused on "the role of the waterfront" that sets a policy of promoting the use of green infrastructure to reduce and mitigate the impacts of flooding.)

Village of Piermont. 2014. Resilience Roadmap: Planning for Piermont's Future, Report of the Piermont Waterfront Resilience Task Force Executive Summary. http://www.scenichudson.org/sites/default/files/files/Piermont%20Waterfront%20Resilience%20Task%20Force%20Final%20Report%20-%20Executive%20Summary.pdf. (Revitalization plan for the Village of Piermont focused on the "role of the waterfront" that addresses risks from coastal flooding due to sea level rise. Planning is still in very early stages.)

Virginia Coastal Zone Management Program. 2012. Virginia Coastal and Estuarine Land Conservation Program Plan. https://coast.noaa.gov/czm/landconservation/media/celcpplanvafinal.pdf. (Sets priorities for land acquisition strategy. Eligible projects must have significant conservation or ecological value or must be threatened by conversation from their natural state. Priority areas build off the Natural Heritage Plan and priority wildlife diversity conservation areas.)

Virginia Coastal Zone Management Program. 2015. Coastal Gems. http://www.coastalgems.org/. (Interactive map providing a visualization of Virginia's coastal resource and identifies potential restoration sites and results from the Virginia Ecological Value Assessment, among other features.)

Virginia Department of Conservation and Recreation. 2007. Virginia Natural Landscape Assessment. http://www.dcr.virginia.gov/natural-heritage/vaconvisvnla. (A "landscape-scale geospatial analysis" to help decision-makers identify and prioritize lands in order to reduce fragmentation of natural lands in Virginia. Climate impacts are not mentioned.)

Virginia Department of Environmental Quality. 2011. Comprehensive Wetland Program Plan Commonwealth of Virginia 2011-2015. http://ccrm.vims.edu/publications/pubs/Virginia_wetland_plan_Final.pdf. (Outline of Virginia's strategy to achieve no-net-loss and net resources gain of wetlands for 2011-2014. Plan recognizes loss of tidal wetlands due to sea level rise as a priority issue.)

Virginia Department of Environmental Quality. 2015. Virginia State Wetlands Program Plan 2015-2020. http://www.deq.virginia.gov/Portals/0/DEQ/Water/WetlandsStreams/Virginia%20wetland%20plan%20Final%202016.pdf. (Outline of Virginia's strategy to achieve no-net-loss and net resources gain of wetlands and to meet the Chesapeake Bay Commitments. Plan recognizes loss of tidal wetlands due to sea level rise as a priority issue. It also summaries ongoing efforts.)

Virginia Department of Game and Inland Fisheries. 2015. Virginia's 2015 Wildlife Action Plan. http://bewildvirginia.org/wildlife-action-plan/draft/1_Introduction_and_Statewide_Overview.pdf. (Habitat -focused approach to wildlife conservation has several climate-related recommendations for NNBFs, including restoring and conserving wetlands that can withstand changing conditions, acquiring uplands to allow for wetlands migration, and prioritizing wetlands that "may provide some opportunity for adaptation and resiliency as sea levels rise.")

Virginia Department of Natural Resources. 2015. Report and Final Recommendations to the Governor. https://naturalresources.virginia.gov/media/5101/climate-commission-and-resiliency-update-commission-report.pdf. (Update to the 2008 Climate Change Action Plan. Policies include: considering climate impacts in all infrastructure planning and maintenance; "leverage[ing] federal funding to make coastal communities more resilient," and; improving baseline data on the carbon sequestration capacity of wetlands.)

Virginia Institute of Marine Science. 2016. Wetland Condition Assessment Tool (WetCAT). http://cmap.vims.edu/WetlandViewer/Virginia/WetCAT_VA.html. (Interactive map providing a spatial record of wetland permits and identifying wetland losses and gains over time.)

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2009. Climate Change Database Clearinghouse. http://ccrm.vims.edu/climate_change/index.html (Inventory of databases).

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2009. Vulnerability of shallow tidal water habitats in Virginia to climate change. http://ccrm.vims.edu/research/climate_change/index.html (Mapper for segments of shallow tidal habitats in Chesapeake Bay portion of Virginia).

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2010. Estuarine Blue Infrastructure: Priority Conservation Areas on the Seaside of Virginia's Eastern Shore. http://ccrm.vims.edu/resources/conservation_planning/Seaside_Final%20Report_FY07_Task96.01.pdf. (Analysis identifying aquatic areas for preservation based on habitat, ecosystem services, and proximity to upland priority conservation areas. In the assessment, climate factors were applied only to conservation areas deemed vulnerable to sea level rise.)

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2013. Comprehensive Coastal Resource Management Guidance Planning Information and Guidance for the Living Shoreline Preference. http://ccrm.vims.edu/ccrmp/Guidance_General.pdf (Overview guidance for choices on shoreline management).

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2016. Comprehensive Coastal Resource Management Portal. http://ccrm.vims.edu/ccrmp/index.html. (Portal collecting decision making tools tailored to local governmental needs. Information includes local conditions, risks to natural and built environments, preferred shoreline strategies, and opportunities for future shoreline resources, as well as model language.)

Virginia Institute of Marine Science, Center for Coastal Resources Management. 2016. Wetlands Mitigation Targeting Tool. http://www.ccrm.vims.edu/gis_data_maps/interactive_maps/wet_target/index.html. (Visualization tool that allows users to define parameters for their mitigation/restoration project. Intended to help decision-makers select appropriate sites for wetlands creation.)

Virginia Legislature. 2016. SB 282 Virginia Shoreline Resiliency Fund. https://lis.virginia.gov/cgi-bin/legp604.exe?161+sum+SB282. (Program creating loan program to help residents and businesses recover from recurring flooding.)

Warren Pinnacle Consulting, Inc. 2016. SLAMM: Sea Level Affecting Marshes Model. http://warrenpinnacle.com/prof/SLAMM/index.html. (Widely used tool that maps the "dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise.")

Watershed Resources Registry. 2015. Watershed Resources Registry. http://staging.mesgis.com/wrr/index.html. (Interactive mapping tool to help decision-makers in Maryland identify opportunities for restoration or preservation using a "Watershed Approach." Data used include sea level rise, wetlands, and blue and green infrastructure.)

Weber, J. T., and Bulluck, J. F.. Virginia Department of Conservation and Recreation, Division of Natural Heritage. 2014. Virginia Wetlands Catalog: An Inventory of Wetlands and Potential Wetlands with Prioritization Summaries for Conservation and Restoration Purposes by Parcel, Subwatershed, and Wetland Boundaries. Natural Heritage Technical Report. http://www.dcr.virginia.gov/natural-heritage/document/final-report-vdcr-wetlandcatalog.pdf. (Prioritization scheme to help the Agricultural Conservation Easement Program developed primarily to prioritize wetland parcels for conservation and restoration purposes.)

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