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Framework for a Coastal Ecological Adaptation Prioritization Support Tool: Methodology

Prepared for the New Jersey Coastal Management Program

Urban Coast Institute
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Executive Summary

Historically, coastal hazard mitigation and resilience has been approached from the perspective of hardening the coast to reduce the impact of long-term shoreline erosion, coastal storm surge, wave attack, and inundation, and more recently sea level rise. Prior protective measures were based on the widespread public perception that coastal change is primarily a hazard to property and infrastructure and that both hard and soft structural defenses are required to mitigate coastal hazards. In almost all instances, the benefits utilized to justify the cost of coastal protection projects are solely based on the value of reduced damages to private property and public infrastructure. There is, however, growing recognition that emphasizing natural and nature-based approaches for reducing coastal hazards can offer tremendous benefits to society through storm damage mitigation and natural resource restoration and preservation. In contrast to hard or traditional "gray" engineered structures, natural systems can offer equal or better hazard protection, avoid negative resource impacts, be able to respond dynamically to episodic changes, and potentially adapt to changing conditions over time.

Herein, a methodology for the development of a framework to prioritize the selection of ecological adaptation projects for coastal ecosystem and community resilience has been developed to 1) reduce the loss of existing coastal ecosystems that provide coastal resilience benefits through preserving, restoring and enhancing natural coastal resources, 2) support and enhance existing ecosystem services that provide socioeconomic, climate, and natural resource benefits, and 3) mitigate present and future risk associated with increasingly severe environmental conditions. The methodology is designed to identify potential natural and nature-based adaptations for ecosystem and coastal community resilience to climate change impacts at the ***landscape scale***. The objective is to prioritize those adaptations that address a particular issue of concern, such as coastal inundation, and are aligned with existing and/or future land use and management objectives. The goal is to provide a methodology that considers natural and nature-based adaptations on par with more traditional gray protection structures when planning and developing coastal flood-risk reduction projects.

The proposed methodology provides a high-level screening of a number of possible coastal ecological adaptations for specific coastal regions of New Jersey. The screening process utilizes readily available spatial data in the form of Geographical Information System (GIS) data layers housed and managed by the NJDEP and a rating scheme to identify the most viable natural and/or nature-base feature to address a particular issue of concern. The objective of the screening process is to apply an assessment scheme that prioritizes the preservation, enhancement and extension of existing coastal ecosystems followed by restoration of degraded areas and then the creation of new lands and ecosystems.

The screening scheme considers nine broad categories through which adaptation measures are assessed. Each screening category is associated with one of four broad planning objectives:

1. Is the adaptation consistent with existing and planned land uses?
2. What are the social and cultural impacts of the adaptation project?
3. What is the scale and connectivity of the adaptation?
4. What impact on infrastructure will that adaptation project create?

Within the planning objectives, two or more categories of measurable metrics are provided to assess each adaptation for its relevance to a specific objective. The metrics provide a numerical value for each adaptation that can be used to produce a ranked prioritization for users to consider in selecting the most appropriate adaptation measure for a specific area.

The Framework Methodology detailed in this report has been reviewed by coastal stakeholders and experts in the fields of biology, ecology, ecosystem management, conservation and restoration, engineering, and GIS-based technologies. This document reflects the recommendations and suggested changes provided by coastal stakeholders and external reviewers. The resulting Framework Methodology provides a georeferenced list of potential adaptations at the landscape scale that are aligned with the existing land use and management objectives, provides ecosystem benefits through scale and connectivity, and provides resilience to coastal communities, cultural resources, infrastructure and critical facilities. The identified coastal ecological adaptations can be used as a starting point for a more refined site specific analysis of adaptation projects and as a list of potential natural and nature-based infrastructure options to be considered alongside traditional gray coastal protection options during coastal resilience project planning.

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Introduction

Coastal resilience is often approached from the perspective of adapting the built environment to withstand and rapidly recover from a variety of natural coastal hazards that are driven by episodic events (storm surge, inundation, erosion) and long-term coastal changes (sea level rise). The anthropogenic view is based on widespread public perception that coastal change is primarily a hazard to property and infrastructure and that both hard and soft structural defenses are required to mitigate coastal hazards (Cooper and Jackson, 2019). There is a growing body of evidence, however, that indicates coastal ecosystems can, and often do, provide coastal protection and resilience to coastal communities (Shepard et al. 2011; Gittman et al. 2014; Narayan et al. 2017; Reguero et al. 2018) and that nature-based solutions, such as living shorelines, enhance the resilience of natural ecosystems and coastal communities (Smith et al. 2016). The ability of natural features to provide resilience is dependent on the health and integrity of the coastal ecosystem both now and in the future. In many locations, the ability of coastal ecosystems to provide resilience services is undermined by past and present human impacts and climate related stresses (Arkema et al. 2013) and further degradation or loss of these ecosystems will increase coastal risk (Hauser et al. 2015).

Coastal ecosystems are the most diverse and productive ecosystems on earth (Barbier et al. 2011). They occupy a very small percentage of the total biosphere and are intensively inhabited by humans (Cooper and Jackson, 2019). Coastal ecosystems are pristine resources that contribute to local and regional economies through tourism, fishing, and recreation. Natural resources such as beaches, dunes, wetlands, and marshes play a critical role in supporting fisheries, nutrient cycling, sustaining local economies and protecting coastal communities from storm surge and flooding. However, severe rates of coastal ecosystem degradation due to development, sea level rise, and increasing storm severity has led to a 50% loss of coastal marshes worldwide (Mossman et al. 2012). Over the past century parts of New Jersey such as Barnegat Bay have lost more than 25% of their salt marshes to infilling and development (Narayan et al. 2017). In the Delaware Estuary, approximately one acre per day of coastal wetlands are lost through conversion to tidal flats and open water (Partnership for the Delaware Estuary, 2012).

As coastal communities anticipate future hazards in a rapidly changing environment, it is important to pro-actively reduce risks to lives and livelihoods in ways that benefit people and the natural resources upon which the coastal economy relies. There is growing recognition that emphasizing natural and nature-based approaches for reducing coastal hazards can offer tremendous benefits to society through storm damage mitigation and natural resource restoration and preservation. In contrast to hard or traditional "gray" engineered structures, natural systems can offer equal or better hazard protection, avoid negative resource impacts, be able to respond dynamically to episodic changes, and potentially adapt to changing conditions over time.

This document provides a methodology for the development of a framework to prioritize the selection of ecological adaptation projects for coastal ecosystem and community resilience. The objectives of the prioritization framework are to 1) reduce the loss of existing coastal ecosystems that provide coastal resilience benefits through preserving, restoring and enhancing natural coastal resources, 2) support and enhance existing ecosystem services that provide socioeconomic, climate, and natural resource benefits, and 3) mitigate present and future risk associated with increasingly severe environmental conditions. The methodology is designed to be adaptable and scalable in recognition that any future ecological adaptation plans should be amended based on evolving knowledge, issues, needs, and societal preferences.

Purpose and Objectives

The purpose of this document is to present a methodology for the creation of a framework to support the prioritization of Coastal Ecological Adaptations (CEAs) for coastal resilience planning in New Jersey. The methodology is designed to identify potential natural and nature-based adaptations for ecosystem and coastal community resilience to climate change impacts at the ***landscape scale***. The objective is to prioritize those adaptations that address a particular issue of concern, are aligned with existing and/or future land use and management objectives, and that provide both coastal ecosystem and community resilience benefits. The methodology is ***not designed for*** site specific evaluation and project design but rather intended to guide planners and practitioners on the types and range of adaptation measures to consider within a specific region.

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Coastal Ecological Adaptations (CEAs)

All coastal communities in New Jersey are surrounded by ecological landscapes that benefit them in multiple ways (Small-Lorenz et al. 2017). New Jersey's beaches and dunes, maritime forests, tidal marshes, and subaqueous flora and fauna provide habitat, economic, recreational, aesthetic, and risk reduction benefits. The natural resources of the coast are increasingly threatened by climate change driven natural hazards due to sea level rise, increasing coastal storm frequency and intensity, inland flooding and runoff, shoreline erosion, and reduced water quality. Natural resource deterioration due to development, high population density and resource extraction has resulted in fisheries decline, nursery habitat reduction, filtering and detoxification reduction, lost carbon sequestration, and reduced coastal protection.

The 2015 Paris Agreement acknowledged for the first time that reducing carbon emissions is no longer enough to halt the impacts of climate change and established a Global Adaptation Goal (United Nations, 2015). Coastal Ecosystem-based Adaptation (EbA) is one of the strategies promoted by the United Nations to help people adapt to climate change in coastal areas. Coastal EbA is an approach that uses coastal ecosystem services as part of a holistic adaptation strategy that protects vulnerable communities from extreme weather while simultaneously providing a variety of ecological benefits crucial for human well-being, such as clean water and food. Though primarily an adaptation approach, EbA can also contribute to climate change mitigation by reducing the emissions that transpire from habitat loss and ecosystem degradation.

Coastal Ecological Adaptation (CEA) refers to the use of specific natural and nature-based features of ecosystems to moderate anticipated impacts from climate change to the environment and coastal communities. *Natural* approaches conserve, restore, or accommodate changes in existing natural systems for their ecosystem and risk reduction benefits. Riparian forests and floodplains can capture and store floodwaters to reduce downstream flooding impacts at the coast; healthy tidal marshes buffer coastal communities from flood waters and erosion, while supporting valuable fisheries and terrestrial habitats; beaches and dunes serve as buffers to storm surge and wave attack while providing habitat to beach dwelling wildlife (Small-Lorenz et al. 2017). In contrast to hard shore protection structures like seawalls, revetments, and bulkheads, natural systems have the ability to naturally recover after storm events and to adapt to changing conditions over time, including migrating inland as sea level rises. *Nature-based* features are engineered approaches that seek to mimic the risk reduction functions of natural systems. Living shorelines and engineered dunes often apply both natural and structural elements (hybrid structures) to provide both natural resources and risk reduction benefits. Nature-based approaches can offer equal or better hazard protection compared to hard structures, while avoiding the negative impacts of hard structures on the environment (Bridges et al. 2015) and can be applied to protect both coastal communities and coastal natural resources.

In the proposed framework methodology, a range of natural and nature-based coastal ecological adaptations are considered. Broadly, natural CEAs are those that conserve or restore existing ecosystems and nature-based CEAs are those that create new ecological elements and green infrastructure within an existing ecosystem. Table 1 lists the specific CEAs considered in the development of the methodology. The CEAs listed in Table 1 should not be considered a complete list of all possible ecological adaptations and should be appended as new green infrastructure concepts and land restoration techniques are identified and developed. It should also be recognized that as climate change impacts worsen, such as an acceleration in sea level rise, some CEAs will no longer be effective in providing resiliency benefits to ecosystems and communities. The adaptability of CEAs over time or the viable lifespan of a specific CEA should be considered in the assessment process.

TABLE 1: Ecological Adaptation Measures	
Conservation	**Restoration**
Marsh Preservation	Regional Sediment Management
Marsh Migration Corridors/Easements	Thin Layer Spreading
Tidal Flat Preservation	Hydraulic Restoration
Maritime Forest Preservation	Floodway Restoration
Maritime Forest Buffer	Sediment Supply
Maritime Forest Migration Corridors/Easements	Freshwater- Saltwater Marsh Conversion
Subaqueous Vegetation Conservation	Marsh Grass Plantings
Beach stabilization	Dune Planting
	Upland Barrier Removal
Creation	Dam Bypassing/Removal
Tidal Flat Creation	
Living Reef Creation	
Oyster Reef Creation	**Green Infrastructure**
Oyster Reef Sills	Living Shoreline Berms
Blue Mussel Beds	Living Shoreline Slopes
Marsh Edge Replacement of Sediment	Green walls/ Blue walls
Dredge Fill (within 1977 tidelands line)	Planted Revetment
Maritime Forest Planting	Bio-log Sills
Subaqueous Vegetation Creation	Raingardens/Bio-swales
Sandbar/Island Creation	Oyster Racks
Beach nourishment	
Dune Creation	**Gray Infrastructure**
Marsh Platform Construction	Dune Fencing
	Hybrid Coastal Structures (hard core)
	Eco-concrete
	Rock Sills
	Geotubes

Framework Methodology

The methodology is focused on developing a framework that will provide a high-level screening of CEAs for the selection and prioritization of potential projects in specific coastal regions of New Jersey. The screening process utilizes readily available spatial data in the form of Geographical Information System (GIS) data layers housed and managed by the Department of Environmental Protection (NJDEP) and a parametric scoring scheme to identify the most viable natural and/or nature-base feature to address a particular issue of concern for ecosystem and community resilience. The screening process applies an assessment scheme that identifies the preservation of existing coastal lands, and the restoration and the creation of new lands and natural features where possible (Figure 1). The assessment scheme rational is founded on the results of a multitude of scientific studies that all conclude that the preservation of existing landforms and habitats provide the maximum ecosystem and community resilience benefits (e.g., Gittman et al. 2014; Zhao et al. 2016; Negandhi et al. 2019).

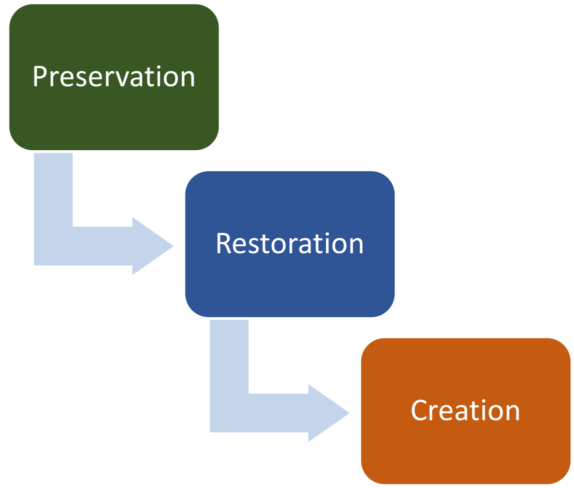

Figure 1. Assessment scheme applied by the Coastal Ecological Adaptation Prioritization Methodology.

The application of the CEA assessment methodology starts with the selection of the Issues of Concern (IOC) that needs to be addressed to promote ecosystem and community resilience. IOC represent natural processes and/or human activities that are generating stressors on the natural and built environment. The IOC are typically manifested through deterioration and damage to the environment such as habitat loss and degradation, shoreline erosion, coastal inundation and flood damage, impaired water quality, and the reduction of carbon sequestration. Addressing these IOC is the primary goal of the methodology when assessing ecological adaptations for coastal ecosystem and community resilience.

Once the desired IOC to be addressed have been identified, the screening scheme considers nine broad categories through which the CEA measures are assessed (Table 2). Each potential CEA measure is screened through the categories based on the assessment scheme presented in Figure 1. Each screening category addresses a number of broad planning objectives (PO): 1) Is the adaptation consistent with existing and planned land uses?, 2) What are the social and cultural impacts of the adaptation project?, 3) What is the scale and connectivity of the adaptation?, and 4) What impact on infrastructure will that adaptation project create? Figure 2 presents the screening categories associated with each planning objective.

TABLE 2: Assessment Categories
Existing Landform
Existing Land Use & Management Goals
Habitat Use
Social Impacts
Cultural Resource Impacts
Scale of Adaptation
Connectivity of Habitat
Infrastructure Impacts
Transportation Impacts

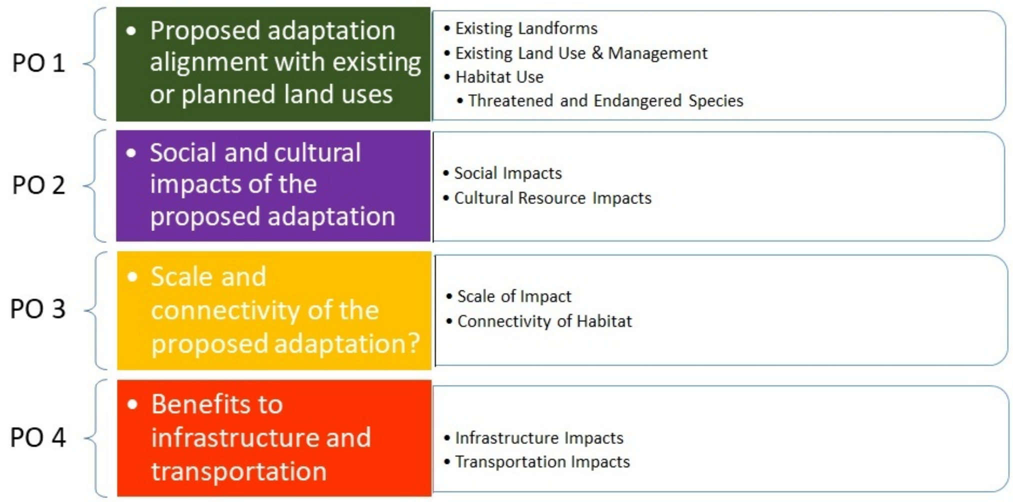

Figure 2. Alignment of Planning Objectives (PO) with Ecological Adaptation screening categories.

Planning objective 1 assesses how well aligned the proposed CEA is with the existing landscape, land use, and management goals of the location. A majority of the federal and state lands in New Jersey have been preserved as wildlife refuge and management areas. Additional coastal lands have been established as preservation and restoration areas and research reserves. PO 1 is designed to ensure that the proposed adaptation preserves, enhances, or restores the coastal lands in a way that supports the existing land use and management objectives and, at a minimum, does not negatively impact the present uses. PO 1 includes an assessment of threaten and endangered species that inhabit and/or use specific coastal lands to make sure that any proposed adaptation will have no negative impact on the natural resources that support these species. If the management objectives of the area of interest and/or the use by threatened and endangered species is anticipated to change in the future, the future use(s) condition can be used in the framework to evaluate proposed CEAs.

Panning objective 2 assesses the degree to which any proposed CEA positively affects coastal community resilience and the resilience of cultural and historic resources in the coastal zone. PO 2 provides a mechanism to screen adaptations that are located in or near coastal communities and prioritize those that enhance and improve the resilience of socially vulnerable populations. Adaptations that protect and create resilience for cultural and historic resources located within the influence of a proposed adaptation are prioritized over those that have a negligible impact on resilience. Population density within the area of a proposed ecological adaptation has the potential to negatively impact the success of CEAs through stressors such as impaired water quality, reduced sediment supply, and intense anthropogenic use of the natural resources. The CEA methodology, however, seeks to prioritize those adaptations that provide resilience to both ecosystems and coastal communities and therefore prioritizes those adaptations that provide resilience benefits to population centers where applicable.

Planning objective 3 is designed to evaluate the scale of proposed CEAs and how effective the adaptations are in connecting existing habitats. The objective is to prioritize those adaptations that span or extend across a large area of the coastal landscape or connect isolated habitats together. The PO 3 assessment scheme is based on the understanding that larger natural areas provide more ecosystem services (Chmura et al, 2003; Barbier et al. 2011) and coastal resilience benefits (Costanza et al. 2008; Narayan et al. 2017) than smaller or isolated habitats. Connectivity of coastal habitats is important to many species that migrate though New Jersey. For instance, many conservation areas in New Jersey are managed to support migratory bird flyways.

Connectivity of lands provide essential resources for birds migrating along the Atlantic flyway, which includes the Delaware Bayshore that has been deemed a flyway of global significance.

Planning objective 4 assesses the benefits to infrastructure and transportation systems that CEAs provide. There are many essential private and public critical facilities, utilities, and transportation corridors within the coastal zone. These include hospitals, public safety centers, highways, transportation centers, power plants, sewage and water treatment plants, electric, gas, and water transmission easements, as well as marinas and port and harbor facilities. PO 4 evaluates the benefits CEAs provide to increasing the resilience of the infrastructure against coastal hazards and filters out those adaptations that have the potential to negatively impact the operation and function of critical facilities and transportation systems.

Each of the nine categories include a number of sub-categories that provide measurable metrics that are scored through rating factors. Each metric is given a rating factor score (typically between 0 and 3) that is based on the underlying GIS data in the region of interest. Figure 3 presents the subcategories and evaluation metrics for assessing the scale of a propose CEA in the methodology. In this assessment category, adaptations that extend across a larger spatial area, as determined by the GIS data layers, receive a higher rating factor value (3) than those adaptations that only cover a small or isolated area (1). Note that CEAs that cover a small area still receive a rating of 1 since any adaptation is deemed better than none at all.

Category	Weight	Sub-Categories	Metrics	Rating Factor
7 - Influence Area		System-wide	Adaptation spans the entire ecosystem	3
			Adaptation extends existing ecosystem elements	2
			Adaptation connects disjointed segments of the existing ecosystem	2
			Adaptation is isolated from the broader ecosystem	1
		Regional	Adaptation spans the entire region	3
			Adaptation spans a segment of the region	2
			Adaptation convers an sub-regional (i.e., watershed) segment of the region	2
			Adaptation covers a small segment (<100 acres) of the region	1
		County	Adaptation spans the entire county	3
			Adaptation extends across three or more contiguous municipalities of the county	2
			Adaptation connects disjointed ecosystem segments within the county	2
			Adaptation covers a small area (<10 acres) of the county	1
		Municipal/Local	Adaptation spans the entire municipality	3
			Adaptation connected/extends existing open space within the municipality	2
			Adaptation connects disjointed ecosystem segments within the municipality	2
			Adaptation covers a small area (1 lot/block) of the municipality	1
		Lot & Block	Adaptation spans across multiple lots/blocks of a municipality	3
			Adaptation extends existing ecosystem elements across the lot/block	2
			Adaptation connects disjointed ecosystem segments across the lot/block	2
			Adaptation covers one lot/block) of the municipality	1

Figure 3. Sub-categories and associated metrics and rating factors for the Scale and Connectivity Assessment Category.

All CEAs that can address a specific IOC would be assessed through the scale and connectivity category of PO 3 and a category score assigned to each individual adaptation based on the sum of the subcategory rating factors. All CEAs would similarly be assessed through each of the other eight categories and assigned a category score. The nine category scores are then summed and the selected CEAs ranked on a descending scale providing a prioritization for users to consider in selecting the most appropriate adaptation measure. If specific categories are considered more important or relevant than others for a particular area or planning objective, the methodology allows for the weighting of each category based on expert judgement. Although flexible in its application, for an unbiased screening and prioritization of CEAs, framework categories should be weighted equally.

The methodology is designed to provide an initial assessment of potential adaptation locations and types for local and regional planning. Implementation of identified adaptations will require site-specific information and assessments prior to final selection and design of an ecological adaptation project. If more specific information is known about an area and/or the project objectives, the prioritization framework can be extended to include four additional categories to qualitatively assess the physical, economic, coordination, and constructability constraints that will govern the final selection of a specific CEA at a specific location. If available, the site specific data can be used as a way to further refine the prioritization of CEAs (Table 3).

TABLE 3: Additional Considerations
Physical & Environmental Conditions
Economic Factors
Plan Coordination
Feasibility of Construction and Maintenance

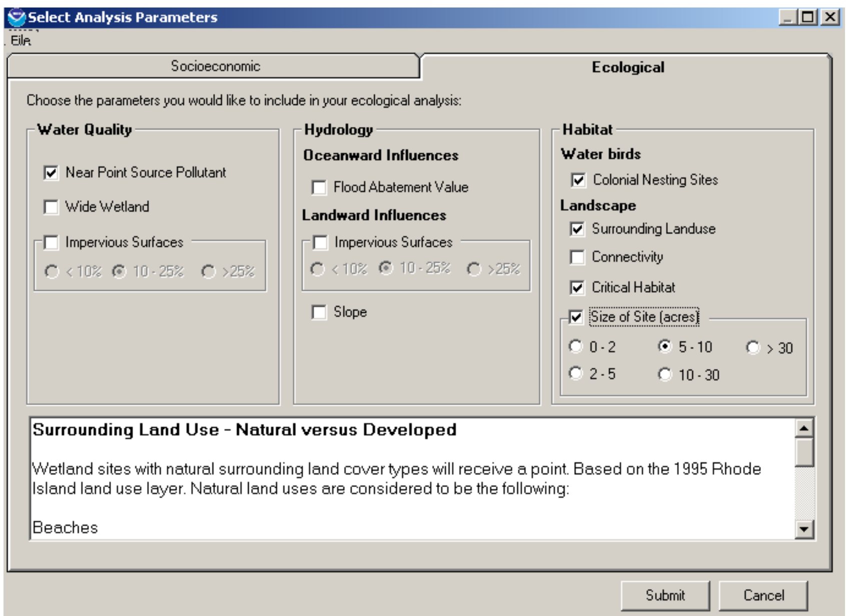

Figure 4. User defined ecological management objectives interface, Rhode Island Salt Marsh Restoration Site Selection Tool: *http://www.edc.uri.edu/restoration/html/spatial/modlsalt.htm*

Unlike the nine categories associated with the four broad planning objectives, the assessment categories listed in Table 3 have limited or no existing GIS data available for analysis and instead require user defined input based on data or expert judgement. Blended automated/user specified spatial analysis architectures are common among GIS-based assessment tools as a way to incorporate user defined data. In Figure 4, the dialog box allows the user to select from a number of predefined ecological management objectives to refine the selection of salt marsh restoration sites based on an underlying GIS land use layer. In other instances, the user interface may use slider bars to select from range of probable values such as local tide range, river discharge, and salinity range.

An expanded CEA methodology could provide a series of tables for users to select a range of present or future physical and environmental condition within an area of interest, identify the economic impacts on existing and future marine dependent industries, assess alignment with existing and planned coastal projects, and define the cost effectiveness, feasibility and operation and maintenance costs of a project. It is expected that only a limited amount of data will be available at a landscape scale, therefore, the user selected data elements of the methodology should only be viewed as providing a sensitivity analysis of possible CEAs based on limited physical and economic data or expert judgement.

Following, the details of the methodology of the Framework are provided starting with a description of the IOC followed by a description of the nine assessment categories and their associated subcategory metrics.

Photo courtesy of Monmouth University Urban Coast Institute

Coastal Issues of Concern (IOC)

The Issues of Concern represent the problems introduced by the dominant Drivers and Pressures that influence the conditions (e.g., ecosystem health and human well-being) of the coast (Texas GLO, 2017). Drivers can be social, economic or natural, and are largely external to the coastal system. Pressures resulting from these Drivers cause IOC along the coast, which directly disturb the established natural and built environments. For instance, social Drivers, such as an increase in the population density along the coast, may create Pressures on the coastal system by expanding development in natural areas. Economic Drivers, such as increased tourism, can cause Pressure on coastal environments through increased human exposure. Natural Drivers, like long-term changes in climate, can result in Pressures such as sea level rise and shifts in coastal storm frequency and intensity. The coastal IOC will not resolve themselves and, if left unaddressed, will continue to have adverse impacts on natural resources, infrastructure, economic activities, and the health and safety of residents and visitors (Texas GLO, 2017).

IOC can be addressed in a number of different ways. Structural solutions involve the construction of hard infrastructure such as seawalls, revetments and bulkheads, and elevating and hardening infrastructure and private property. Structural solutions are designed to reduce exposure and damage to the built environment and coastal populations caused by Natural Drivers and Pressures, often at the expense of the natural coastal systems. Green Infrastructure solutions are hybrid solutions that incorporate natural elements into hard structures to provide protection to infrastructure and communities while also providing ecosystem benefits that would otherwise be lost if a structural solution was applied. Natural and Nature-based solutions seek to provide reduced exposure, and resulting damage from Natural Drivers and Pressures by preserving and enhancing the natural coastal elements that provide ecosystem and community resilience.

The CEA Prioritization Methodology identifies areas where investments in the preservation, restoration and creation of natural and nature-based features address the IOC created by the Drivers and Pressures on the coastal zone. The current IOC include Coastal Ecosystem Degradation and Habitat Loss, Shoreline Erosion, Coastal Flood Damage, Nuisance Flooding, Coastal Storm Damage, Water Quality, and CO_2 Sequestration. The methodology is flexible such that additional IOC can be added as the coastal environment continues to respond to changing Drivers and Pressures over time.

Ecosystem Degradation and Habitat Loss

Land-use change, coastal development, erosion, subsidence and sea level rise have caused and are causing fragmentation and loss of coastal habitats and their ecosystem services. Fragmentation of estuarine wetlands caused from the construction of roads, mosquito ditching, and navigation channels has changed water circulation patterns and altered movements of sediment and nutrients to coastal ecosystems. In some instances, fragmented habitat may not be large enough or close enough in proximity to support species that need large territories. This also affects migratory species that are dependent upon large areas along their migration routes with access to resources for feeding and resting. Landscape changes from development, erosion, and relative sea level rise is reducing wetland area. Dams and reservoirs upstream of the coast limit the quantity of sediments reaching the coast, reducing sedimentation rates. In order for wetlands to maintain or expand their current coverage, the rates of sedimentation must be equal to or greater than the rate of relative sea level rise.

Coastal communities are directly affected by habitat alterations, degradation and losses. Coastal ecosystem degradation and habitat loss decreases their ability to provide the shoreline stabilization and flood risk reduction that protects infrastructure and communities from coastal hazards. Conservation and restoration of coastal habitats from loss and fragmentation is critical to the future health of ecosystems, coastal communities and economies.

Shoreline Erosion

Ninety-three of the ninety-eight miles of developed Atlantic Ocean shoreline of New Jersey is stabilized with engineered beaches and dunes. Since the armoring of the coastal bluffs in Monmouth County in the early 20th century, the New Jersey coastline has had no natural sources of beach sediments and is considered chronically eroding. To maintain an appropriate level of coastal storm damage risk reduction, the state of New Jersey continuously renourishes the oceanfront beaches every 4 to 8 years. Limitations in compatible sources of beach sand on the continental shelf is creating increasing demand for sand resources to mitigate shoreline erosion.

The shorelines of the Raritan, Sandy Hook, and Delaware Bays are characterized by low beaches and dunes fronting large marsh and wetland areas and, in low energy environments, salt marshes that extend to the edge of the Bays. The sheltered bay shorelines landward of the barrier islands have extensive salt marshes and tidal flats interspersed with sandy pocket beaches. The coastal bays are connected to the open sea by multiple inlets and have limited direct riverine inputs. Decreasing sediment supply from the Hudson and Delaware River estuaries since the late 19th century due to navigation channel dredging and the construction of dams has drastically reduced the sediment supply to all the bay shorelines and coastal bays (Mariotti and Fagherazzi, 2013). Shoreline erosion and breaching has led to recession of the coastline and the creation of large areas of open water where marshes once existed. Increasing open water area creates larger fetch for wave generation, resulting in greater shoreline erosion. In a regime of limited sediment supply, the negative feedback between erosion and increasing open water area will persist, accelerating shoreline erosion.

Shoreline erosion is a threat to public access and use of the coast, public and private property and infrastructure, and public health and safety. In addition to adversely affecting the built environment, persistent erosion of shorelines can compromise the integrity of the natural environment, leading to breaches that transport seawater and sand into estuaries, wetlands and marshes, changing ambient salinity gradients and land formations. Structures and structural defenses built along the shoreline can inhibit the natural landward movement of shoreline in response to sea level rise and storms. Habitat loss and degradation due to erosion compromise wildlife and recreational opportunities.

Beaches and dunes serve as a natural first line of defense from storm surge for inland populations, infrastructure, evacuation routes and coastal habitats by absorbing storm surge and waves. Natural or restored shorelines provide recreation areas and foraging and nesting habitat for wildlife, including threatened and endangered species, such as red knots and piping plovers. Mitigating erosion of these critical shoreline systems safeguards coastal habitats and natural resources, and prevents loss of life and property.

Coastal Flood Damage

Since 2009, NJ has added 4,524 homes worth $4.6 billion in the floodplain, mostly due to reconstruction after Sandy (Climate Central, 2019). Locally projected median increases in sea level of 0.8 ft by 2030 and 1.5 ft by 2050 (Kopp et al. 2014; Kopp et al. 2017) will increase the frequency of nuisance tidal flooding (Sweet et al. 2018) and the probability of moderate to severe coastal flooding and economic disruption (Hino et al. 2019) over the life of a 30-year mortgage. Pluvial and coastal flooding due to tropical systems and Nor'easters are the most frequent, destructive and costly natural hazards affecting New Jersey. Flood events can last from a few hours to several days under certain weather conditions. High tide events, in combination with increased watershed loadings from upstream precipitation, cause coastal flooding in low-lying areas and along rivers and streams. Increased development in the floodplain, wetland loss and ongoing processes such as erosion, subsidence and sea level rise exacerbate the impacts of coastal flooding.

Wetlands, salt marshes, maritime forests, beaches and dunes act as a system to attenuate floodwaters and reduce coastal flooding (Narayan et al. 2017). Seawalls, bulkheads and revetments stabilize the edge of coastal lands through the replacement of natural slopes and vegetation, reducing the floodplain width, deepening local water depths and increasing the depth and intensity of floodwaters locally and downstream. Continued landscape changes, particularly those that do not incorporate nature-based and green infrastructure features, will increase a coastal community's risk and exposure to flooding hazards, even in areas not previously prone to flooding.

Nuisance Flooding

Nuisance flooding (also described as "high tide" and "sunny day" flooding) is flooding that occurs at high tide that leads to public inconvenience such as roadway closures, an inability to leave one's house, overwhelmed storm drains, and compromised infrastructure. Relative Sea Level (RSL) rise of 4 mm/yr in New Jersey over the past century has increased the number of nuisance flooding events (defined by NOAA as water elevations 0.5m above the daily higher high tide) from 0 to 10 days/year since 1950 in Atlantic City. With RSL rise, the vertical gap between coastal infrastructure and the ocean surface will continue to decrease and the risk of flooding at high tide will continue to increase, and more so simply from the daily high tide, which today is very rare (Sweet et al. 2018). By 2050, under the U.S. Federal Interagency Sea Level Rise and Coastal Flood Hazard Task Force Intermediate Low (0.5 m) and Intermediate (1.0 m) projections of a global mean sea level rise, annual high tide flood frequencies along the Northeast Atlantic coast will increase to 45 and 130 days/year, respectively (Sweet et al. 2018). By 2100, high tide flooding is expected to occur a minimum of once per day for the Intermediate Low projection and twice per day for the Intermediate projection.

High tide floodwaters generally enter coastal communities through the storm water drainage system and by overland flow across salt marshes, low berms and maritime forests along the edge of developed areas. Nuisance flooding provides very little risk to existing coastal ecosystems that often rely on high tide inundation to sustain sedimentation, and salt tolerant plants and species. Expansive wetlands, salt marshes, maritime forests, beaches and dunes are effective in attenuating tidal flow and reducing nuisance flooding through bottom friction and increased land elevation. CEAs that provide topographical relief along the edge of developed areas and broad shallow bays and wetlands can reduce nuisance flood impacts to communities while increasing coastal ecosystem resilience. Storm water infrastructure can be altered to eliminate tidal inflow though outfall pipes (e.g., rubber discharge valves) or redesigned to limit discharge to occur only at low water elevations.

Coastal Storm Damage

Coastal storms present a major threat to the people and property along the highly populated coast of New Jersey. Coastal storms can also generate long-lasting impacts to the natural environment and coastal economy. Strong coastal storm events elevate the water level (storm tide) and generate large waves along the open coast. The elevated water levels enter the coastal bays through inlets and the estuaries through river mouths, inundation the low lying coastal plain. Elevated water levels also allow the large waves along the coast to break farther landward and at higher elevations along the shoreline generating coastal erosion. During extreme storm events, surge and wave action generate high velocity flood flow and can cause dune overtopping and erosion resulting in the movement of water inland, exposing structures and infrastructure to high velocity overland flow, scour, and direct wave attack that can lead to extensive damage. Overtopping of the coastline can also lead to the overwash and breaching of barrier islands and spits, transporting large volumes of sediment and salt water into shallow coastal bays and marshes. Coastal protection structures like seawalls and revetments can be overtopped by the surge and waves allowing the propagation of high-velocity flow and waves landward of the structure.

Coastal storm risk reduction measures that improve coastal resiliency are extremely cost effective compared to the tens of billions of dollars required to recover from coastal disasters. By restoring eroded coastal beaches and dunes prior to Sandy, the US Army Corps' beach nourishment projects in New York and New Jersey saved an estimated $1.3 Billion in avoided damages in what was a $65 Billion natural disaster (Castagna 2016). Similar storm damage protection levels can be provided to low lying marsh and wetland areas through the restoration of bayshore beaches and dunes, while at the same time increasing sandy habitat for horseshoe crabs and shorebirds. Restored beaches and dunes that can withstand and resist storm surge and wave generated erosion will reduce shoreline recession, maintain natural sediment supplies, and limit the conversion of coastal marshes and wetlands into open water and tidal flats. Conversion of existing hard structures to hybrid structures through sediment and vegetation covers will increase coastal resiliency by transforming static structures into dynamic protection elements that can adapt to changing environmental conditions. This is especially important when one realizes that the level of protection provided by existing coastal protection structures is reduced as sea levels continue to rise.

Water Quality

Water quality continues to be an issue along the coast, and in many places, the presence of contaminants leads to coastal water bodies being classified as impaired. Dense coastal development has increased non-point source pollution, sewage discharge, and chemical and nutrient inputs that negatively impact water quality in bays, estuaries, and nearshore environments. The conversion of coastal habitats to impervious cover has increased the amount of stormwater runoff into estuaries and bays. Non-point sources of water pollution include stormwater runoff from residential neighborhoods, commercial sites and agricultural fields. Urban and agricultural runoff carries waste, chemicals, fertilizers, pesticides, pet waste and other contaminants into bays and estuaries that can degrade water quality. Stormwater runoff carrying nutrient pollution, such as excess nitrogen and phosphorous, into coastal waterbodies leads to algae growth that depletes oxygen in the water, killing fish and other marine life. If the water temperature and nutrient conditions in the water reach certain levels, toxic cyanobacteria blooms can occur.

Additional sources of water pollutants include sewage effluents from sewage treatment plants and combined sewer overflow during rain events that lead to increased bacteria and viruses in water bodies. Water quality can also be impacted by oil spills and industrial activities, suspended sediments from boat activities, and illegal dumping of waste. Poor water quality leads to habitat and wildlife degradation, public health and safety issues, and negative economic impacts on tourism, recreation and commercial activities. Intercepting non-point source runoff with green infrastructure such as bioswales and rain gardens can filter out nutrients and contaminants before the water enters coastal water bodies. Elimination of combined sewer overflow systems and sanitary sewer overflows will reduce nutrients and contaminant loads on coastal systems. Prohibiting the use of specific fertilizers high in nitrogen and phosphorus in the coastal zone will reduce large algae blooms and low dissolved oxygen conditions, improving the health of seagrass beds, wetlands and other coastal habitats and the species they support.

Carbon Sequestration

Carbon dioxide is the most commonly produced greenhouse gas. Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide (CO_2) through geologic, biologic and technologic processes in an effort to reduce global warming and climate change impacts such as sea level rise. Terrestrial and aquatic ecosystems in the United States are significant carbon sinks, taking up approximately a quarter of the nation's CO_2 emissions (USGCRP, 2018). Terrestrial plants capture CO_2 from the atmosphere, and carbon is converted through photosynthesis and stored in plant biomass and in soils. Carbon is returned to the atmosphere as CO_2, or methane under anaerobic conditions, through respiration (Mcleod et al. 2011).

Coastal salt marshes sequester carbon within the underlying soils, which, due to vertical sediment accretion in response to sea-level rise, do not become saturated with carbon in the way that terrestrial sediments do (Mcleod et al. 2011). The rate of sediment carbon sequestration and the size of the sediment carbon sink may therefore continue to increase over time (Chmura et al. 2003). Another reason for the high carbon storage rate is that microbial decomposition is relatively slow in marine anaerobic soils, where sulfate reduction is the primary organic matter decomposition pathway (Weston et al. 2014). In natural salt marshes, anaerobic conditions are maintained by regular tidal inundation with sea water. Prior conversion of salt marshes for agriculture, flood risk reduction and insect control have largely been achieved through diking and draining of the land. Wetland draining alters the biogeochemical characteristics of the soils leading to lower carbon sequestration. The restoration of tidal flow to formerly drained marsh land has been found to greatly decrease aerobic decomposition and enhance carbon sequestration (Negandhi et al. 2019; Wang et al. 2019). The conversion of drained salt marshes back to tidally flowed wetlands will provide immediate benefits through restoring coastal ecosystem benefits and sequestering greenhouse gasses.

The ecosystem carbon sink can be highly variable over space and time due to natural disturbances and land use decisions. Coastal wetlands—salt marshes, mangroves, and seagrasses—have been identified as having the greatest carbon dioxide removal capacity of all coastal ecosystems. Long-term soil carbon burial rates of seagrass beds (138±38 g C/m^2 year), salt marshes (218±24 g C/m^2 year), and mangroves (226±39 g C/m^2 year), exceed those in forests (NAS, 2011). Nationally, marshes and mangroves store 3,190 million metric tons of CO_2 in the top 1 m of soil and sequester a net of about 8 million metric tons of CO_2 equivalents/year. In comparison, current wetland restoration efforts sequester 0.02 million metric tons of CO_2 equivalents/year (EPA, 2017). Given the large amount of CO_2 presently stored in coastal wetlands, the most significant climate mitigation opportunity is the avoidance of carbon emissions by preventing their loss, erosion, or drainage. Ensuring that salt marshes maintain their footprint and can adapt to sea level rise by migrating landward provides the greatest carbon sequestration and climate mitigation value (e.g., EPA, 2017).

Photo by T. Herrington

Photo courtesy of Monmouth University Urban Coast Institute

Coastal Ecological Adaptation Assessment Categories

The prioritization support methodology evaluates all of the identified CEAs that address a specific IOC through the nine assessment categories that support the planning objective detailed in the Framework Methodology section: (1) Existing Landform, (2) Land Use and Management, (3) Habitat Use, (4) Social Impacts, (5) Cultural Resources, (6) Scale of Impact, (7) Connectivity of Habitat, (8) Infrastructure Impacts, and (9) Transportation Impacts.

Existing Landform

The existing coastal landforms of New Jersey are identified using the Anderson landform classification system modified by NJDEP[1]. The coastal landforms applied in the methodology include Low and High Salt Marsh, Freshwater Marsh, Bog, Swamp, Tidal Flat, Submerged Vegetation, Maritime Forest, Beach and Dune, and Coastal Headland. A description of the Land Use/Land Cover (LU/LC) data can be found in Table 4 and the layers can be downloaded at https://www.nj.gov/dep/gis/lulc12c.html. After merging the LU/LC data for the whole state, the layers represent the complete extents of different landform types in New Jersey. A map of existing landform layers can be accessed at: https://arcg.is/0Sb14X. Existing GIS layers were readily available for all of the coastal landforms except maritime forest and coastal headlands. Layers containing the missing land convers may be available from federal agency or academic sources (Appendix A).

The ten landforms that make up the measurable subcategories and the rating metrics are presented in Figure 5. The existing landform metrics are designed to assess how well aligned CEAs proposed within the boundary or immediately adjacent to a specific LU/LC are with the landform classification. CEAs that preserve or extend the existing LU/LC classification are rated the highest (3) and those that restore or enhance the existing landform given a rating of 2.

[1] A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U. S. Geological Survey Professional Paper 964, 1976; edited by NJDEP, OIRM, BGIA, 1998, 2000, 2001, 2002, 2007, 2012 https://www.state.nj.us/dep/gis/digidownload/metadata/lulc12/anderson2012.html

Table 4. Existing landform GIS layers linked to CEA Assessment Methodology

Adaptation measure	LU/LC class	LU/LC code	LU/LC description	Layer name
Salt Marsh (low)	Saline Marsh (Low marsh)	6111	Primarily flooded herbaceous vegetation less than a foot above mean high water[1]	Low_Salt_Marsh
Salt Marsh (high)	Saline Marsh (High marsh)	6112	Intermittently flooded herbaceous vegetation 1-3 feet above mean high water[1]	High_Salt_Marsh
Freshwater Marsh	Herbaceous Wetlands	6240	Herbaceous vegetation in non-tidal wetlands	Freshwater_Marsh
Bog	Included in above class	-	-	-
Swamp	Combination[2]	6210-6221 and 6251-6252	A combination of mature wooded wetland types	Wooded_Wetland
Tidal Flat	Tidal Mud Flat	5412	Unvegetated areas next to tidal water bodies	Tidal_Flat
Submerged Vegetation	Submerged Aquatic Vegetation[3]	-	Submerged aquatic vegetation mapped for Barnegat Bay and Little Egg Harbor	Submerged_Vegetation
Maritime Forest	Not available[4]	-	-	-
Beach and Dune	Beaches and Vegetated Dune Communities	6130 and 7100	Open beaches and vegetated/unvegetated dunes	Beach_and_Dune
Coastal Headland	Not available[5]	-	-	-

[1]Units of "mean high water" are inferred since description does not specify units
[2]Combination includes Deciduous Wooded Wetlands, Coniferous Wooded Wetlands, Atlantic White Cedar Wetlands, Mixed Wooded Wetlands (Deciduous Dominant), and Mixed Wooded Wetlands (Coniferous Dominant)
[3]A Rutgers dataset (https://crssa.rutgers.edu/projects/sav) that maps submerged aquatic vegetation for Barnegat Bay and Little Egg Harbor last updated in 2009
[4]Does not correspond to a LU/LC class, and extensive internet search revealed no specialized map product for maritime forest (see an example for the state of Virginia at http://ccrm.vims.edu/gis_data_maps/data/maritimeforest)
[5]Does not correspond to a LU/LC class, and extensive internet search revealed no specialized map product for coastal headland

Category	Weight	Sub-Categories	Metrics	Rating Factor
1 - Existing Landform		Salt Marsh (low)	Preserves and/or extends existing low marsh	3
			Restores and/or enhances existing low marsh	2
			Not Aligned but Negligible impact on existing low marsh	1
			Not Aligned and Potential for Negative Impacts to existing low marsh	0
		Salt Marsh (high)	Preserves and/or extends existing high marsh	3
			Restores and/or enhances existing high marsh	2
			Not Aligned but Negligible impact on existing high marsh	1
			Not Aligned and Potential for Negative Impacts to existing high marsh	0
		Freshwater Marsh	Preserves and/or extends existing freshwater marsh	3
			Restores and/or enhances existing freshwater marsh	2
			Not Aligned but Negligible impact on existing freshwater marsh	1
			Not Aligned and Potential for Negative Impacts to existing freshwater marsh	0
		Bog	Preserves and/or extends existing bog land	3
			Restores and/or enhances existing bog land	2
			Not Aligned but Negligible impact on existing bog land	1
			Not Aligned and Potential for Negative Impacts to existing bog land	0
		Swamp	Preserves and/or extends existing swamp land	3
			Restores and/or enhances existing swamp land	2
			Not Aligned but Negligible impact on existing swamp land	1
			Not Aligned and Potential for Negative Impacts to existing swamp land	0
		Tidal Flat	Preserves and/or extends existing tidal flat	3
			Restores and/or enhances existing tidal flat	2
			Not Aligned but Negligible impact on existing tidal flat	1
			Not Aligned and Potential for Negative Impacts to existing tidal flat	0
		Submerged Vegetation	Preserves and/or extends existing submerged vegetation	3
			Restores and/or enhances existing submerged vegetation	2
			Not Aligned but Negligible impact on existing submerged vegetation	1
			Not Aligned and Potential for Negative Impacts to existing submerged vegetation	0
		Maritime Forest	Preserves and/or extends existing Maritime Forest	3
			Restores and/or enhances existing Maritime Forest	2
			Not Aligned but Negligible impact on existing Maritime Forest	1
			Not Aligned and Potential for Negative Impacts to existing Maritime Forest	0
		Beach & Dune	Preserves and/or extends existing beach & dune	3
			Restores and/or enhances existing beach & dune	2
			Not Aligned but Negligible impact on existing beach and dune	1
			Not Aligned and Potential for Negative Impacts to existing beach and dune	0
		Coastal Headland	Preserves and/or extends existing coastal headlands	3
			Restores and/or enhances existing coastal headlands	2
			Not Aligned but Negligible impact on existing coastal headlands	1
			Not Aligned and Potential for Negative Impacts to existing coastal headlands	0

Figure 5. Landform Assessment categories, metrics, and rating factors.

The prioritization of preservation and extension over restoration and enhancement is based on the significantly greater ecosystem benefits provided by existing natural systems than those provided by restored landforms (e.g., EPA, 2017). CEAs that are not aligned with the existing LU/LC classification but will have a negligible impact on the landform are given a rating factor of 1. An example of a CEA that may not be aligned with the landform but has negligible impact are those that stabilize an eroding shoreline with material different from the existing landform. By awarding a rating factor of 1, the CEA is valued for the positive benefits it will provide to the ecosystem but not as highly as those CEAs that provide similar ecosystem services to that of the existing landform. If the CEA is not aligned with the LU/LC classification and will have a negative impact on the landform it is given a rating factor of 0 to discourage the use of CEAs that will degraded the existing ecosystem.

The existing landform assessment category is purposely designed to promote those CEAs that conserve or restore existing landforms. The metrics and rating factors rate highly preservation, the creation of landform migration corridors, acquisition of lands adjacent to the landform, and the restoration and creation of similar landforms within or adjacent to the existing landform. CEAs that are associated with different LU/LC classifications are not prioritized unless they provide some positive benefit to the landform such as stabilizing an eroding edge, restoring hydraulic connectivity, and adapting the landform to adjust to climate change drivers. In the application of the existing landform assessment, it is anticipated that the CEAs will only be evaluated within the subcategory related to the existing LU/LC classification.

Existing Land Use and Management Goals

Land use and management describes different forms of land management that can be related to adaptation measures (i.e., does the adaptation measure align with the existing land management program?). The coastal land use and management subcategories applied in the methodology include Public Property, Federal Wildlife Refuges, State Wildlife Management Areas, National Estuary Program Areas, National Estuarine Research Reserve Locations, Federal Coastal Barrier Resource System Areas, National Parks, State, County, and Local Parks and Recreation Areas, and Private Property. Land management layers are from various data sources, most of which are different land management programs, like the National Wildlife Refuge System. Land ownership (i.e. public versus private) is distinguished using statewide property parcel data. The layers derived from land management programs and property parcel data are described in Table 5. A map of existing land use/management layers can be accessed at: https://arcg.is/04aLub and the individual layers can be downloaded from:
https://monmouth.maps.arcgis.com/home/item.html?id=4f340dccea814df2939985b1263f5448.

The nine land use/management subcategories and the rating metrics are presented in Figure 6. The land use and management metrics are designed to assess how well aligned CEAs proposed within the boundary or immediately adjacent to a specific use and/or management area are with present or future use and management objectives. CEAs that are located within managed lands and aligned with the specific use or management objective of an area are rated the highest (3) in the matrix. CEAs that are located adjacent to existing managed lands and aligned with the management objectives are given a rating factor of 2 and those that are adjacent but not aligned with the management and use goals rated a 1. CEAs that are within managed lands but not aligned with the specific use or management objective are not prioritized and given a rating factor score of 0.

The objective of the assessment is to prioritize CEAs that are within and support the existing use and management objectives of designated areas as a way to filter out CEAs that support conflicting objectives. Landowners adjacent to managed lands are not required to support the management objectives of those lands but the assessment methodology seeks to prioritize CEAs on adjacent lands that support the land management and use goals of the area. CEAs that are not aligned with the adjacent land management/use objective but that support ecosystem and community resilience are prioritized but not as strongly. CEA

Table 5. Land Management and Property Parcel GIS layers linked to CEA Assessment Methodology

Adaptation measure	Data source	Layer description	Layer name
Public Property	New Jersey Property Parcels	Public property based on 15C property class code	Public_Property
Federal Wildlife Refuge Area	US Fish and Wildlife Service Cadastral Database	Lands in the National Wildlife Refuge System	Federal_Wildlife_Refuge
State Wildlife Management Area	New Jersey Open Space Dataset	Wildlife management area owned by NJDEP	State_Wildlife_Refuge
National Estuary Program	NEPmap	National Estuary Program boundaries	National_Estuary
National Estuarine Research Reserve	NERR Centralized Data Management Office	National Estuarine Research Reserve boundaries	Estuary_Reserve
Coastal Barrier Resources System	CBRS Digital Data	Coastal Barrier Resources System boundaries	Coastal_Barrier
National Park	National Park Service Official Service-wide Dataset	National Park Service boundaries	National_Park
State, County, Local Park and Recreation Area	New Jersey Open Space Dataset	Variety of open spaces for preservation and recreation (excludes wildlife management areas owned by NJDEP)	Open_Space
Private Property	New Jersey Property Parcels	Private property based on 2 (residential), 3A/3B (farm), 4A (commercial), 4B (industrial), and 4C (apartment) property class codes	Private_Property

Category	Weight	Sub-Categories	Metrics	Rating Factor
2 - Land Use/Management		Public Property	Adaptation is on public land and aligned with public use	3
			Adaptation is on adjacent private land and aligned with public use	2
			Adaptation is on adjacent private land but not aligned with public use	1
			Adaptation is on public land but not aligned with public use	0
		Federal Wildlife Refuge Area	Adaptation is on refuge land and is aligned with wildlife management goals	3
			Adaptation is adjacent to refuge land and is aligned with wildlife management goals	2
			Adaptation is adjacent to refuge land but not aligned with wildlife management goals	1
			Adaptation is on refuge land but not aligned with wildlife management goals	0
		State Wildlife Management Area	Adaptation is on wildlife management land and is aligned with wildlife management goals	3
			Adaptation is adjacent to wildlife management land and is aligned with wildlife management goals	2
			Adaptation is adjacent to wildlife management land but not aligned with wildlife management goals	1
			Adaptation is on wildlife management land but not aligned with wildlife management goals	0
		National Estuary Program	Adaptation is within a NEP area and is aligned with management goals	3
			Adaptation is adjacent to a NEP area and is aligned with management goals	2
			Adaptation is adjacent to a NEP area but not aligned with management goals	1
			Adaptation is within a NEP area but not aligned with management goals	0
		NERR Location	Adaptation is within a reserve and is aligned with management goals	3
			Adaptation is adjacent to a reserve and is aligned with management goals	2
			Adaptation is adjacent to a reserve but not aligned with management goals	1
			Adaptation is within a reserve but not aligned with management goals	0
		Designated Coastal Barrier Resources System Area	Adaptation is within a CBRS area, is not federally funded and is aligned with CBRS goals	3
			Adaptation is adjacent to a CBRS area and is aligned with CBRS goals	2
			Adaptation is adjacent to a CBRS area but not aligned with CBRS goals	1
			Adaptation is in a CBRS area but not aligned with CBRS goals or is federally funded	0
		National Park	Adaptation is within a National Park and is aligned with conservation goals	3
			Adaptation is adjacent to a National Park and is aligned with conservation goals	2
			Adaptation is adjacent to a National Park but not aligned with conservation goals	1
			Adaptation is within a National Park but not aligned with conservation goals	0
		State, County, Local Park & Recreation Areas	Adaptation is within a State, County, or Municipal Park and is aligned with preservation goals	3
			Adaptation is adjacent to a State, County, or Municipal Park and is aligned with preservation goals	2
			Adaptation is adjacent to a State, County, or Municipal Park but not aligned with preservation goals	1
			Adaptation is within a State, County, or Municipal Park but not aligned with preservation goals	0
		Private Property	Adaptation is on private property and being constructed by property owner	3
			Adaptation is on private property and being constructed within an easement	1
			Adaptation is on private property without owners consent	0

Figure 6. Land Use and Management Assessment categories, metrics, and rating factors.

projects on public lands and those that are on private land, if implemented by the landowner, are encouraged in the assessment but not those that are not aligned with the public good or without a property owner's consent.

Habitat Use

The NJDEP presently provides GIS layers for habitat cores and corridors in New Jersey through Connecting Habitat Across New Jersey (CHANJ[2]). CHANJ represents a statewide habitat connectivity plan, developed in collaboration with a multi-partner, multi-disciplinary working group representing over 40 different agencies across the state to address the importance of landscape permeability for the persistence of native terrestrial wildlife species. CHANJ mapping identifies core terrestrial wildlife habitat and corridors connecting them across the state, as well as intersecting road segments that serve as road barriers to mitigation opportunities. The mapping is based on a naturalness index approach and does not identify all species and habitat use. Additional resources at the landscape scale include the US Fish and Wildlife Service Nature's Network[3] that identifies a network of places that help define the highest conservation priorities in the Northeast region to sustain natural resources and imperiled species. Nature's Network was created by the North Atlantic Landscape Conservation Cooperative and the Northeast Association of Fish and Wildlife Agencies in coordination with a team of partners from 13 states (including New Jersey), the U.S. Fish and Wildlife Service, nongovernmental organizations, and universities, to develop a regional conservation design that provides a foundation for unified conservation action from Maine to Virginia.

The habitat use assessment applied in the methodology is designed to identify those critical core habitats that support coastal dependent species, including Threatened & Endangered Species, Migratory Flyways of Significance, Essential Fish Habitat, Rookeries, and Marine Mammal Habitat, and assess whether or not a specific CEA is in alignment with the habitat uses. Not all of the habitat information required by the assessment methodology is presently available but the CHANJ and Nature's Network data layers provide a foundation for developing a coastal habitat GIS data layer for New Jersey.

The five habitat use subcategories and the rating metrics are presented in Figure 7. CEAs that are located within an existing habitat use and that conserve or enhance that use are rated the highest (3) in the matrix. CEAs that create or restore habitat for use by species are given a rating factor of 2 and those that provide no habitat benefits are rated as a 1. CEAs that will negatively impact the habitat are not prioritized and given a rating factor score of 0. The fact that the metrics and rating factors rate conservation and enhancement of habitat greater than the creation and restoration of new habitat is again based on the significantly greater ecosystem benefits provided by existing natural systems than those provided by new or restored habitat. CEAs that provide no habitat benefits but provide some positive benefit to habitat stabilization are valued but not as highly as those that enhance the habitat.

[2] https://gisdata-njdep.opendata.arcgis.com/datasets/terrestrial-wildlife-habitat-cores-and-corridors-in-new-jersey-connecting-habitat-across-new-jersey-chanj

[3] http://www.naturesnetwork.org/about/

Category	Weight	Sub-Categories	Metrics	Rating Factor
3 - Habitat		Threatened & Endangered Species	Adaptation will conserve or enhance existing conditions that support use by threatened and endangered species	3
			Adaptation will create or restore conditions that support use by threatened and endangered species	2
			Adaptation will provide no benefits to threatened and endangered species	1
			Adaptation will negatively impact conditions that support use by threatened and endangered species	0
		Migratory Flyway of Significance	Adaptation will conserve or enhance areas along a migratory flyway	3
			Adaptation will create or restore conditions that support a migratory flyway	2
			Adaptation will provide no benefits to migratory flyways	1
			Adaptation will negatively impact conditions along a migratory flyway	0
		Essential Fish Habitat	Adaptation will conserve or enhance essential fish habitat	2
			Adaptation will create or restore essential fish habitat	2
			Adaptation will provide no benefits to essential fish habitat	1
			Adaptation will negatively impact essential fish habitat	0
		Rookery	Adaptation will conserve or enhance existing rookery areas	3
			Adaptation will create or restore rookery areas	2
			Adaptation will provide no benefits to rokery areas	1
			Adaptation will negatively impact existing rookery areas	0
		Marine Mammals	Adaptation will conserve or enhance the use of the area by Marine Mammals	3
			Adaptation will create or restore areas for use by Marine Mammals	2
			Adaptation will no benefit to the use of the are by Marine Mammals	1
			Adaptation will negatively impact or prevent the use of the are by Marine Mammals	0

Figure 7. Habitat Use Assessment categories, metrics, and rating factors.

Social and Cultural Resources

Social impacts describe demographic and cultural factors that should be considered when evaluating the benefits a CEA provides to coastal communities. Demographic factors include population density and indicators of vulnerability to hazards. Cultural factors are historic/cultural resources. The social impact of CEAs are assessed against the size of the population that the CEA benefits and the percentage of that population that is identified as socially vulnerable. The resilience benefits to cultural resources provided by CEAs is assessed based on the proximity of the CEA to a mapped historic or archeological resource. This is reflective of the goal of the CEA methodology to prioritize those adaptations that provide resilience to both ecosystems and coastal communities and therefore prioritizes those adaptations that provide resilience benefits to population centers, socially vulnerable populations and cultural resources.

Population density is mapped at the county scale using official boundaries of the New Jersey Office of Information Technology (http://njogis-newjersey.opendata.arcgis.com/datasets/new-jersey-counties) and population estimates from the 2017 American Community Survey Demographic and Housing Estimates survey, DP05, downloaded at https://data.census.gov/cedsci/. The county population estimate is divided by the county square miles provided in the layer named County Population. Indicators of hazard vulnerability are used to assess socially vulnerable populations (Bickers, 2014). A sample of these indicators have been compiled using 2017 US Census tracts downloaded at https://www.census.gov/cgi-bin/geo/shapefiles. The indicators are extracted from various 2017 American Community Survey products available for download at https://data.census.gov/cedsci/. Each indicator is used to categorize tracts based on quartiles (i.e. tracts in upper quartile, tracts > 25% and < 75% of tracts, and tracts in the lower quartile). Tracts then receive ranks from 1-3, with larger numbers indicating more potential vulnerability. Tracts are categorized using the sample of indicators described in Table 6.

Table 6. Sample indicators to assess socially vulnerable populations in the CEA assessment methodology

Indicator	Survey product	Indicator[1] description	Field name[2]
Poverty	DP03	Percentage of people below poverty level	POVRANK (POV2017)
No High School Education	S1501	Percentage of people 25 years and over without a high school degree	NOHSRANK (NOHS2017)
Single-Parent Household	DP02	Percentage of family households with a single parent for children under 18 years old	SINGLERANK (SINGLE2017)
Renter	DP04	Percentage of occupied homes occupied by renters	RENTERRANK (RENTER2017)
Limited English	DP02	Percentage of people 5 years and over who speak a language other than English and do not speak English "very well"	ESLRANK (ESL2017)
Minority	DP05	Percentage of people belonging to the following minority groups: (1) Black, (2) Native American, (3) Asian, (4) Hawaiian or Pacific Islander, (5) some other group, (6) multiple groups, and (7) Hispanic	<group name>RANK (<group name>2017)
No Vehicle	DP04	Percentage of occupied homes with no vehicles available	NOCARRANK (NOCAR2017)

[1] Indicators are attribute columns (fields) in the map layer named Social_Vulnerability
[2] Ranked indicator percentages to determine potential social vulnerability

Historic and cultural resources are mapped based on historic properties and archaeological sites. Historic properties of New Jersey can be downloaded at https://gisdata-njdep.opendata.arcgis.com/datasets/historic-properties-of-new-jersey. The dataset is a product of NJDEP, and includes historic properties recognized by various federal and state agencies. Properties that have been delisted or are ineligible are excluded from the historic properties layer named Historic_Property.

Archaeological sites mapped by NJDEP can be downloaded at https://gisdata-njdep.opendata.arcgis.com/datasets/archaeological-site-grid-of-new-jersey. The sites are mapped using a grid of about 0.5-square-mile grid cells to protect the exact location of sites. Grid cells including identified archaeological sites are in the layer named Archaeological_Site.

The two social impact and one historic and cultural resource subcategories and the associated rating metrics are presented in Figure 8. CEAs that benefit larger populations and percentages of socially vulnerable people are rated higher in the social impact assessment. The closer a CEA is to a designated cultural (archaeological) or historic resource the higher the rating factor of the CEA. The assessment method does prioritize CEAs that benefit low population centers (<500 people) and those that provide no benefits to socially vulnerable populations (rating factors of 1) but not as highly as those that do. This is not to say that CEAs that benefit low or unpopulated areas only are not desirable but rather to prioritize those CEAs in the methodology that maximizes the benefits to ecosystems and communities.

Scale and Connectivity of Habitat

The scale and connectivity of a CEA is evaluated using an influence area, such as an ecosystem or region. The influence area is used to evaluate if a CEA spans the entire area, part of the area, or extends/connects the area. The scale of an influence area ranges from a large system, such as coastal waterways, to individual property parcels. Natural or legal boundaries can delineate influence areas. Influence areas are project specific (e.g. the influence area of a wetland restoration is a wetland layer). Thus, the layers presented here are a sample of possible influence areas. Table 7 arranges influence areas from large to small, and presents different boundary types (natural/legal) for the evaluation of adaptation measures.

Table 7. A sample of influence areas mapped using various GIS layers that delineate natural or legal boundaries. The layers are in order from large- to small-scale influence areas.

Influence area	Data source	Layer description	Layer name
System-wide	NJDEP 2012 LU/LC (2015 Update)	Two examples of system-wide layers covering (1) all coastal marshes and (2) all coastal waterways	Coastal_Marsh, Coastal_Waterway
Regional	NJDEP Landscape Regions	Regions of ecologic similarity	Landscape_Region
County	New Jersey Counties	County boundaries	County
Municipal	New Jersey Municipalities	Municipal boundaries	Municipality
Lot	New Jersey Property Parcels	Property parcels divided into public and private property as previously described in the Land Use/Management section (see Table 2, first and last entries)	Public_Property, Private_Property

Category	Weight	Sub-Categories	Metrics	Rating Factor
4 & 5 - Social & Cultural Resources		Population Density	> 5,000 people/sq. mile	3
			1,000 people/sq. mile to 5,000 people/sq. mile	2
			500 people/sq. mile to 1,000 people/sq. mile	1
			< 500 people/sq. mile	1
		Socially Vulnerable Populations	Census Tracts within the Upper Quartile (top 75%)	3
			Census Tracts within the Middle Quartile (Between 25% - 75%)	2
			Census Tracts within the Lower Quartile (bottom 25%)	1
			Areas outside coverage of CDC	1
		Historic & Cultural Resources	Areas within NJ Archaeological Grid or Historic District	3
			Areas adjacent to a NJ Archeological Grid or Historic District	2
			Areas within 500 ft of a Cultural & Historic resource or property	1
			Areas not located in the designations above	1

Figure 8. Social and Cultural Resource Assessment categories, metrics, and rating factors.

Category	Weight	Sub-Categories	Metrics	Rating Factor
6 & 7 - Scale and Connectivity		System-wide	Adaptation spans the entire ecosystem	3
			Adaptation spans or extends existing ecosystem elements	2
			Adaptation connects disjointed segments of the existing ecosystem	2
			Adaptation is isolated from the broader ecosystem	1
		Regional	Adaptation spans the entire region	3
			Adaptation spans or extends a segment of the region	2
			Adaptation connects disjointed segments of the region	2
			Adaptation covers a small segment (<100 acres) of the region	1
		County	Adaptation spans the entire county	3
			Adaptation extends across three or more contiguous municipalities of the county	2
			Adaptation connects disjointed ecosystem segments within the county	2
			Adaptation covers a small area (<10 acres) of the county	1
		Municipal/Local	Adaptation spans the entire municipality	3
			Adaptation spans or extends existing open space within the municipality	2
			Adaptation connects disjointed ecosystem segments within the municipality	2
			Adaptation covers a small area (1 lot/block) of the municipality	1
		Lot & Block	Adaptation spans across multiple lots/blocks of a municipality	3
			Adaptation spans or extends existing ecosystem elements across the lot/block	2
			Adaptation connects disjointed ecosystem segments across the lot/block	2
			Adaptation covers one lot/block) of the municipality	1

Figure 9. Scale and Connectivity Assessment categories, metrics, and rating factors.

The scale and connectivity assessment applied in the methodology is designed to identify opportunities for conserving, expanding, and connecting habitats and ecosystems in recognition of the importance of scale in landscape ecosystem services provided and permeability for the persistence of native terrestrial and aquatic wildlife species. The scale (coverage area) of an coastal landforms such as marshes, eel grass beds, tidal flats, and maritime forests is also directly proportional to the ecosystem service benefits (e.g., habitat, coastal protection, carbon sequestration) the landforms provide (Barbier et al. 2011). Interconnected habitats and ecosystems increase species range and migration corridors.

Scale and connectivity is assessed through five subcategories of descending scale: System-wide, Regional, County, Municipal/Local, and Lot & Block (Figure 9). CEAs are evaluated by the extent of coverage within each scale category or if they connect disjointed segments of a habitat and/or ecosystem. CEAs that span an entire system, region or area are rated highest (3) in the matrix. CEAs that span or extend a portion of the system, region, or area, or connect disjointed segments of the ecosystem are given a rating factor of 2. CEAs that cover isolated elements or small areas of a system, region or area are given a rating factor score of 1. The assessment method reflects the objective to protect and/or enhancing the entirety of an existing ecosystem and services that those ecosystems provide. Extending and connecting existing ecosystems is also a high priority in the assessment method and could be rated as a 3, especially if conserving an area extends an ecosystem or connect to existing natural areas. CEAs could also be used to extend and connect existing ecosystem, however, the ecosystem services benefits of the CEAs would be lower than conserving an existing area, and therefore the assessment methodology provides these two methods with a rating factor of 2. CEAs that conserve, extend or create new ecosystem elements are still provide ecosystem service value over implementing hard structures and the methodology reflects this by providing small CEAs with a rating factor of 1.

Infrastructure and Transportation Impacts

CEAs can be implemented to provide resilience benefits to infrastructure and transportation corridors that in turn increase the resilience of coastal communities. The location of a CEA relative to a critical facility or roadway is the primary factor used to assess the impact the CEA will have on providing resilience. Infrastructure data for the United States is primarily available via Homeland Infrastructure Foundation-Level Data (HIFLD). However, some state sources, like the New Jersey Office of Information Technology (NJOIT), also offer infrastructure data. A number of infrastructure layers used in the methodology from various sources are described in Table 8.

Table 8. A sample of GIS layers for infrastructure used in the CEA assessment methodology

Infrastructure	Data source	Layer description	Layer name
Hospital	NJOIT	Point locations for any type of hospital	Hospital
Emergency Medical Service	HIFLD	Point locations for any form of emergency medical service facility, excluding hospitals	Emergency_Medical_Service
Police	HIFLD	Point locations for law enforcement facilities as defined by the US Department of Justice	Law_Enforcement
Fire Station	HIFLD	Point locations for fire stations	Fire_Station
Evacuation Route	HIFLD	Hurricane evacuation routes	Evacuation_Route

Continued on next page

Infrastructure	Data source	Layer description	Layer name
Power Plant	NJDEP	Point locations for power plants that can generate at least one megawatt of power	Power_Plant
Water Treatment Plant	HIFLD	Point locations for wastewater treatment plants derived from the Environmental Protection Agency's Facility Registry Service	Water_Treatment_Plant
Airport	NJOIT	Point locations for public airports	Airport
Dam	National Inventory of Dams	Point locations for dams based on a nationwide database maintained by the US Army Corps of Engineers	Dam
Major Road	NJOIT	Major roads supplied by NJOIT	Major_Road
Railroad	New Jersey Department of Transportation	Railroad lines for both freight and passenger travel	Railroad
Bus Route	NJOIT	Bus routes traveled by New Jersey Transit	Bus_Route
Ferry Terminal	New Jersey Office of Planning Advocacy	Point locations for boarding a ferry	Ferry_Terminal
Ferry Route	OpenStreetMap	Ferry routes based on OpenStreetMap (HIFLD ferry routes did not cover New Jersey waterways)	Ferry_Route
Power Line	HIFLD	Large power lines transmitting between 69 and 765 kilovolts	Power_Line
Port	HIFLD	Point locations for port facilities assigned to New Jersey by the US Department of Transportation National Transportation Atlas Database	Port
Marina	Not available[1]	-	-

[1]An extensive internet search revealed no readily available marina data at the state or federal level. Marina data may be compiled at a later date using NJDEP permit records of approved marina facilities

A map of infrastructure layers is at: https://arcg.is/1G9rnX and the layers can be downloaded at: https://monmouth.maps.arcgis.com/home/item.html?id=55054bca24d6421abae348e0dd00cade.

The assessment methodology evaluates the CEA resilience benefits to seven infrastructure/transportation categories: Critical Facilities, Routes of Importance, Utilities, Mass Transportation, Transmission and Supply Lines, Port and Harbor Facilities, and Marina Facilities. The assessment method rates adaptations that are closer to a facility higher than those that are farther away, however, it should be recognized that CEAs that enhance ecosystem areas can provide resilience benefits to infrastructure located far from the coast (e.g., storm surge reduction). It is understood that some CEA will have negative impacts on the operation of certain facilities and transportation systems. The assessment method is designed to filter out those

Category	Weight	Sub-Categories	Metrics	Rating Factor
8 & 9 - Infrastructure & Transportation		Critical Facilities	Adaptation is located within the footprint of the Critical Facility and provides resilience benefits	3
			Adaptation is located adjacent to the Critical Facility and provides resilience benefits	3
			Adaptation is located within 1000 ft of the Critical Facility and provides resilience benefits	2
			Adaptation is not located near a Critical Facility but does provide ecosystem and/or resiliency benefits	1
			Adaptation will negatively impact the operation of the critical facility	0
		Routes of Importance	Adaptation is located within the footprint of the Transpotation Route and provides resilience benefits	3
			Adaptation is located adjacent to the Transportation Route and provides resilience benefits	3
			Adaptation is located within 1000 ft of the Transportation Route and provides resilience benefits	2
			Adaptation is not located near a Transportation Route but does provide ecosystem and/or resiliency benefits	1
			Adaptation will negatively impact the operation of the Transportation Route	0
		Utilities	Adaptation is located within the footprint of the Utility and provides resilience benefits	3
			Adaptation is located adjacent to the Utility and provides resilience benefits	3
			Adaptation is located within 1000 ft of the Utility and provides resilience benefits	2
			Adaptation is not located near a Utility but does provide ecosystem and/or resiliency benefits	1
			Adaptation will negatively impact the operation of the Utility	0
		Mass Transportation	Adaptation is located within the footprint of the Mass Transpotation Asset and provides resilience benefits	3
			Adaptation is located adjacent to the Mass Transportation Asset and provides resilience benefits	3
			Adaptation is located within 1000 ft of the Mass Transportation Asset and provides resilience benefits	2
			Adaptation is not located near a Mass Transportation Asset but does provide ecosystem and/or resilience benefits	1
			Adaptation will negatively impact the operation of the Mass Transportation Asset	0
		Transmission/Supply Lines	Adaptation is located within the footprint of the Utility Line and/or Easement and provides resilience benefits	3
			Adaptation is located adjacent to the Utility Line and/or Easement and provides resilience benefits	3
			Adaptation is located within 1000 ft of the Utility Line and/or Easement and provides resilience benefits	2
			Adaptation is not located near a Utility Line and/or Easemen but does provide ecosystem and/or resilience benefits	1
			Adaptation will negatively impact the operation of the Utility Line and/or Easement	0
		Port & Harbor Facilities	Adaptation is located within the footprint of the Port & Harbor Facility and provides resilience benefits	3
			Adaptation is adjacent to the footprint of the Port & Harbor Facility and provides resilience benefits	3
			Adaptation is within 1000 ft of the footprint of the Port & Harbor Facility and provides resilience benefits	2
			Adaptation is not located near a Port & Harbor Facility but does provide ecosystem and/or resilience benefits	1
			Adaptation will negatively impact the operation of the Port & Harbor Facility	0
		Marina Facilities	Adaptation is located within the footprint of the Marina Facility and provides resilience benefits	3
			Adaptation is adjacent to the footprint of the MairnaFacility and provides resilience benefits	3
			Adaptation is within 1000 ft of the footprint of the Marina Facility and provides resilience benefits	2
			Adaptation is not located near a Marina Facility but does provide ecosystem and/or resilience benefits	1
			Adaptation will negatively impact the operation of the Marina Facility	0

Figure 10. Infrastructure and Transportation Assessment categories, metrics, and rating factors.

adaptations that have the potential to negatively impact the operation and function of critical facilities and transportation systems.

The seven infrastructure and transportation subcategories and the rating metrics are presented in Figure 10. CEAs that are located within or adjacent to the footprint of an infrastructure asset or transportation route and provide resilience benefits are rated the highest (3) in the matrix. CEAs that are located within 1000 feet of an infrastructure asset or transportation route and provide resilience are given a rating factor of 2. A thousand foot influence area was chosen as the limit for direct benefits provided to the facility, easement or transportation route by a CEA, however, as described above, CEAs farther from infrastructure can provide resilience benefits. CEAs that will negatively impact the function, transmission or use of infrastructure are not prioritized and given a rating factor score of 0.

Additional Assessment Categories

Four additional assessment categories are provided in the methodology to further refine the prioritization of CEAs: Physical and Environmental Conditions, Economic Factors, Project Coordination, and Feasibility of Construction and Maintenance. Unlike the nine categories associated with the four broad planning objectives, the four additional assessment categories have limited or no GIS data available for analysis and rely on existing information and/or expert knowledge about the area of interest. The assessment methodology is designed in a way that an initial high-level, landscape scale ("30,000 foot level") analysis of a region or area can be conducted with the nine assessment categories associated with the four planning objectives for the prioritization of CEAs for ecosystem and community resilience. It is anticipated that not all of the information required to complete the additional assessment categories will be known or readily available. In some instances, the information may need to be collected though site visits and field assessments. As such, the additional information/knowledge used in the four additional assessment categories should be viewed as a sensitivity analysis of CEAs to area and project specific information rather than used as a prioritization of adaptations.

Physical and Environmental Conditions

The physical and environmental characteristics within a region or area of interest are assessed through five broad subcategories; System, Hydrodynamic and Hydraulic, Geologic, Geomorphologic, and Ecological, and a set of measurable parameters associated with each subcategory (Figures 11a -11c).

Physical parameters to assess System-wide conditions include erosion history, sea level rise and tidal range (Figure 11a). Hydrodynamic and hydraulic conditions are characterized through an assessment of waves, wakes, currents, river discharge, storm surge and ice within the area of interest (Figure 11a). The assessment metrics for each parameter in Figure 11a where drawn from Miller et al. (2016). The rating factor for each parameter metric is provided as "0, 1" indicating that the user is required to select one of the listed ranges for each parameter. Alternatively, in the development of a prioritization support tool, the developer may want to consider a slider bar for each parameter range that will allow the user to provide more resolution to the area specific parameters.

The parameters used to assess the Geologic and Geomorphologic conditions of an area are presented in Figure 11b. Geologic considerations include land elevation, upland, shoreline and nearshore slope, shoreline width, offshore depth and soil bearing capacity. Excluding elevation, which is related to tidal range, the assessment metrics are drawn from Miller et al. (2016). Geomorphic considerations include sediment discharge from rivers and the transport of sediment within the coastal system. The ranges of sediment transport rates are from US Army Corps of Engineers sediment budgets for New Jersey (USACE, 2006; Massaros et al. 2018). Sediment discharge ranges were developed from river specific studies (Wall et al. 2008; Sea Engineering and HDR HydroQual, 2011; Gebert et al. 2013) and USGS stream gauges with available annual suspended sediment discharge data (https://waterdata.usgs.gov/nwis).

Category	Weight	Sub-Categories	Parameter	Metrics	Rating Factor
Physical Environment		System	Erosion History	< 2 ft/yr	0, 1
				2 ft/yr to 4 ft/yr	0, 1
				> 4ft/yr	0, 1
			Sea Level Rise	< 5 mm/yr	0, 1
				5 mm/yr to 10 mm/yr	0, 1
				> 10 mm/yr	0, 1
			Tide Range	< 1.5 ft	0, 1
				1.5 ft to 4 ft	0, 1
				> 4 ft	0, 1
		Hydrodynamic & Hydraulic	Wind Waves	< 1 ft	0, 1
				1 ft to 3 ft	0, 1
				> 3 ft	0, 1
			Wakes	< 1 ft	0, 1
				1 ft to 3 ft	0, 1
				> 3 ft	0, 1
			Currents	< 1.25 kts	0, 1
				1.25 kts to 4.75 kts	0, 1
				> 4.75 kts	0, 1
			River Discharge	< 100 cfs	0, 1
				100 cfs to 1,000 cfs	0, 1
				> 1000 cfs	0, 1
			Storm Surge	< 1 ft	0, 1
				1 ft to 3 ft	0, 1
				> 3 ft	0, 1
			Ice	< 2 in	0, 1
				2 in to 6 in	0, 1
				> 6 in	0, 1

Figure 11a. Physical and Environmental Condition Assessment categories for System, Hydrodynamic and Hydraulic parameters, metrics, and rating factors.

Category	Weight	Sub-Categories	Parameter	Metrics	Rating Factor
		Geologic	Elevation	< 0 ft above MHHW	0, 1
				0 to 3 ft above MHHW	0, 1
				3 ft to 6 ft above MHHW	0, 1
				> 6 ft above MHHW	0, 1
			Upland Slope[18]	< 1 on 30	0, 1
				1 on 30 to 1 on 10	0, 1
				> 1 on 10	0, 1
			Shoreline Slope[18]	< 1 on 15	0, 1
				1 on 15 to 1 on 5	0, 1
				> 1on 5	0, 1
			Nearshore Slope[18]	< 1 on 30	0, 1
				1 on 30 to 1 on 10	0, 1
				> 1 on 10	0, 1
			Shoreline Width[18]	< 30 ft	0, 1
				30 ft to 60 ft	0, 1
				> 60 ft	0, 1
			Offshore Depth[18]	< 2ft	0, 1
				2 ft to 5 ft	0, 1
				> 5 ft	0, 1
			Soil Bearing Capacity[18]	< 500 psf	0, 1
				500 psf to 1500 psf	0, 1
				> 1500 psf	0, 1
		Geomorphology	Sediment Transport[11, 12, 13]	< 100,000 cu yd/yr	0, 1
				100,000 cu yd/yr to 250,000 cu yd/yr	0, 1
				> 250,000 cu yd/yr	0, 1
			Sediment Discharge[14, 15, 16, 17, 19]	< 10,000 tons/yr	0, 1
				10,000 tons/yr to 100,000 tons/yr	0, 1
				> 100,000 tons/yr	0, 1

Figure 11b. Physical and Environmental Condition Assessment categories for Geologic and Geomorphology parameters, metrics, and rating factors.

Category	Weight	Sub-Categories	Parameter	Metrics	Rating Factor
		Ecological	Soil Type	Primarily Sand	0 1
				Primarily Silt and Silty Clay	0, 1
				Primarily Silty Clay and Peat	0, 1
			Soil pH	< 5	0, 1
				5 to 7	0, 1
				> 7	0, 1
			Water Salinity	0 ppt	0, 1
				0 ppt to 15 ppt	0, 1
				15 ppt to 30 ppt	0, 1
			Water pH	5 to 6	0, 1
				6 to 7	0, 1
				7 to 8	0, 1
			Dissolved Oxygen	< 6 mg/l	0, 1
				6 mg/l to 10 mg/l	0, 1
				> 10 mg/l	0, 1
			Light Penetration in upper 10 ft	0 % to 25%	0, 1
				25% to 75%	0, 1
				75% to 100 %	0, 1
			Sunlight Exposure	< 2 hrs/day	0, 1
				2 hrs/day to 10 hrs/day	0, 1
				> 10 hrs/day	0, 1
			Stratification	0 ppt	0, 1
				5 ppt to 10 ppt	0, 1
				> 10 ppt	0, 1

Figure 11c. Physical and Environmental Condition Assessment categories for Geologic and Geomorphology parameters, metrics, and rating factors.

The Ecological parameters that can be used to assess CEAs are presented in Figure 11c and include soil type and pH, water salinity and pH, dissolved oxygen, sunlight exposure and water penetration, and water stratification. The data ranges provided for each parameter are related to conditions found in fresh, brackish, and saltwater environments and those required for sustaining aquatic and terrestrial life. The assessment methodology only includes parameters that are easily obtained or are commonly recorded in coastal environments. If required, more complex assessment parameters, such as species density, root penetration, nutrients, contaminants, taxa richness, among others, could be included.

Economic Factors

The economic factors that could be considered when assessing various CEA alternatives include impacts on Aquaculture and Fisheries, Marine Dependent Industry, Tourism, and Ecosystem Services (Figure 12). The assessment methodology is designed to prioritize those CEA that provide both resilience and create, enhance and/or extend conditions that support a healthy coastal economy and ecosystem services. CEAs that negatively impact the existing coastal economy, such as hindering a marine related use, are not prioritized. The selected economic factors do have geospatial relationships to specific areas but not all factors presently exist as GIS data layers for use in the assessment methodology. As an example, the ecosystem services assessment data for New Jersey (Liu et al. 2010) is delineated by Hydrologic Unit Code 11 (HUC 11) and presented as geospatial data but industries dependent on proximity to the coast are not presently mapped.

Project Coordination

There are many existing and planned federal, state, municipal and private coastal resilience and storm damage reduction projects in New Jersey. The project coordination subcategories used in the assessment methodology include existing and planned projects by the U.S. Army Corps of Engineers (USACE), Federal and State Agencies, Counties and Municipalities, NGOs, Private Interests, Military, and Department of Homeland Security (Figure 13). The project coordination assessment evaluates how well aligned specific CEAs that are proposed within, adjacent to, or near an existing or planned project are with the objectives of that project. CEAs that are within or adjacent to a project and add value to that project are rated the highest. CEAs that are not aligned with the objective of a project are still desirable but not rated as highly as those that are aligned with the objectives. Any adaptation that negatively impacts the function of an existing or planned project is not prioritized in the assessment methodology. Presently there are no comprehensive GIS data layers that contain the location and extent of all coastal resilience and storm damage reduction projects in New Jersey, although it is reasonable to assume one will be developed. Geospatial data will help identify the location of CEA overlap with existing and planned projects but expert knowledge will still be necessary to assess the potential impact a CEA will have on those projects.

Feasibility of Construction and Maintenance

The feasibility of construction and maintenance assessment methodology is designed to evaluate the overall viability of a proposed CEA in terms of regulatory compliance, benefits derived from a project, funding availability, and ongoing operation and maintenance costs over the life of the CEA. The subcategories used to assess the feasibility of a CEA are: Fundability, Operation and Maintenance costs, Regulatory Compliance, Benefit to Cost Ratio, Adaptability, and Potential for Negative Impacts (Figure 14). All of the measurable metrics associated with the subcategories will require site specific and project level data, analysis, and expert judgement that is not easily applied at a landscape scale analysis. However, there may be benefits in conducting a high level assessment of possible CEAs based on expert judgement to determine if there will be regulatory, cost, or adaptability concerns that need to be addressed before a CEA will be a viable option in a specific area or region.

Category	Weight	Sub-Categories	Metrics	Rating Factor
Economic		Aquaculture/Fishery	Adaptation will create and/or extend existing conditions for aquaculture/fishery	3
			Adaptation will enhance existing aquaculture/fishery	2
			Adaptation will have no impact on existing aquaculture/fishery areas	1
			Adaptation will have a negative impact on existing aquaculture/fishery areas	0
		Marine Dependent Industry	Adaptation will create and/or extend existing marine dependent uses	3
			Adaptation will enhance marine dependent use	2
			Adaptation will have no impact on existing marine dependent use	1
			Adaptation will have a negative impact on existing marine dependent use	0
		Tourism	Adaptation will create and/or extend existing tourism uses	3
			Adaptation will enhance existing tourism use	2
			Adaptation will have no impact on existing tourism	1
			Adaptation will have a negative impact on existing tourism	0
		Ecosystem Services	Adaptation will increase the Avg Ecosystem Service Value per Acre in the HUC 11 Watershed	3
			Adaptation will maintain the Avg Ecosystem Service Value per Acre in the HUC 11 Watershed	2
			Adaptation will decrease the Avg Ecosystem Service Value per Acre in the HUC 11 Watershed	0

Figure 12. Economic Assessment categories, metrics, and rating factors.

Category	Weight	Sub-Categories	Metrics	Rating Factor
Project Coordination		USACE Projects	Adaptation is within or adjacent to an existing or planned USACE project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned USACE project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned USACE project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned USACE project	0
		Federal Agency Projects	Adaptation is within or adjacent to an existing or planned Federal Agency project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned Federal Agency project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned Federal Agency project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned Federal Agency project	0
		NJ State Projects	Adaptation is within or adjacent to an existing or planned NJ State Agency project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned NJ State Agency project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned NJ State Agency project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned NJ State Agency project	0
		County Projects	Adaptation is within or adjacent to an existing or planned County project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned County project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned County project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned County project	0
		Municipal Projects	Adaptation is within or adjacent to an existing or planned Municipal project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned Municipal project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned Municipal project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned Municipal project	0
		NGO & Private Projects	Adaptation is within or adjacent to an existing or planned NGO/Private project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned NGO/Private project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned NGO/Private project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned NGO/Private project	0
		Military & DHS Projects	Adaptation is within or adjacent to an existing or planned Military or DHS project and aligned with project objectives	3
			Adaptation is within the influence and aligned with an existing or planned Military or DHS project	2
			Adaptation is within, adjacent to, or within the influence of an existing or planned Military or DHS project but not aligned with the objectives	1
			Adaptation will negatively impact an existing or planned Military or DHS project	0

Figure 13. Project Coordination Assessment categories, metrics, and rating factors.

Category	Weight	Sub-Categories	Metrics	Rating Factor
Feasibility of Construction and Maintenance		Fundability	The adaptation has a high probability for funding	2
			The adaptation has a 50/50 chance of being funded	1
			The adaptation has a low probability for funding	0
		Operation and Maintenance	O & M cost are expected to be minimal over the life of the project	2
			O & M cost are expected to be within existing budget requirements	1
			O & M cost will be excessive over the life of the project	0
		Regulatory Compliance	Adaptation project meets all federal, state and local regulatory requirements	2
			Adaptation will need permit modification or variance to be constructed	1
			Adaptation project does not meet one or more federal, state or local regulatory requirement	0
		Benefit - Cost Ratio	Benefit to Cost ratio exceeds 1.0	2
			Benefit to Cost ratio is 1.0	1
			Benefit to Cost ratio is less than 1.0	0
		Adaptable	Adaptation can be easily modified or can readily adapt to changing conditions	2
			Adaptation can be modified with some effort or may be able to adapt to changing conditions	1
			Adaptation cannot be modified or adapt to changing conditions in the future	0
		Potential Negative Impacts	Adaptation will not create any negative impacts	2
			Adaptation has the potential to create negative impacts	1
			Adaptation will create negative impacts	0

Figure 14. Feasibility of Construction and Maintenance Assessment categories, metrics, and rating factors.

Photo courtesy of Monmouth University Urban Coast Institute

Stakeholder Workshops

Three stakeholder workshops were held in late summer and early fall of 2019. The workshops were structured to introduce the framework and prioritization methodology and provide an opportunity for discussion and feedback from the participants. Forty-nine experts in the field of land use planning, wildlife management, conservation, ecosystem restoration and management, engineering, and spatial planning were identified by the project team and invited to participate in one of the three workshops. Twenty-nine of the invited experts attended a workshop (Appendix B) and provided feedback on the overall methodology, identified gaps, suggested changes, and provided overall thoughts on how the framework may be applied in the development of a prioritization tool.

Feedback received from the participants included comments and suggestions on the overall structure of the framework, prioritization categories, data layers, prioritization metrics, and the potential application of the Framework Methodology. Many of the comments were repeated at each of the workshops. A summary of the most common comments received can be found in Appendix B. Workshop participants were also provided a survey form to submit additional feedback. Three survey forms were submitted by email and can be found in Appendix B. Many of the comments and suggested changes have been addressed or incorporated into the final Framework Methodology.

Expert Review

In addition to the stakeholder workshops, 16 of the experts identified by the project team were invited to provide a more detailed review of the Prioritization Framework Methodology. Five expert reviews were completed (Appendix C). In reviewing the framework, the experts were asked to identify the strengths and weaknesses of the methodology, provide recommendations that could improve the methodology and provide their perspective on how the methodology may be applied by the NJDEP to prioritize CEAs. A summary of the common comments of each review are provided below.

Strengths and Weaknesses

Common strengths of the Framework Methodology identified by the reviewers included the following. The reviewers stated that the Framework filled an identified need in the state to inform the selection of ecological adaptation projects to bolster the resilience of New Jersey's coastline in both natural and built environments. It provides a foundation to develop a high-level site prioritization tool that includes all the suitable GIS layers currently available. The framework provides an objective, consistent framework to allow for more ready comparison between projects and allows for coastal decision-makers to drill down to see the nuance if desired. Additionally, the framework is plastic and will be able to accommodate any structural or quantitative changes identified though continuing workgroup activity or through updates to information provided in primary literature sources. The eleven assessment category areas identified provide a comprehensive list of considerations that should be addressed when evaluating potential projects or broad scale management strategies. The framework provides a list, "adaptation database", of various measures that can be taken to support coastal resiliency. Finally, the idea of a user weighted parametric scaling was viewed as a smart approach. The idea of the framework user being able to adjust and weight the criteria attributes based on their perspective rather than relying on a preset potentially biased parametric.

A common weakness identified by all of the reviewers is that the Framework Methodology seem to foster a high-level assessment but some aspects of the assessment criteria get into the weeds of a site-specific approach. As presented the methodology evaluates the effects of project types on the landscape instead of evaluating the needs of the landscape. The approach was viewed as difficult to implement and will not be particularly useful, and in fact rather cumbersome, if it was to be deployed proactively statewide to identify where adaptation practices should and could be employed. The parameterization scheme was viewed to set a global bias that even with the possibility of weighting seems as though it would be challenging to overcome. In the end with so many rankings, it just seems like the resulting prioritization score will be meaningless. It was viewed that the framework would benefit from the ability of users to be able to weight, or select/deselect, the various categories to focus the analysis. Finally, it was suggested that in a world with a changing climate and increasing rates of sea level rise, the tool should not necessarily enforce a default hierarchy that prioritizes preservation over restoration opportunities. The most important, and therefore highest ranked, action would likely depend on your issue of concern and many other factors that might not easily be teased out from the hierarchy.

Recommendations to improve the methodology

The reviewers provided numerous recommendations that could improve the methodology. Common among all the reviewers was that the primary goal of the methodology should be clearly defined and that the goal should guide the assessment criteria in the prioritization metrics. It was recommended that the methodology be focused on screening potential project areas to rank each area for both flood reduction benefits (community resilience) and value for ecological resilience separately, which would then enable NJDEP to identify areas of overlap if desired. The achieve the stated goals of ecosystem and community resilience, the methodology should start with the Issue of Concerns as the first screening and then assess potential adaptions through the landscape scale categories. To simplify the assessment, it was recommended that the more site/project specific assessments be removed from the methodology. Other recommendations included reducing the number of assessment categories by combining similar elements, reducing the bias in the rating factors, including a case study of the methodologies use, including fishery/aquaculture infrastructure as an adaptation measures, and provide a clear definition of the term "ecological adaptation."

Potential application of the methodology

The reviewers varied in their assessment of potential applications of the methodology. Half of the reviewers thought that the prioritization framework could be useful for both broad landscape level management plans and for site specific project development and funding decisions. The reviewers felt that, as it is presently constructed, the methodology most likely could adequately support either landscape or project scale prioritization. Other reviewers felt that, if modified, the methodology could be applied to compare possible alternatives at a landscape scale. The framework was viewed to provide the necessary categories and scoring mechanism to accomplish its intent by changing some of the metrics. As a GIS application, if an area is selected, the assessment score for each adaptation in a particular area can be used to rank alternatives that would preserve, enhance or restore the underlying ecosystem. All reviewers thought the methodology provides a useful inventory of data resources and as a structure to support the evaluation of relevant criteria.

Overall Rating

The reviewers were asked to provide an overall rating of the Framework Methodology by ranking it as either poor, fair, good, and excellent. Ratings ranged from poor to good/excellent, with an average rating of good. All of the reviewers stated that the developed Framework Methodology is a good starting point for the development of a prioritization tool but that much more refinement is needed before it can be implemented.

Photo courtesy of Monmouth University Urban Coast Institute

Summary and Recommendations

A methodology for the development of a Framework to prioritize the selection of ecological adaptation projects for coastal ecosystem and community resilience has been developed to 1) reduce the loss of existing coastal ecosystems that provide coastal resilience benefits through preserving, restoring and enhancing natural coastal resources, 2) support and enhance existing ecosystem services that provide socioeconomic, climate, and natural resource benefits, and 3) mitigate present and future risk associated with increasingly severe environmental conditions. The methodology is designed to identify potential natural and nature-based adaptations for ecosystem and coastal community resilience to climate change impacts at the ***landscape scale***. The objective is to prioritize those adaptations that address a particular Issue of Concern (IOC), are aligned with existing and/or future land use and management objectives, and that provide both coastal ecosystem and community resilience benefits. The methodology is ***not designed for*** site specific evaluation and project design but rather intended to guide planners and practitioners on the types and range of adaptation measures to consider within a specific region.

The methodology is focused on developing a Framework that will provide a high-level screening of Coastal Ecological Adaptations (CEAs) for the selection and prioritization of potential CEAs in specific coastal regions of New Jersey. The screening process utilizes readily available spatial data in the form of Geographical Information System (GIS) data layers housed and managed by the NJDEP along with user defined input and a scoring scheme to identify the most viable natural and/or nature-base feature to address a particular IOC. The objective of the screening process is to apply an assessment scheme that prioritizes the preservation, enhancement and extension of existing coastal lands. Where existing lands are degraded, the assessment scheme prioritizes the restoration of existing lands over the creation of new lands and natural features. The rational for the prioritization is founded on the results of a number of scientific studies that all conclude that the preservation of existing landforms and habitats provide the maximum ecosystem and community resilience benefits.

The Framework Methodology detailed in this report reflects the recommendations and suggested changes provided by the stakeholders that participated in the three workshops and the comments and recommendations provided by the external reviewers. Specifically, the original Framework Methodology was adjusted to start with the IOC as the first tier of screening, followed by the assessment of potential adaptions through the landscape scale categories. To focus the assessment, only the landscape scale assessment categories were retained and the site/project specific assessments were removed from the methodology. The rating factors were adjusted to a common scale and only positive values that reflect both community and ecological resilience are included in the assessment. The resulting methodology primarily used available GIS data layers to conduct a "first-cut" assessment of those CEAs that are aligned with the existing land from, land use, and land management objectives, and the socioeconomic resilience benefits provided to the area of interest.

The IOC identified in the methodology are categorized as habitat loss and degradation, shoreline erosion, coastal inundation and flood damage, impaired water quality, and the reduction of carbon sequestration. Addressing these concerns is the primary goal of the methodology when assessing ecological adaptations for coastal ecosystem and community resilience. Once the desired IOC to be addressed have been identified, the screening scheme considers nine broad categories through which the CEA measures are assessed. Each screening category is associated with one of four broad planning objectives (PO): 1) Is the adaptation consistent with existing and planned land uses?, 2) What are the social and cultural impacts of the adaptation project?, 3) What is the scale and connectivity of the adaptation?, and 4) What impact on infrastructure will that adaptation project create? Each PO includes two or more categories of measurable metrics through which each adaptation is assessed. In total, nine landscape scale assessment categories are used to prioritize multiple CEAs. The metric score of each of the nine categories are totaled and all CEAs ranked on a descending scale to produce a ranked prioritization for users to consider in selecting the most appropriate adaptation measure for a specific area. If specific categories are considered more important or relevant than others for a particular area or planning objective, the methodology allows for the weighting of each category based on expert judgement. Although flexible in its application, for an unbiased screening and prioritization of CEAs, framework categories should be weighted equally.

The resulting prioritization provides a georeferenced list of potential adaptations at the landscape scale that are aligned with the existing land use and management objectives, provides ecosystem benefits through scale and connectivity, and provides resilience to coastal communities, cultural resources, infrastructure and critical facilities. The identified CEAs can be used as a starting point for a more refined site specific analysis of adaptation projects and as a list of potential natural and green infrastructure options to be considered alongside traditional gray coastal protection options during coastal resilience project planning.

A number of recommendations have been put forward by the stakeholders and experts that have reviewed the framework, as well as by the authors of the report. Recommendations that should be considered as the next steps in the development of a Coastal Ecological Adaptation Prioritization include:

1. The objective of the assessment scheme to weight preservation of natural lands over restoration or the creation of new lands is based on the current and best available research on ecological preservation and restoration. The actual objectives of the final Framework should be based on goals set by the NJDEP for long-term coastal resiliency. Climate change stresses and increasing rates of sea level rise may not necessarily be well addressed by a hierarchy that prioritizes preservation over restoration opportunities. The CEA prioritization should depend on your IOC and overall objectives of the Coastal Resilience Plan.
2. The 44 coastal ecological adaptations listed in Table 1 were taken from the existing research literature and design guidance documents focused on natural and nature-based features for coastal resilience. Each CEA was coarsely parameterized through expert judgement based on the rating factors within each subcategory of the nine assessment categories. The result is a preset CEA score based on the prioritization scheme of preservation, restoration and creation. As a next step, the rating factors associated with each CEA should be significantly refined to allow for a more robust prioritization of potential adaptations.
3. A series of case studies of the application of the Framework Methodology should be conducted to determine if the CEA assessment scheme produces the desired results in terms of a viable prioritization of adaptations in specific regions and varying scales. Sensitivity studies of the influence of specific metrics and rating factors should also be conducted to determine if particular subcategories are disproportionally influencing the resulting prioritizations. The results of the case studies and sensitivity analysis can be used to refine the Framework and transition it toward an assessment tool.

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APPENDICES

Appendix A
Additional GIS Data Layers

Attendees of three separate workshops suggested layers for consideration in the future development of an adaptation measures framework. Suggested layers either address gaps in the layers provided in the framework methodology or are related to layer categories not investigated here.

The following bulleted list presents layers that may address gaps in the layers compiled for this project.

- Maritime forest (see *Existing Landform* section) may be found in the Northeast Regional Conservation Needs Spatial Data products at:

  https://rcngrants.org/spatialData

- Social vulnerability indicators (see *Social* section) may be summarized using the Center for Disease Control's Social Vulnerability Index available for download at:

  https://svi.cdc.gov/data-and-tools-download.html

- Wastewater treatment plants are overlooked among the various infrastructure assets (see *Infrastructure* section). However, these sites may be mapped based on the Environmental Protection Agency's Facility Registry Service available for download at (ignore security certificates to proceed with download):

  https://edg.epa.gov/data/PUBLIC/OEI/OIC/FRS_Wastewater.zip

- Landfills may be considered a component of infrastructure, and a statewide layer of landfills covering 35 acres or more land area can be downloaded at:

  https://gisdata-njdep.opendata.arcgis.com/datasets/solid-waste-landfill-sites-35-acres-and-above-in-new-jersey

- Facilities in the *Infrastructure* section are mapped using points. A suggestion was made to use the recently released Microsoft dataset that maps building footprints to identify the area of facilities. Microsoft's building footprint data for the United States can be downloaded for free at:

  https://github.com/Microsoft/USBuildingFootprints

Layers not in the categories reviewed here that may however be useful in future development of the adaptation framework are listed below.

- Habitat data, while likely site specific, may be evaluated at the landscape scale using the US Fish and Wildlife Service Nature's Network data at:

  http://www.naturesnetwork.org/data-tools

- Marsh migration follows a larger theme of landscape change over time, which may need to be examined in future development of the adaptation framework. A marsh migration layer has been developed by NJDEP, although at present it cannot be found for download. The layer has been provided on a hard drive, and on that drive, it is named

"Marsh Migration Index", which assumedly provides an index score of potential areas where marshes may migrate.

- Like the above, shoreline erosion is also indicative of landscape change over time. A shoreline erosion layer developed by the Center for Remote Sensing and Spatial Analysis (CRSSA) at Rutgers University was alluded to in workshops. However, the layer could not be found for download upon searching the internet. Future developers of the adaptation framework may inquire about the availability of the shoreline erosion layer with CRSSA Director, Richard Lathrop (lathrop@crssa.rutgers.edu – 848-932-1580).

- Sea level rise is another factor to consider for the future, and layers that map potential areas of sea level rise inundation are available via the National Oceanic and Atmospheric Administration's Digital Coast platform at:

  https://coast.noaa.gov/digitalcoast/data/slr.html

- A carbon sequestration layer is either in development or completed at NJDEP based on workshop discussions. Future adaptation framework developers should inquire with NJDEP about the availability of the carbon sequestration layer, which presumably maps carbon storage (realized or potential) at the landscape scale.

- Storm surge may be of importance for future development of the adaptation framework, and is available as a modeled product generated by the National Hurricane Center at:

  https://www.nhc.noaa.gov/nationalsurge/#data

- Subaqueous soils data was deemed important for a number of reasons, like aquatic habitat or potential dredge material. Soil survey data exists for Barnegat Bay and Little Egg Harbor, and possibly other coastal waterways, on the United States Department of Agriculture's Web Soil Survey site at:

  https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

- Dredge material placement sites were identified as a factor that may need to be considered to assess adaptation measures. The above soils data may assist in the placement process, or a layer specifically designed for locating placement sites developed by Stockton University's Coastal Research Center may also be of use. The layer could not be found for an internet download, but may be available upon contacting the Coastal Research Center (crc@stockton.edu – 609-652-4245).

- Navigation channels in coastal waterways may be required for planning decisions, and can be downloaded from the National Oceanic and Atmospheric Administration's Electronic Navigational Charts Direct to GIS service at:

  https://nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis

- Contaminated sites were identified as part of a broader discussion on "environmental quality" and the need to assess factors that could be associated with degraded environments. A variety of layers may be used to assess contaminations, and layers to consider are hyperlinked in the following list: (1) Known Contaminated Sites List for New Jersey, (2) Currently Known Extent of Groundwater Contamination for New Jersey, (3) Well Restriction Areas for New Jersey, (4) Chromate Waste Site Boundaries for New Jersey, and (5) National Priorities List (Superfund) Sites.

- Property values were suggested as a possible layer to consider for socioeconomic evaluation of adaptation measures. However, this may be controversial if higher property values contribute to a higher prioritization score for an adaptation measure. If property values are to be considered, then an aggregate measure, like median home values at the census tract scale, may be evaluated using US Census data available for download at:

  https://factfinder.census.gov

- Potential losses due to coastal flooding and other hazards may be assessed via layers, such as "Direct Economic and Social Loss", provided with the Federal Emergency Management Agency's Hazus software available for download at:

  https://msc.fema.gov/portal/resources/hazus

- Mitigation plans to reduce potential losses were suggested as possible additional layers for consideration. These layers may be viewed based on instructions at this link, but do not appear to be publicly available for download at this time. Download privileges may be granted through the Mitigation Planning Portal at this link. However, it is not clear how to gain access to the portal (e.g. users may have to be federal employees).

- Community Rating System data of communities participating in a national floodplain management program was suggested as a possible layer. However, a layer of these communities was not found online. Instead, a list of communities participating in the program can be found at this link.

Appendix B
Stakeholder Workshops

ECOLOGICAL ADAPTATION PRIORITIZATION METHODOLOGY WORKSHOP

New Jersey Department of Environmental Protection,
401 East State Street, Trenton, NJ 08625
Monday, September 16, 2019
12:30pm – 3:30pm

Agenda Items

12:30 pm	**Welcome and Introductions** *Rebecca Hill, NJDEP*
12:45 pm	**Ecological Adaptation Goals and Objectives** *Tom Herrington, Monmouth University*
1:00 pm	**Overview of Ecological Adaptation Prioritization Framework** *Tom Herrington & Geoff Fouad, Monmouth University* • Structure, method, and metrics • GIS data layers • User defined input
2:00 pm	**Break**
2:15 pm	**Example application of the framework** *Geoff Fouad, Monmouth University*
2:45 pm	**Discussion, feedback and survey**
3:30 pm	**Adjourn**

WORKSHOP PARTICIPANTS

Name	Organization
Alexis Taylor	NJ Department of Environmental Protection
Taylor Coppa	NJ Department of Environmental Protection
Dave Dumont	NJ Department of Environmental Protection
Julie Blum	NJ Department of Environmental Protection
Metthea Yepsen	NJ Department of Environmental Protection
Liz Semple	NJ Department of Environmental Protection
Jessica Jahre	NJ Department of Environmental Protection
Colleen Keller	NJ Department of Environmental Protection
Jill Aspinwall	NJ Department of Environmental Protection
Patrick Woerner	NJ Department of Environmental Protection
Capt. Al Modjeski	American Littoral Society
Rob Pirani	NY/NJ Harbor Estuary Program
Isabelle Stinnette	NY/NJ Harbor Estuary Program
Jim Lodge	Hudson River Foundation
Patty Doerr	The Nature Conservancy
Bill Shadel	The Nature Conservancy
Kim McKenna	Stockton University
Anna Pfeiffer-Herbert	Stockton University
Jon Miller	Stevens Institute of Technology
Lisa Auermuller	JCNERR
Patti Rafferty	National Parks Service
Martha Maxwell Doyle	Barnegat Bay Partnership
Josh Moody	Partnership for the Delaware Estuary
Linda Brennen	Monmouth County Planning Office
Dan Barone	Michael Baker International
Bethany McClanahan	McLaren Engineering
Monica Chasten	US Army Corps of Engineers (Phila. Dist.)
Kathleen Walz	NJ Fish & Wildlife
Amy Williams	Stevens/NJ Sea Grant

Participant Comments and Suggestions

Framework Structure

- There should be a clear goal and objective that structures the use of the framework.
- The Issue of Concern that you are trying to address should govern the prioritization.
- Which of these layers make sense for the state-level identification we're looking for?
- Need to understand how to make sense of all this information/the output (category scales).
- Maybe use initial questions to filter out those that are not applicable.
- Make sure report includes definitions of what we mean by all categories.

Prioritization Categories

- What is the time boundary when considering these layers?
- Are we managing to maintain the status quo or managing to support systems through the changing climate
  - Some refuge areas are no longer preserving as is, they know a change is coming
  - Need to know the states goals and objectives to know this answer
- How do we consider this today when we know there will be a very different future?
- Need to be able to prioritize land use/cover dependent on what your goal is - keep the same or transform.
- Consider framing this depending if you want to have coping, incremental, or transformative change.
- First consideration should be what you're most interested in and then all the other layers/data would filter to be specific to that concern (e.g., Issue of Concern)
  - Everyone agrees with this suggestion.

Missing data Layers

- tidal brackish and tidal freshwater
- Include shellfish culture under Restoration
- NE Habitat Classification System and Report. Aquatic and terrestrial reports. RCN grant? (ID maritime forests and brackish water. TNC has this online.
- TNC has layers that look at salt marshes ability to persist. If not available online.
- Low/high marsh distinction isn't good from the Anderson Classification in the Land Use/Land Cover. There is a better layer.
- Additional species information at Nature Serve.
- Look NFWF Coastal Resiliency Assessments through Nature Serve - look at the layers they used
- Consider looking at areas beneficial for ecosystems and areas beneficial for community resilience.
- How large of an area would this id for a potential project area?
  - The criteria we're using seem more specific than "high level". For example, most counties will have high marsh.
- How could you capture Sea Level Rise? Prioritization or feasibility considerations/ranking be added to the output.

Prioritization Metrics

- Consider having all the rankings go from 0-2 or 0-3 as it varies right now.
    - Having different value ranges values created bias in rankings.
- Why is there no negative values?
- Have category scores instead of a full matrix score so you can see where an area is doing well based on your goal and where it's missing the goal.
    - Since outputs on a state-level assessment can be difficult to do given the scale, having various scores for each category allows a deeper dive to understand the ranking.
    - Suggestion to rank based on goal - can get an individual score for each goal
- For user defined categories - have an unknown value so it would flag where you need more data to get an accurate output. Or catalogued off to the side.
- We need to make sure that categories are at the land scape scale
- Or, we id those that cannot be at the landscape scale, so are not appropriate at this time.

Application of the Framework Methodology

- Might need to pick a primary driver(s) to develop a list of projects. Example, flood reduction and birds. There may be a framework for each driver.
- If you just stack all the layers, you have competing ranks. One score makes it hard to understand what it actually means. Example, if you're looking to preserve land you would look for different optimal conditions than if you were looking at lands to restore.
    - If the goal is to identify lands not currently preserved that would allow for marsh migration, how does the framework identify these lands?
        - Need to look at public lands adjacent to marsh
    - It might made sense to base the framework on adaptation measure.
- Irrelevant layers and problematic factors (Rank 0) should not be the same. Need to be able to skip rows.
    - Layers associated with goal
- Consider multiplicative vs additive so "0" can be used and it’s useful and that layer has no affect.
- There can be go-no-go factors that will kill a project. Then there are other factors that are stacked to give a score.
    - For example, if the sate only wants to do projects on state lands, that is a go-no-go layer.
- Identify those factors that would be beneficial across all goals/systems, etc. Then there wouldn't be competing factors.

ECOLOGICAL ADAPTATION PRIORITIZATION METHODOLOGY SURVEY

1. Does the hierarchy underlying the Prioritization Framework make sense?

If not, why and how should it be modified?

Yes, prioritizing preservation makes sense, especially if “preservation” allows for mitigating actions such as creating inland migration corridors for low elevation habitats impacted by sea level rise and increasing storminess.

2. Please let us know if the Framework is missing any important categories and/or if any categories should be removed?

This list looks complete—all the categories are important (maybe not equally important, but that is where weighting could come in eventually)

3. Should the framework only focus on categories that can be easily assessed by existing GIS data?

No, that would likely leave out important aspects simply because they are more difficult to organize spatially or because the data are not available. I think the strategy that you presented of rating metrics without GIS layers as 0/1 based on user inputs is reasonable.

4. What GIS layers are missing that should be included in the Framework?

I don’t know if this is already in a GIS layer, but there are recently updated subaqueous soil data for Barnegat Bay-Little Egg Harbor here: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Substrate type would be important for fish/shellfish habitat and suitability for seagrass.

5. Should modifications be made to the evaluation metrics? If so, what types of changes should be made?

Salinity: The appropriate range will be goal (or species) specific. For example, sites for oyster restoration could be in salinity <15 but not as low as <10 ppt. A more common salinity classification for estuarine habitats is oligohaline (0-5), mesohaline (5-18) and polyhaline (>18).

Stratification: I do not fully understand the stratification metric connection to many of the ecological adaptation measures (i.e., assuming that I'm interpreting your stratification ranking method correctly, I do not think that stratification is important for most of adaptation measures.

6. Should the framework be static or adjustable (by region, land use, objective, user)?

Adjustable by objective through user input of certain metrics and weights.

7. Should the Categories be weighted and if so, how?

I think weighting of the categories is inevitable (and necessary) at some stage of the process. Since the framework is intended as a first look, running without user selected weights is reasonable in the initial iterations. One suggestion as an intermediate step: In the map viewer of metric scores, make it easy to identify which categories contributed to an area's high score.

8. Please provide any additional comments you would like us to consider in the development of the methodology

Thank you for taking the time to participate in the workshop and for providing your feedback through this survey. If you have additional comments please send them to therring@monmouth.edu

ECOLOGICAL ADAPTATION PRIORITIZATION METHODOLOGY SURVEY

1. Does the hierarchy underlying the Prioritization Framework make sense?

If not, why and how should it be modified? **YES**

2. Please let us know if the Framework is missing any important categories and/or if any categories should be removed?

Landfills/ Dredge Material Placement Sites/ Contamination Category

3. Should the framework only focus on categories that can be easily assessed by existing GIS data?

No, limited user input could add unknown information into the project and final outcomes.

4. What GIS layers are missing that should be included in the Framework?

   Landfills/ Dredge Material Placement Sites/ Contamination/ State and Federal Navigation Channels

5. Should modifications be made to the evaluation metrics? If so, what types of changes should be made?

Some metrics may need to be different per region for example Northeast NJ, Barnegat Bay and Delaware Bay.

6. Should the framework be static or adjustable (by region, land use, objective, user)?

Adjustable, for example Delaware Bay Region has much different socio economics/ infrastructure than Barnegat Bay Region. Additionally, the tide range is much larger in the Delaware Bay than Barnegat Bay.

7. Should the Categories be weighted and if so, how?

Maybe, would need to see draft results at statewide and regional levels both at non weighted and weighted.

8. Please provide any additional comments you would like us to consider in the development of the methodology

Draft Ecological Adaptation Prioritization method is very comprehensive.

If a web map is be developed the goal should be to keep as simple (transparent) as possible for all levels of users.

For GIS work it may be useful to document intermediate steps that were utilized up to final layer/ output results.

Thank you for taking the time to participate in the workshop and for providing your feedback through this survey. If you have additional comments please send them to therring@monmouth.edu

ECOLOGICAL ADAPTATION PRIORITIZATION METHODOLOGY SURVEY

1. Does the hierarchy underlying the Prioritization Framework make sense?

If not, why and how should it be modified?

Yes. One comment: for the topics where data does not exist there is a way to evaluate it using numbers (ex: 0-1 or 0-3), but the data will still not be there. Is this data going to be entered by the person proposing the project, will this data be assumed, or will this be needed to be obtained by either the entity or DEP in order to move forward with the analysis? Suggest identifying which data is critical path and which data is supportive. That said, during the workshop it was mentioned that this is a tool for a high-level overview and not meant for a project by project evaluation so this data would be needed for the entire coastal zone in order to move forward with the analysis?

2. Please let us know if the Framework is missing any important categories and/or if any categories should be removed?

Existing Landforms- A site might be in an area that is currently urban, covered in impervious surfaces, or even contaminated. Suggest making “Other” a subcategory.

Habitat- Just a note that Migratory Flyway of Significance and Rookery subcategories both include breeding ground for birds and may potentially have some overlap. Suggest including Threatened & Endangered Species Habitat (DEP - Landscape Project).

Physical Environment- Does “ice” have a timeframe or season? Does storm surge have a time period as well or are most of these topics going to be the “average” for the area?

When the rating factor is 0,1 is it assumed that the middle metric is 1 and the metrics above and below are 0? If not, suggest labeling what they would be (re: Category Data Sources Crosswalk.pdf) unless they are already labeled in another PDF.

General comment- PDFs show information for categories 1, 3, 4, 8 and 11. Are the other categories combined with those or are some not shown here.

3. Should the framework only focus on categories that can be easily assessed by existing GIS data?

If the data is considered important to making the decision it should be included, even if it is not available in a GIS format.

4. What GIS layers are missing that should be included in the Framework?

Under economic, is there a way to consider the economic benefits due to a wetland or living shoreline reducing wave velocity/flooding during a storm event? Maybe include an economic layer of the surrounding area.

Under Infrastructure, suggest considering the location of businesses.

Under Existing & Planned Projects- would USACE and Dept. of Homeland Security projects be combined with Federal Agency Projects since they are federal?

Under Constructability would cost of building the project be included?

5. Should modifications be made to the evaluation metrics? If so, what types of changes should be made?

The adaptation measure metrics are color coded green, yellow, orange, red. When looking at this, it implies that the green and yellow may be better than the red and orange. That said, I believe these are the desired evaluations for the best case for each project type. Maybe these should be color coded by project type (column) instead of by number?

6. Should the framework be static or adjustable (by region, land use, objective, user)?

The framework should provide some flexibility so that when new data becomes available it can be updated and/or if any external factors change, the tool can still be adjusted for different objectives and used. That said, it should not be so adjustable that the scope of creating the tool is too large, costly and time consuming.

7. Should the Categories be weighted and if so, how?

If the categories are weighted, there needs to be substantial justification for why one category is considered more or less than another. This becomes difficult without specific subject matter experts.

8. Please provide any additional comments you would like us to consider in the development of the methodology.

Great methodology. Looking forward to seeing the next iteration!

Thank you for taking the time to participate in the workshop and for providing your feedback through this survey. If you have additional comments please send them to therring@monmouth.edu

ECOLOGICAL ADAPTATION PRIORITIZATION METHODOLOGY SURVEY

1. Does the hierarchy underlying the Prioritization Framework make sense? If not, why and how should it be modified?

Thank you for the opportunity to comment on the methodology used to develop the Ecological Adaptation Prioritization Framework (Framework). I think the initiative is a good start for assisting the NJDEP or other permitting/funding authority in choosing an appropriate nature-based adaptation measure to reduce risk to human life and coastal natural resources.

As I understand from the presentation and materials, the Framework is a GIS-based "desk top" assessment that rates ecological adaptation projects in selected areas of the NJ coastal zone. The ecological adaptation measures used (Table 2) assume that we will hold the line for some number of years and that the existing landforms will not migrate or change.

The Framework contains 11 Assessment Categories, each with sub-categories, descriptions, metrics, and a rating factor based on the metrics. The metric ratings range from 0 (least preferred) to 3 (optimal outcome) and metrics are scored accordingly via the Framework. I assume that the User who will add information to the metric score will be a NJDEP employee, not a public or commercial applicant or environmental advocate. It is unclear where the User-defined weighting occurs within the Framework. The User will utilize the Framework when recommending adaptation projects

that satisfy the state's broad planning objectives (preserve, restore, or create habitat and provide the
maximum ecosystem and flood risk reduction benefit).

The rating factor system needs to be explained further. I have questions regarding how the Screening Tier review process works and the metrics/rating factor connection. The Screening Tiers
listed in Figure 2 appear to be reasonable planning objectives, but I am not sure how these are tied to the overall planning objectives (preserve, restore, or create habitat and provide the maximum ecosystem and flood risk reduction benefit). Does the Framework incorporate only these four Screening Tier questions to rate the areas of the coastal zone in greatest need for an adaptation
measure, or rate an adaptation measure at a project scale in a specific coastal area? Are the GIS ratings checked by an expert? Where does the User defined weighting occur in the Framework?
Only where GIS data and ratings are not available, or through the adaptation measures (Table 2 and Adaptation Measures Metrics)? The Adaptation Measures Metrics spreadsheet includes ratings for only 2 of the 10 landforms (maritime forest and coastal headland). Perhaps the Framework could be run to include salt marsh or tidal flat landforms since those are the areas typically covered under the NJDEP permitting process.

2. Please let us know if the Framework is missing any important categories and/or if any categories should be removed?

Assessment Categories: I assume the 11 Assessment Categories match those listed in Table 1 (Ecological Adaptation Prioritization Methodology Background.pdf), though these are not identical to those identified in the Framework spreadsheet (for example, item 1. Existing Landforms in the
Ecological Adaptation Prioritization Framework whereas Table 1 item 1 lists Existing Land Use). Suggest that the categories match in both the spreadsheet and accompanying explanation documents. I think that the categories listed on the spreadsheet work better than those listed in Table 1. And,
those listed appear adequate for the Framework system to work.

Sub-Categories/Description: Overall, these look fine. For Category 1, I would like to add Overwash areas to the Beach & Dune subcategory.

3. Should the framework only focus on categories that can be easily assessed by existing GIS data?

Yes, use the existing state-derived GIS datasets for now even though it kicks out some of the Categories/Subcategories in the assessment. I think the Framework should be beta-tested by NJDEP permitting and coastal project staff and possibly federal natural resource staff and schedule meetings

for them to compare rating factors. These folks have the knowledge to identify habitats or other areas that are not mapped in GIS (for example, submerged aquatic vegetation). Also, it will give you an
idea on where to make changes to the Framework.

4. What GIS layers are missing that should be included in the Framework?

Submerged aquatic vegetation since this habitat can limit the use of some adaptation measures (e.g. marsh edge replacement with sediment or the use of dredged fill in open waters-RSM).

5. Should modifications be made to the evaluation metrics? If so, what types of changes should be made?

I think that the GIS-produced ratings should be carefully evaluated by the User. The examples provided (Adaptation Measure Metrics, Connectivity Measures Metrics, Environmental Conditions Metrics, Maritime Forest Measures Metrics, Shoreline Measures Metrics, and Wetland and Bay Shoreline Measures Metrics) only include evaluations of two subcategories of landforms – maritime forest and coastal headland. Perhaps the test group mentioned in the question 3 response could go
through the process for other landforms such as salt marsh and tidal flat. That would help provide an idea of the changes that should be made to the metrics or overall Framework design.

Also, it is unclear how the rating of metrics in Categories 5. Physical Environment and 6. Social Factors were derived (assumed from the referenced studies list). The rating factors for these
Categories include only undesirable or less desirable ratings (0, 1) assuming one or other if the Metric is a positive or negative Physical or Environmental Constraint. I do not know how this affects the overall ranking for a specific adaptation if it is changed. Perhaps include a different numbering system in the beta test as well.

6. Should the framework be static or adjustable (by region, land use, objective, user)?

I feel that the Framework should be adjustable to allow a NJDEP coastal project manager (User) the flexibility to determine the best type of adaptation measure for the region (if that is the goal of the Framework analysis). However, I’m not sure if the flexibility is good for the other User, the NJDEP permit reviewer.

7. Should the Categories be weighted and if so, how?

Yes, though since you do not have GIS data layers for many of the subcategories, the weighting process will rely on the User input. It was discussed at the September 16, 2019 workshop that instead of summing the ratings for a proposed project, that the ratings be multiplied. That way, if a proposed adaptation measure provides any undesired outcome for any of the metrics it is automatically assigned a least preferred (0) rating. The two methods should be tested and analyzed by several stakeholders to review if the results are appropriate.

8. Please provide any additional comments you would like us to consider in the development of the methodology

The GIS-based desk top analysis is the best method for beginning to prioritize projects and areas to achieve the state's planning objectives. The proposed Framework should provide this
prioritization service, but it may need some tweaking and beta testing by a selected user group before it is used at the NJDEP. I think the User input will be key to the rating system.

Thank you for taking the time to participate in the workshop and for providing your feedback through this survey. If you have additional comments please send them to therring@monmouth.edu

Appendix C
Expert Review Comments

Coastal Ecological Adaptation Framework Methodology External Peer Review

Thank you for agreeing to provide a review of the Ecological Adaptation Prioritization Methodology currently being developed by the Urban Coast Institute for the New Jersey Department of Environmental Protection. Reflecting on the prioritization categories, subcategories, scoring metrics, rating factors, and adaptation measure parameterizations, please answer the following questions:

1. What are the strengths and weaknesses of the proposed framework for prioritizing ecological adaptation opportunities for nature and community resilience?

2. What recommendations do you have to improve the ecological adaptation prioritization framework?

3. How do you envision the ecological adaptation prioritization framework being utilized by the NJDEP for nature and community resilience?

4. How do you rate this framework and why?

Excellent
Good
Fair
Poor

Thank you for taking the time to providing a review. If you have any questions or require any additional information, please do not hesitate to contact Tom Herrington at therring@monmouth.edu or by phone at (732) 263-5588.

Dr. Thomas Herrington, Associate Director
Urban Coast Institute, Monmouth University
400 Cedar Avenue
West Long Branch, NJ 07764
Via email: *therring@monmouth.edu*

Dear Tom,

Thank you for the opportunity to provide review of the Ecological Adaptation Prioritization Methodology currently being developed by the Urban Coast Institute for the New Jersey Department of Environmental Protection (NJDEP). On behalf of The Nature Conservancy in New Jersey (TNC-NJ), we commend you for taking on such a complex task and hope that our comments prove useful as you develop your final report for NJDEP. Please find below our responses to the evaluation questions provided. We would welcome the opportunity to continue our discussions with you and/or NJDEP as it continues to develop and test out the framework.

5. *What are the strengths and weaknesses of the proposed framework for prioritizing ecological adaptation opportunities for nature and community resilience?*
    a. *Strengths* – TNC believes that a framework to inform the selection of ecological adaptation projects to bolster the resilience of NJ's coastline – both natural and built environments – should be a key component to a state coastal resilience plan. Therefore, one if its strengths is that it will be filling an identified need in the state. It is also very comprehensive and thorough in terms of identifying potential data sources/analyses, which should allow for flexibility when being implemented should there be missing data/analyses.
    b. *Weaknesses* – It seems as though the framework may be trying to address multiple needs beyond its stated intent of being used for the state coastal resilience plan to screen potential adaptation projects (*not prioritize among projects)*. This is evident by the inclusion of several metrics that speak more towards project design. In addition, it is not currently clear what the specific purpose of a lot of the data layers/analyses included (see further comments below regarding benefit vs feasibility) is. Finally, in a world with a changing climate and increasing rates of sea level rise, the tool should not necessarily enforce a default hierarchy that prioritizes preservation over restoration opportunities. The most important, and therefore highest ranked, action would likely depend on your issue of concern and many other factors that might not easily be teased out from the hierarchy.

6. What recommendations do you have to improve the ecological adaptation prioritization framework?

    - TNC-NJ recommends that NJDEP/UCI be very clear on the primary goal of this framework and let that drive its development, as well as the development of any associated tools should that be planned. Having a framework that tries to accomplish too many things at once will minimize its overall value for that primary purpose. As such,

    - TNC recommends it be focused on screening potential project areas to rank each area for both flood reduction benefits (community resilience) and value for ecological resilience separately, which would then enable NJDEP to identify areas of overlap if desired. A comprehensive coastal resilience plan should promote both the individual and combined benefits based on the priorities of a particular region. From there, potential projects can then be screened for multiple, stacked benefits, followed by feasibility.
    - To help achieve this goal, the “Issue of Concern” should be the first screening criteria, which should include just the primary issues and remove those that would likely be considered an added benefit. For example,
        - “Degradation and habitat loss” and “shoreline erosion” can be combined into “Habitat Loss.” “Coastal flood damage,” “Coastal Storm Damage,” and possibly “Nuisance flooding” can be combined into “Flood Damage.”
        - If the primary goal is to use this framework within a coastal resilience plan aimed at reducing the impacts of flooding and sea level rise, “Water quality” and “CO_2 Sequestration” should be removed as issues of concern since they would be primarily be considered benefits in this scenario. In addition, both of these benefits, especially sequestration, require too much site-specific data collection to determine the level of benefit to an accuracy worth including in screening criteria as an issue of concern. However, we would theoretically want to know which potential projects had these added, stacked benefits to help highlight potential projects and project areas with multiple benefits.
- The metrics within each of the sub-categories seem to be a mix between those that speak more towards project feasibility and those that speak towards project benefits. However, our reading of the summary indicates that the framework first looks at the impacts or benefits, then screens based on feasibility or additional “nice to have” elements to make projects more attractive. TNC-NJ suggests you consider separating them out if trying to ‘prioritize or rank’ based on benefits, then screen based on feasibility. For example,
    - 1 - Existing Landform (Points of information, unless want to be able to screen out projects specific to a particular habitat type based on funding availability or if one landform type has a greater flood reduction value than another.)
    - 2 - Land Use/Management (feasibility)
    - 3 – Habitat (Benefit – ecologic resilience)
    - 4 - Issues of Concern (starting point—what you’re trying to address underneath flood reduction vs ecologic resilience)
    - 5 - Physical Environment (feasibility)
    - 6 - Social (Benefit - flood reduction)
    - 7 - Influence Area (Feasibility)
    - 8 – Economic (Benefit, however, ecosystem services” is so general, as well as captured indirectly by many other metrics within the framework work, we recommend dropping it.)

    - 9 – Infrastructure (Benefit – flood reduction)
    - 10 - Existing & Planned Projects (Benefit—both)
    - 11 – Constructability (feasibility)
  - Separate out metrics that are more conducive to project design. For example, many of the metrics under “Physical Environment” would be rated as Yes/No, thus only providing additional information during a screening process. The framework could be simplified by pulling out such metrics.
  - If using an additive approach in the final version, consider using negative (-) values when doing the rankings. This would help to flag potential issues, as opposed to placing a more neutral value of zero on something with actual negative impacts.

7. How do you envision the ecological adaptation prioritization framework being utilized by the NJDEP for nature and community resilience?
    a. See comments in #2

8. *How do you rate this framework and why?*

Excellent

Good. While I think the framework has a lot of potential, and it is very comprehensive with regards to the underlying input, it seems to be trying to do too much and satisfy too many audiences. This is especially true if envisioning to create an online tool. But with the amount of information included, there’s a very strong starting point for a more useful tool—just need to become a lot more targeted and clearer on why/the value of the information included.

Fair

Poor

Sincerely,
Patty Doerr, Director of Coastal and Marine Programs
Ellen Creveling, Director of Freshwater Programs
The Nature Conservancy in New Jersey

To: Thomas Herrington, Urban Coast Institute, Monmouth University

From: Richard Lathrop, Center for Remote Sensing & Spatial Analysis, Rutgers University,

Re: Ecological Adaptation Prioritization Methodology Review

Date: September 30, 2019

1. What are the strengths and weaknesses of the proposed framework for prioritizing ecological adaptation opportunities for nature and community resilience?

I suggest that the proposed methodology is most appropriate to be employed in the following situations: 1) on a case by case basis to assess a specific project site and evaluate the possible different alternative adaptation approaches; and/or
2) to objectively rank a whole series of potential projects across a county, region or state and assess which rank highest as one means of prioritizing funding. A strength in this respect is the development of an objective, consistent framework to allow for more ready comparison between projects. I would caution that rolling this all up into one final number (i.e. per project) will obscure a lot of the underlying nuance. However, the methodology allows for coastal decision-makers to drill down to see that nuance if desired.

I suggest that proposed methodology will not be particularly useful, and in fact rather cumbersome, if it was to be deployed proactively statewide to identify where adaptation practices should and could be employed. As it is my understanding (from the document) that "The Framework is a high-level screening method for the selection and prioritization of ecological adaptation projects in specific regions and locations" then I feel comfortable with the methodology.

I agree with the overall hierarch of actions: 1st Preserve; then Restore; and, as a last resort, Create. I believe that the broader coastal decision-making community would also concur. The devil is in the details of the ranking schema. Having the ranking schema available for all to see is a system strength. More documentation as to what backs up the ranking choices would be useful.

For the methodology to be truly useful, it needs to be embraced by the larger coastal decision-making community. NJDEP might actually need to require that proposed projects employ the methodology to facilitate the funding decision process.

Employing the methodology will still require a high level of end-user training/experience and extensive GIS expertise. It is not a turn-key system. The intended NJDEP target audience should have the requisite knowledge, experience and expertise to make it work. However, some NGOs may not have the wherewithal to apply the methodology.

2. What recommendations do you have to improve the ecological adaptation prioritization framework?

While the basic prioritization approach has been laid out in straight forward manner, there are some steps that need further clarification. In particular the linkage to the Adaptation Measures Matrix.xlsx and the ranking/color-coding system therein. **More guidance is needed for the User on this step of the process.** The existing Powerpoint is inadequate in this respect.

The inclusion of several worked examples (i.e., different scenarios) where the ranking schema is applied would be very useful.

I have included more specific comments on the different components on the pages below.

3. How do you envision the ecological adaptation prioritization framework being utilized by the NJDEP for nature and community resilience?

I envision NJDEP or potentially other funding agencies such as NFWF applying the methodology to objectively rank a whole series of potential projects put forth by various partners across a county, region or state as one means of helping to prioritize funding. I can also envision NJDEP and other NGO partners employing the methodology on a case by case basis to assess a specific project site and evaluate the possible different alternative adaptation approaches.

4. How do you rate this framework and why?

Good to Excellent

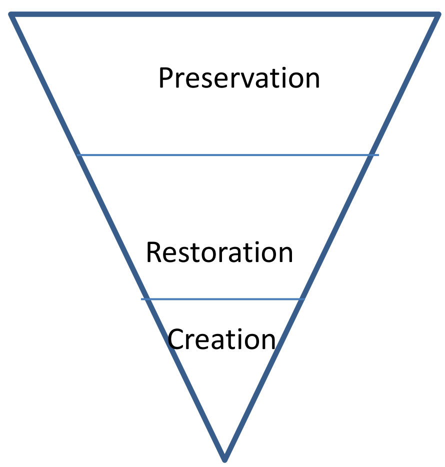
<u>Ecological Adaptation Prioritization Methodology Background.pdf</u>

I suggest that this methodology is most appropriate to be employed in the following situations:
1) on a case by case basis to assess a specific project site and evaluate the possible different alternative adaptation approaches; and/or
2) to objectively rank a whole series of potential projects across a county, region or state and assess which rank highest as one means of prioritizing funding.

I suggest that it would not be particularly useful, and in fact rather cumbersome, if this was to be deployed proactively statewide to identify where adaptation practices should and could be employed. As it is my understanding (from the document) that "The Framework is a high-level screening method for the selection and prioritization of ecological adaptation projects in specific regions and locations" then I feel comfortable with the methodology.

I have marked up the pdf with some minor edits. Some specific comments are below.

Figure 1. the design of Figure 1 doesn't convey to me the intended message that Framework is based on a hierarchal assessment that weights the preservation of existing coastal lands over restoration and the creation of new lands and natural features. Appears that Preservation leads to Restoration to Creation. Maybe something like this.



On Page 4 of the document, it states that there is a database of adaptation measures (outlined in Table 2). It is unclear to me how the Adaptation Measures Matrix.xlsx relates to this Table 2. It appears that the various adaptation measures appropriate for the Habitat Category are included, however, I am unclear on the numerical ranking and the color-coding**. More guidance is needed for the User on this step of the process.**

Also it is unclear as to why Maritime Forest and Coastal Headland are included under each of the Habitat tabs.

Ecological Adaptation Prioritization Framework.xlsx

The framework includes a reasonably complete enumeration of the various environmental factors important when considering ecological adaptation in NJ's coastal zone. Some specific comments are below.

Existing Landforms – while most of these are readily identifiable through existing state/federal mapping programs, some categories might be problematic or inadequately defined. For example, ***Bog***.

Land Use /Management – would be worthwhile to identify Blue Acres types of purchases, even if transferred to other agencies for long term management.

Issues of Concern – I would suggest adding: present or potential future lack of public access to the shoreline or water

Physical Environment – the 0,1 Rating system is unclear to me. Simple Presence/Absence? It is different than the other criteria.

Constructability – I would separate the post construction operation/maintenance costs from whether there is an agency/group that has taken "ownership" of the project and agree to maintain the site in the future

GIS layer cross walk.xlsx and GIS_Layers.pdf

The project has compiled a very extensive database of existing relevant GIS layers. I assume that the column GIS Layer with the attributes of Yes/No is recording whether there is existing information concerning the Data Parameter in question (i.e. the row). I would suggest that there is existing GIS data on some of the parameters listed as No GIS Layer:

Maritime Forest – there is a coastal dune scrub/shrub category in the NJ LU/CL data set. This should be useful to map out Maritime Forest. Additional work might be needed to map out some back-bay locations.

T&E Habitat, Rookery – the Endangered & Nongame Species Program on NJ Fish & Wildlife has GIS data.

Issues of Concern - Shoreline Erosion – NJAdapt includes GIS map on change in shoreline between 1977 and 2010. There is also GIS layers on sea level rise, storm surge,

Physical Environment - For the TNC Restoration Explorer, Rutgers CRSSA developed GIS Layers of shoreline erosion, tide range, high energy coastlines, ice cover, elevation, upland slope, shoreline slope, nearshore slope, offshore depth, water salinity.

Economic – state NJDEP Marine Fisheries has GIS on aquaculture leases.

Infrastructure – locational data on Marinas is collected by Mike Danko of NJ SeaGrant.

Comments on the Ecological Adaptation Prioritization Methodology

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Summary Comments

The Ecological Adaptation Prioritization Methodology fills an essential gap regarding the first stage of resiliency planning. That is, in times of high need and limited resources, where should the efforts be focused? Other efforts focused on site-specific deficiencies and needs are appropriate for relative assessments and tactic identification, but these assessments require a larger investment of resources (e.g., time, effort, equipment, sample processing, etc…) that should be reserved for sites that have already been identified as being in need and of high priority to stakeholders. Recent work by Rutgers University, PDE, and Barnegat Bay Partnership (article in prep) showed that although regional, high-level assessments (e.g. SLAMM) underestimated the site-specific magnitude and time-frame regarding habitat degradation and loss, the relative ranking of these changes among sites was similar. This means that although low resolution efforts underestimate the severity of changes, they were able to identify the relative need across a suite of sites that is essential for planning efforts. This is the primary goal of high level assessments – what areas are most likely to experience change? The Ecological Adaptation Prioritization Methodology aims to make this high-level assessment though the "stacking" of GIS-layer to score sites based on a variety of criteria. Additionally, the methodology may help to identify overlap regarding potential stakeholder missions, allowing the user to gauge where multiple agencies may have a vested interest.

The major strength of this methodology is that it provides a foundation to develop a high-level site prioritization tool that includes all the suitable GIS layers currently available. Additionally the framework is plastic and will be able to accommodate any structural or calculatory changes identified though continuing workgroup activity or through updates to information provided in primary literature sources. The major weakness of the methodology is that it seems to aim to evaluate the effects of project types on the landscape instead of evaluating the needs of the landscape so that goals, spatial distribution of conditions, factors of interest (critical infrastructure, T&E species, etc…), and stakeholder interest can be identified. This would allow for a first-cut evaluation of the distribution and magnitude of site-specific needs for further site specific evaluation. Additionally, this framework would benefit from the ability of user to be able to weight, or select/deselect, the various categories for the identification of user or agency-specific high priority areas.

Structure

The name Ecological Adaptation and Prioritization Methodology does not actually reflect this work as it stand to date, but is more of a goal for which this work provides the foundation. Currently, this methodology is framework for the relationships between and among various categories and suggests an initial integration mechanism based on relative levels of scoring within categories. The proposed integration is preliminary, and ultimately needs further work to provide a more nuanced evaluation of location based conditions, needs, and alignment with stakeholder interests (see Next Steps and Future Applications section).

The primary goals appears to be to assess the place-based effects of a specific adaptation action on the following Tiers:

1. Current conditions
2. Issues of concern
3. The social fabric of the area
4. Adjacent actions

The framework does this by asking the user to rate the impact of the proposed project on the previously mentioned Tiers as having (in highest to lowest rating)

1. Preservation impact (score=3)
2. Restoration impact (score=2)
3. No impact (score=1)
4. Negative impact (score=0)

This hierarchy is based on the current findings that older, established habitats provide greater services/function than new, restored habitats (that take time to mature and provide functions at a high level), and that these outcomes are preferable to a negligible or negative impact. These Tier-based scores are then added together to provide a place-based final score regarding the effects of the planned adaptation effort. This would allow the user to evaluate which among multiple efforts would have the highest relative ranking.

Two initial flaws appear to be with the nomenclature and the user-based impact ratings. First, the term Tier implies that there are levels, either virtual (e.g., good vs. bad) or concrete (e.g., 1:300 resolution vs. 1:30,000 resolution). As this framework stands, no hierarchy currently exists among levels, since they are weighted evenly. The term “factor” may be more appropriate. If no weighting scheme will ever be applied to these groups as a whole, delineation among categories may not be needed. If there is room to weight by either the category level or by the category grouping level (currently referred to as Tier for which Factor was recommended), then the categorical groupings should remain.

Second, the user-based impact rating will have a fundamental bias embedded in each score. Since the user will describe the potential impacts of a proposed project on the aforementioned categories, and projects are designed with the best intentions, it is unlikely that a scenario will be described where the project has a negligible or negative impact. If this tool is available to any user, it is likely that a scenario will occur where a user can show the value of a proposed project with a high final score that is not reflective of the real outcomes if installed. This is not a jaded scenario in which the worst is assumed about a potential user, but a likely scenario in which the user truly believes that their project will do well and address all of these issues in the development phase. If the user is not aligned with a specific adaptation effort and is conducting an evaluation without project affiliation, this may not be an issue. But, how will an independent user be able to truly assess the impacts of a specific project on the landscape when a site-specific evaluation has not occurred? If this is a high-level first cut look at potential restoration impacts across the landscape, the site-specific high resolution data to truly understand the issues and therefore the tactics that are appropriate to address them and their likely impacts has yet to be conducted. Under either concern scenario, the output will likely be directed by a large degree of user bias.

GIS Layers

The current list of GIS layers appears to be exhaustive. One resource that does not appear to be represented is the spatial wetland assessment data available through the MACWA database. These data can provide scores on relative condition over time and may be useful for identify the relative magnitude of deficiency at the site-level.

Metric Table Evaluation

General Comments

It is very difficult to attribute the ability of a specific tactic to address a specific issue without any knowledge of the underlying site-specific condition, which it assumed that the user of this methodology is not yet aware of as they are preforming a general landscape-level first look. For example, if the waterward edge of a salt marsh is eroding, the installation of energy attenuating materials can address the issue, but only if the erosion is sourced from the waterward direction. If, the erosion is sourced from increased inundation leading to waterlogging and vegetation die-off, no amount of energy attenuation will stabilize the marsh. If a marsh is seeing a loss of vegetation on the platform, sediment Spreading (TLP, Beneficial re-use, etc…) has the potential to address this issue, but only if the issue is one of elevation capital deficiency. If the issue is from sediment toxicity due to enhanced nutrient input (point or non-point, natural or anthropogenic) elevation augmentation will not help. Additionally, a tactic may provide positive outcomes for one condition while having a negative impact on another. For example, altering the hydrology of marsh though the filling of a portion of the intra-marsh creek system may reduce the volume of water entering a high marsh area and reduce flooding frequency thus enhancing the necessary conditions to main this habitat, but it may also reduce critical fish nursery habitat.

These examples highlight the fact that aligning specific tactics with the ability to address specific issue is preliminary at this stage of site-evaluation. Evaluation of the appropriate tactic to address a site-specific issue happens at a later stage and different scale of site-evaluation. This methodology would benefit from assessing the landscape-level site characteristics rather than trying to align tactics with their ability to address the needs specific metrics.

Next Steps and Future Applications

This methodology moves in the direction of assessing relative effect of adaptation efforts on the landscape instead of evaluating the landscape for the needs to direct or prioritize an adaptation efforts.

Current Direction: Adaptation Effort → Landscape-level Effect

Suggested Direction: Landscape-level Attributes → Adaptation Location Prioritization

Under the current framework, a user would assess the effects of a specific prioritization effort on the landscape (social and environmental) at large. What seems to have a greater need is be able to spatially identify where specific needs are located and who they serve. For example, a user may be interested in which locations currently have a need for adaptation efforts that are located in salt marsh on public land that does not have endangered species but is a good birding area currently suffering from excessive flooding with low tidal energy in a socially vulnerable area. Under this framework, the user would be able to identify those areas. This scenario would work at the general and site-specific level, where user could search the landscape to find locations that meet criteria of interest, or get the categorical summary of a specific site. This framework provides the necessary categories and scoring mechanism to accomplish this by changing some of the metrics from the Preserve:Restore:No Effect:Negative Effect regime to different category-specific scores. These proposed changes are noted in Table 1 below. A user could potentially have the ability to activate only the rows of interest so that output reflects only the categories selected. Conversely, if an area is selected, the score foe each row will be provided in an attribute table associated with the larger polygon in which the location is situated. The identified polygons (sites) can then be exported as a layer with the categorical scores. The user can then evaluate these scores to assess if the location would require protection, restoration, or no action (Intervention Goal Score) which can then be added to each site to sort them based on adaptation goal (to protect or restore using an intervention, or to preserve without activity/no activity needed). A user-based weighting scheme could also be applied to each categorical score in the exported polygon layer, which along with the Intervention Goal score, will provide a relative ranking of these polygon can then be used for prioritization efforts. What this tool will not do is to be able to address potential site-specific deficiencies and appropriate on-the-ground tactics to address them, which can be provided through the use of other tools. Under this proposed regime, multiple habitats and their associated benefits, as well as multiple landowners and issues that can be addressed (goals)on or adjacent to the property, will increase the score. This makes sense as the more types of ecological protection and stakeholders that can be addressed in an area, increases the priority of that area for ecological adaptation.

Table 1 Current and proposed metric structures for categories nested in Tiers of the Ecological Prioritization methodology. Proposed structure describes new scoring regimes associated with ranking sites based on their landscape-level attributes rather than the effects of an adaptation effort on the landscape as proposed and described in the current metric structure. These scores would be applied per row within each category. These scores assume an additive model.

CATEGORY	CURRENT METRIC STRUCTURE	PROPOSED METRIC STRUCTURE
EXISTING LANDFORM	Preserves (3) Restores (2) Negligible(1) Negative (0)	Exists at Location (1) Does Not Exist at Location (0)
LAND USE/ MANAGEMENT	(Generally) Yes and aligned with goals (3) Adjacent and aligned with goals (2) Adjacent and not aligned (1) Not adjacent (0)	Yes, and aligned with goals (2) Adjacent and aligned with goals (1) No (0) Yes and not aligned with goals (-1)
HABITAT	Preserves (3) Restores (2) Negligible(1) Negative (0)	Exists at Location (1) Does Not Exist at Location (0)
ISSUES OF CONCERN	(Generally) Preserves (3) Restores (2) Negligible(1) Negative (0)	Issue exists at this location (1) Issue does not exist at this location (0)
PHYSICAL ENVIRONMENT	Follows Steven's Guide	Keep the sample but make terms negative and increase in magnitude with increasing severity of physical conditions
SOCIAL	Keep as is	Keep as is
INFLUENCE AREA CHANGE TO SCALE OF DEFICIENCY	(Generally) Spans whole area or row (3) Spans segment of row (2) Connects areas of row (1) Isolated /disjointed (0)	More than 75% of total habitat area (3) 50-75% of total habitat area (2) 25-50 of of total habitat area (1) 0-25% of total habitat area (0)
ECONOMIC	Create (3) Enhance (2) No effect (1) Negative effect (0)	Create (3) Enhance (2) No effect (0) Negative effect (-1)
INFRASTRUCTURE	(Generally) Located within AOI (3) Adjacent to AOI (2) Within 100' (1) >1000' (0)	Keep same
EXISTING PLANNED PROJECTS	(Generally) Within or other project area (2) 1mi (1) >1mi (0)	Overlaps with benefit (2) Adjacent with benefit (1) Not adjacent (0) Adjacent with potential conflict (-1) Overlaps with conflict (-2)
CONSTRUCTABILITY	Keep same	Keep same

Reviewer:
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Review: Ecological Adaptation Prioritization Framework

Summary
The project goal is the development of a methodology for an Ecological Adaptation Prioritization Framework (Framework) that can been used for evaluating and prioritizing adaptation strategies as part of New Jersey's climate resiliency planning process. The Framework focuses on the protection, restoration and creation of natural coastal resources and seeks to present a high-level consideration/screening of potential strategies within a context of alignment of existing land use, management goals, and efforts; and scale and benefits. The framework references NJDEP GIS mapping layers of several relevant features. Where GIS information is lacking, the methodology allows for the user to input relevant information. The methodology includes a parametric scoring system to support identification of the most viable nature-based solution to support user goals and scales. Prioritization is given to preservation, over restoration, and restoration over creation of habitats based on the rationale that studies have indicated preservation supports the greatest ecosystem and community resilience benefit. Although parametric scores are established for various elements, the method presents opportunity for the user to weight parameters for their specific purpose.

The framework presents eleven assessment categories, these are attributes that could be considered when evaluating sites for and or types of ecological adaptations that might be implemented to achieve coastal resiliency goals. Within each if these categories are sub-categories that are noted to have measurable metrics and associated rating factors. The method is presented as a useful tool for an initial assessment of ecological adaptations with an understanding that selection and implementation would require more focused site-specific information evaluation.

What are the strengths and weaknesses of the proposed framework for prioritizing ecological adaptation opportunities for nature and community resilience

Strengths

- The proposed framework presents a robust inventory of existing potentially relevant data layers and attributes that could help inform target locations for adaptive measures and how such actions may relate to existing habitats, land use, and physical dynamics.
- The eleven assessment category areas identified provide a comprehensive list of considerations that should be addressed when evaluating potential projects or broad scale management strategies. **Consider adding ecological benefits as an actual category.**
- The concept of having a common suite of criteria that should be considered in the development of management strategies and specific project development makes sense.

- The framework provides a list, “adaptation database”, of various measures that can be taken to support coastal resiliency.
- It is valuable to have data resources, criteria, attributes, and “adaptations” brought together in a single conceptual framework.
- The idea of a user weighted parametric scaling seems like a smart approach. As I think about addressing coastal resiliency/ecological adaptation, the complexity becomes overwhelming and such issues will be approached from varying perspectives, ie. one might have funding to put toward beach nourishment, or migratory shorebird habitat, or maybe a municipality will be thinking about flood abatement, or maybe NJDEP will be want to improve water quality in Barnegat Bay and each of these topics will require consideration at varying scales and resource levels. I like the idea of the framework user being able to adjust and weight the criteria, attributes based on their perspective rather than relying on a preset potentially biased parametric. Having a framework or structure to launch the evaluation is beneficial.

Weaknesses:

- It is difficult to imagine how the framework would be utilized in its current state, or even as further developed with in the current precept. Some aspects seem to foster a high-level assessment, while other aspects get into the weeds of a site-specific approach. Maybe down the road there could be two phases – one more global with a high level evaluation and the second more specific for a local site/project specific approach.
- Parameterization sets a global bias that even with the possibility of weighting seems as though it would be challenging to overcome.
- In the end with so many rankings, it just seems like the resulting prioritization score will be meaningless.
- Would a project proposing three small living shorelines, one each constructed in the upper, middle, and lower portion of an estuary be considered ecosystem wide? Would it also score for three municipalities and three counties, and then get bonus points for not being near a hospital etc, and well it probably gets points for three salinity regimes, endangered species, and migratory flyway— yet the actual benefit of the 90 feet of structure along a high energy 45 mile stretch of shoreline may be questionable.
- The parametric ranking includes physical attributes such as salinity, which are highly relevant for feasibility, but maybe shouldn’t be ranked for an overall prioritization score.
- The project has a general vagueness in respect to exactly how the developer intends it to be used. I understand how it might be used in respect to an inventory and a support structure for decision making, but not as a method for prioritization.
- The reference list is weak. I don’t feel that agency websites are an appropriate reference unless there is a particular document or data source that is being cited. I would like to see a more in-depth literature cited that would include similar types of methods – worldwide.

What recommendations do you have to improve the ecological adaptation prioritization framework?

- Include case study examples of application
- Add ecological benefits to the list of criteria and or tier
- Reduce the number of subcategories – collapsing to broader subcategories.

- There should be additional consideration given the assignment of parametric ranks ie. should they be additive or multiplicative, are values correct, should values be user entered based on application, rather than preset.
- It would be helpful is the term ecological adaptation is defined (relative to framework proposed) in background documentation text.
- Incorporate content of first several power point slides into the framework description text.
- "Why ecological adaptation in NJ" consider food production (fisheries, aquaculture economies) and ecosystem services.
- Additional clarification is needed- are the tiers hierarchical? Seems they might be more parallel.
- Layers to add – shellfish harvest classification (NJDEP, Bureau of Marine water Monitoring) and shellfish leases (NJDEP, Shellfisheries Bureau), working waterfronts (not sure there is such a layer).
- Table 2. Ecological adaptation measures:
    - blue mussel beds change to mussel beds (ribbed, blue, freshwater)
    - add shellfish aquaculture to green infrastructures
    - add nutrient trading

How do you envision the ecological adaptation prioritization framework being utilized by the NJDEP for nature and community resilience?

I believe a prioritization framework could be useful for both broad landscape level management plans and for site specific project development and funding decisions; however, I'm not sure that as it is presently constructed it can adequately support either. It is useful as an inventory of data resources and as a structure to support the evaluation of relevant criteria. I'm not convinced the prioritization score will be at all useful without significant further development.

How do you rate this framework and why?

I would rank this as **good** in respect to serving as an inventory support tool. **Poor to good** in respect to method for prioritization. Further development seems to be needed to get to that next level, or perhaps it would be helpful if there were case studies to demonstrate.

A Fifth review was provided by Ms. Lisa Auermuller, Watershed Coordinator for the Jacques Cousteau National Estuarine Research Reserve in Tuckerton, NJ. The review comments were placed directly on the Microsoft Excel files containing the Framework assessment categories, metrics, rating factors and CEAs parametrizations for each metric. Comments and suggestions provided by Ms. Auermuller are reflected in the Expert Reviews section of the document.

Photo courtesy of Monmouth University Urban Coast Institute