Challenges and Proposed Solutions to Implementing Natural and Nature-based Features in New York State

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Various NNBF sites and monitoring efforts. Photos by Science and Resilience Institute at Jamaica Bay (SRIJB).

Executive Summary

New York State's diverse shorelines face increasing risks from flooding, erosion, storms, and sea level rise. While natural and nature-based features (NNBF) offer promising alternatives to traditional hard infrastructure, their widespread implementation remains limited. This paper identifies three primary challenges hindering NNBF adoption across New York: the wide range of project typologies, insufficient and nonstandardized monitoring, and limited accessibility of existing data. Drawing on statewide stakeholder input and regional case studies from Long Island, New York City, the Hudson River Estuary, and the Great Lakes, the paper illustrates how geographic and ecological variations influence NNBF design, performance, and maintenance. To advance effective implementation, a set of solutions are proposed, including: (1) developing a statewide NNBF community of practice, (2) expanding the use of standardized monitoring frameworks, (3) improving data visualization tools, and (4) establishing a comprehensive, publicly accessible NNBF database. Together, these actions aim to strengthen coastal resilience, improve decision-making, and support the long-term success of NNBF projects across New York State.

Introduction

New York State (NYS) has varying coastlines, including marine, riverine, and lacustrine. While each of these shoreline types experiences flooding and erosion, the causes and solutions include considerations that are unique to the geography. Traditional solutions for increased flooding and/or erosion have mainly involved installing hard shoreline structures, such as seawalls, bulkheads, and revetments to protect at risk communities. However, decision-makers are increasingly interested in ways to improve community resilience and coastal ecosystems using more natural methods. This demand for new and innovative shoreline management strategies and techniques in NYS has grown throughout the decades, particularly in response to the threat of sea level rise, lake level fluctuations, storms, and tropical systems such as Superstorm Sandy and Hurricanes Irene and Ida. The NYS Department of State (DOS) defines resilience as the "capacity for a community and its ecosystem to: withstand extreme events and other forces or risks; quickly recover interconnected social, economic, and ecological systems' structure and function in the aftermath of a disaster; and develop ongoing adaptability to rapidly changing environmental conditions and forces" (New York State Department of State, 2025).

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Natural and nature-based features (NNBF) have become a focal point across the state as a solution that can stabilize shorelines while also improving the resilience of a community and reducing the negative impacts of traditional hard techniques. After Superstorm Sandy caused $19 billion in damages in New York City (NYC) alone in 2012 (New York City, 2013), interest in NNBF as an alternative to conventional hard structure approaches increased. While both hard structures and NNBF provide hazard mitigation from flooding, erosion, and wave attack, NNBF has the potential added benefit of enhancing ecosystem function and improving social value of infrastructure for coastal communities. Since 2013, a number of city, state, and federal guidance and planning documents have encouraged the use of NNBFs (New York State Department of Environmental Conservation, 2020; Bridges et al., 2021; White House Council on Environmental Quality et al., 2022), and NNBF techniques (e.g., living shorelines, artificial dunes, wetlands, oyster reefs, etc.) have been implemented throughout NYS, though at a limited scale. This paper aims to identify the challenges that limit implementation of NNBF across the state and propose solutions that will increase the utilization of NNBF where appropriate in NYS.

NNBF Definitions

Various names and concepts are associated with alternatives to hard infrastructure in coastal contexts, including NNBF, nature-based solutions (NbS), living shorelines, hybrid infrastructure, and green infrastructure. However, these names and concepts are not synonymous, particularly when they are used in statutory and policy frameworks. NbS is the most general of these concepts, and is defined by the International Union for the Conservation of Nature (IUCN, 2016) as:

> *…actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.*

Thus, NbS are not specific to shoreline stabilization and flood risk mitigation. Likewise, the Environmental Protection Agency and NYC often use the term "green infrastructure," specifically in reference to nature-based solutions and hybrid infrastructure for integrated stormwater management. Thus, the term green infrastructure is not synonymous with NNBF.

The term NNBF, as proposed by the U.S. Army Corps of Engineers (USACE), refers to shoreline stabilization projects intended for flood risk mitigation (Bridges et al., 2021), and thus is a subcategory of NbS. Bridges et al. (2021) elaborates on the idea of NNBF:

> *…the term NNBF refers to the use of landscape features, such as beaches, dunes, wetlands, reefs, and islands to produce flood risk management benefits and may be natural (i.e., produced purely by natural processes) or nature-based (i.e., produced by a combination of natural processes and human engineering) that can be used alone, in combinations with each other, and in combination with conventional engineering measures such as levees, floodwalls, and other structures…*

This definition of NNBF is also reflected in the language used by the U.S. Congress. For example, Section 1184 of the 2016 Water Infrastructure Improvements for the Nation Act (WIIN Act, P.L. 114-322) provided definitions for both natural features:

> *…a feature that is created through the action of physical, geological, biological, and chemical processes over time.*

and nature-based features:

> *…a feature that is created by human design, engineering, and construction to provide risk reduction in coastal areas by acting in concert with natural processes.*

The integration of nature-based features and conventional engineering measures, or hard infrastructure, is commonly referred to as hybrid infrastructure.

In 2020, NYS DOS and New York State Energy and Research Development Agency (NYSERDA), in collaboration with other entities and organizations, developed a statewide monitoring framework called "Measuring Success" for shoreline solutions ranging from natural features to hard infrastructure (e.g. sea walls and revetments). For that project, nature-based features have been defined as:

> *"features that mimic natural features and processes and are designed to provide specific services, such as preventing erosion, reducing flood risk, increasing habitat or improving water quality; they typically incorporate or promote the growth of living materials and limit disturbance to existing habitat"* (Science and Resilience Institute at Jamaica Bay 2020).

The Network for Engineering with Nature (N-EWN), describes NNBF as:

> *"landscape features that are used to provide engineering functions relevant to flood risk management, while producing additional economic, environmental, and/or social benefits"* (Bridges et al., 2015).

NNBF can typically utilize native materials paired with structural elements and are constructed in a manner to mimic natural features and processes by considering environmental parameters, like the open water distance over which the wind blows (fetch) and the movement of sediment. Living shorelines, which are a type of NNBF, are an example of this approach.

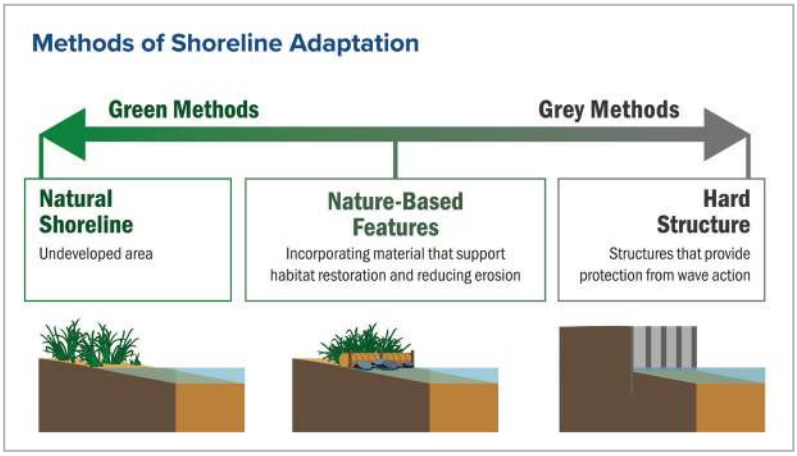
Problem Statement

While interest and implementation of NNBF have grown in recent years, widespread adoption is limited due to lack of knowledge about performance, best practices, and regulatory challenges (Sarabi et al., 2019). Across the U.S., efforts are underway to identify opportunities to streamline the permitting process for implementation of NNBF. The lack of pre-implementation baseline data for project sites and post-construction assessment of the multi-benefits — including shoreline stabilization, hazard mitigation, ecosystem services, and social, economic, and cultural outcomes — is often cited as an impediment to the implementation of NNBF (Eggermont et al., 2015, Arkema et al., 2017, Nesshöver et al., 2017, Raymond et al., 2017). The deficit of long-term data that exists in relation to the success and function of NNBF has led to a gap in decision-makers' comprehension of the suitability and performance of these structures in diverse environments (Elko et al., 2022). Additionally, the paucity of data can be attributed to a lack of funding for pre- and post-project data collection and the lack of cost-effective standardized frameworks and protocols that can include participation by communities and individuals without the need for highly specialized training (Schrass and Mehta, 2017; Wijsman et al., 2021). While efforts across the country are advancing the utilization of NNBF, several hurdles exist within NYS to the implementation of these shoreline management techniques. Through workshops, symposia, and stakeholder engagement, some specific challenges have been identified that this white paper proposes solutions for. These challenges include a lack of differentiation between project types, lack of standardization in monitoring efforts, and inconsistent/lack of data access.

Challenge: Project Typology

NNBF projects vary widely over a range of infrastructure and geographic typologies, which makes comparison of their performance and streamlining of their permitting difficult. Four different dimensions of NNBF project typology are described below:

1. Scale: NNBF projects can vary greatly in scale, measured as linear distance along a shoreline or total acreage. For example, an NNBF project at a street end that abuts open water may have a scale of meters and less than one acre.



The spectrum of shoreline adaptation methods. Artwork by Joel Davenport.

In contrast, a project involving marsh or dune restoration may include hundreds of meters of linear distance along the shoreline and tens of acres. Differences in scale can affect the extent to which a project can affect flood risk reduction, habitat connectivity, recreational use, or other intended benefits.

2. Purpose: Explicit purpose of a project can affect how its performance is assessed. The purposes can include one or more of the following: shoreline stabilization and infrastructure protection; habitat restoration and improvement; enhanced recreational opportunities; and improved shoreline access.
3. Biophysical environment: The biophysical environment can differ widely both within a small region as well as across the state. Relevant biophysical factors include vegetation type, exposure to wave energy, tidal ranges, geologic setting, sediment supply and movement, exposure to ice, and the presence and characteristics of wildlife.
4. Degree of NNBF: The options for shoreline interventions can span the natural (i.e., habitat conservation) to nature-based (i.e., living shoreline) to hard (i.e., gray) infrastructure spectrum.

Challenge: Project Monitoring

When project monitoring does occur, there can be a wide range of approaches, indicators, metrics, and measurement protocols applied. For example, some projects may include pre-construction baseline data collection. Other projects may carry out post-project data collection narrowly focused on satisfying the conditions of a regulatory permit. In other cases, a project may be subject to longer-term monitoring designed to answer questions about performance. Data collection may only address specific project objectives, such as shoreline integrity, and ignore indicators of ecosystem function and socio-cultural or economic effects. In many cases, regulatory authorities, such as the NYS Department of Environmental Conservation (DEC), may require post-construction monitoring, but leave it up to the permittee to determine what and how monitoring is conducted. However, there is a lack of data and metadata standards that would facilitate analysis across NNBF sites.

NNBF projects across the state contribute community benefits and result in habitat improvement; however, there is a need for monitoring and maintenance plans in the implementation of all projects. For example, shorelines across the state are subject to storm impacts, including flooding and erosion. Thus, NNBF projects are also vulnerable to the very threats/storm impacts that they are designed to mitigate. This further promotes the need for ongoing monitoring and maintenance plans, especially during the more vulnerable periods of early establishment when adaptive management may be needed.

Challenge: Data Accessibility

Data collected from across project typologies can be used to fill some of the current knowledge gaps in NYS. When available, these data are extremely useful for assessing the outcomes of different projects and approaches. However, even when monitoring data are collected, access is often limited. One barrier to access is knowing whether and what data exist for a given project, since a comprehensive state-wide database does not exist. Furthermore, if data were collected by a contractor to fulfill a permit requirement, they may not be available to anyone but the regulating authority and the permittee. Access to these data would greatly inform the determination of site suitability and approaches to project implementation, contributing to the potential success of NNBF in NYS.

NNBF Comparisons Across NYS: Regional Variation

Shorelines and coastal environments across NYS vary widely. The processes that occur or act upon these areas can have similarities, but also very important differences. The varied coastal environments of NYS make implementing and managing these techniques site specific, furthering the notion that a “one-size fits all” approach cannot be applied to NNBF projects. Perhaps the most obvious difference is that shorelines range from freshwater in the Great Lakes, to brackish in the Lower Hudson River and the Long Island Sound, and

finally to saltwater along the South Shore of Long Island. The change in, or lack of, salinity will affect the types of vegetation and materials that can be considered in NNBF design. Water level changes are another important consideration when determining NNBF project types; all NYS coastlines experience a form of water level change, but drivers and amplitudes vary across geographies. NNBF projects need to stand up to short-term water level changes (e.g., seiche or storm surge), medium term impacts such as elevated lake levels, and longer term impacts like sea level rise. Additionally, NYS experiences seasonal changes, which may be more or less extreme depending on geography, but which impact NNBF growth and vulnerability. One important factor to consider is ice, which is more common in upstate regions but can occur across the state and result in shoreline damage.

All of the above considerations must be accounted for when decision-makers are exploring the potential for NNBF installation to provide specific resilience services. It is important to note that not all shorelines are appropriate for NNBF and proper siting and design is essential for success. For example, the Hudson River estuary, where nearly 55% of the shoreline is engineered, has several unique challenges to implementing NNBF, including steep bathymetry, tidal and river currents, winter ice, its history of dredging and as a navigable waterway, and the placement of railroads along the shoreline. Furthermore, federal, state, and local municipalities each have specific shoreline regulations and permits are likely needed before project implementation.

Due to the important regional and site-specific differences, the application of NNBF encompasses novel and innovative approaches for shoreline management in NYS. As more projects are being implemented, they may look very different in each of the state's four regions (i.e., Long Island, NYC, Hudson, and the Great Lakes) due to specific physical and ecological characteristics. Below are a few examples of NNBF projects from across NYS presented as part of this project at a 2024 statewide symposium hosted by New York Sea Grant (NYSG) that illustrate some of the regional considerations.

NNBF Regional Case Study: Long Island

In June 2023, construction was completed at a new living shoreline located in the Village of Patchogue's Shorefront Park (40.74916243, -73.0073145), a seven-acre park located on the Great South Bay. This shoreline was built to replace a failed bulkhead installed in the 1970s and increase the resilience of the community, which experienced severe flooding during coastal storms such as Hurricane Irene and Superstorm Sandy. Other goals included creating a transitional shoreline, reducing high wave energy, and treatment of stormwater runoff. The shoreline consists of stone sills, salt marsh restoration, and bioretention basins. As part of the NYS DEC permit conditions, monitoring and routine maintenance of the shoreline will continue until at least 2028.

Successes:

- Establishment of 80-90% of salt marsh vegetation within the first year
- Minimal damage to the shoreline after two major coastal storms
- Overall reduced flooding within the park, increased tidal flushing of creeks, and increased biodiversity
- Improvement in water quality
- Community-based benefits, such as recreation and public access

Shorefront Park Living Shoreline. Photo by Benny Migs Photography.

Lessons Learned:

- Provide community education about coastal processes and NNBF options and garner public input during the design phase of projects
- Manage expectations related to performance
- Prepare a plan for invasive species

NNBF Regional Case Study: New York City

In September 2022, construction and monitoring began on the West Pond Living Shoreline located in the Jamaica Bay Wildlife Refuge Gateway National Recreation Area (40.618707, -73.830306). West Pond breached during Superstorm Sandy in 2012, which prompted discussions about how to enhance the shoreline and prevent future breaching of the freshwater pond. The plan included constructing 2,400 linear feet of shoreline, creating 14 acres of saltmarsh by bringing in sand and plantings, and building breakwaters using natural features, including shells and coir-fiber logs.

West Pond Living Shoreline. Photo by Jamaica Bay Rockaway Parks Conservancy.

Successes:

- A four-fold increase in cordgrass plantings' stem density and a three-fold increase in stem height within the first year
- Increases in habitat complexity, invertebrate density, and biodiversity

Lessons Learned:

- Erosion controls incorporating burlap and coir fiber may disintegrate after the first year
- Herbivore exclusion fencing is a necessity; however, it requires yearly maintenance and its flagging material can worsen litter accumulation. The use of biodegradable materials is recommended
- Planting and replanting should occur early in the growing season. Macroalgae may accumulate on the shore, creating challenges to plant survival
- Wind fetch should be considered during project design and construction

Dockside Park demonstration site. Photo by NYS DEC.

*NNBF Regional Case Study: Hudson**

In 2022, construction began on a sustainable shoreline in the Village of Cold Spring's Dockside Park (41.4182884, -73.9621178). This location was heavily utilized for recreation but was impacted by erosion from wind-driven waves and currents, cumulative impacts of historic shoreline management due to its previous industrial use and ice scour. The goals of this project were to stabilize the park's natural shorelines while still integrating human use with preservation and improvement of habitat value. Research was conducted on what was already known about natural shorelines, past management, and impact on ecology; the project also served to educate the community about the ecology of the Hudson River Estuary and environmental impacts, including sea level rise.

Successes:

- Vegetation growth was successful, despite first-year destabilization requiring replanting

Lessons Learned:

- Community support is needed when proposing construction in areas of high recreational use
- Organic matter may need to be brought in to support vegetation
- Maintenance is necessary, particularly after storms if portions of the shoreline are damaged

NNBF Regional Case Study: Great Lakes

There were a series of NNBFs implemented as part of the Niagara River Habitat Restoration Projects, including installation of rock reefs at the East River Marsh (43.051615, -78.998934) and rock reefs and logs at the West River Shoreline (42.962076, -78.939422). The overall goal of these projects was to address the Niagara River Area of Concern (AOC), particularly related to the beneficial use impairment and the loss of fish and wildlife habitat.

West River shoreline project. Photo by NYS Parks

*Hudson River Sustainable Shorelines Case Study: Dockside Park
bit.ly/DocksideCaseStudy

Successes:

- The establishment of woody structures for fish habitat
- Establishing vegetation utilizing planting bags in shallow water

Lessons Learned:

- Rock reefs should be installed at lower elevations to prevent establishment of invasive vegetation
- Dredging was needed to increase water depth behind the reefs for fish habitat and plant establishment
- Vegetation in deeper water was unsuccessful
- Wildlife fencing may not hold up to the winter and may need to be reinstalled
- Wood structures and planting boxes can be destroyed or damaged in storms
- Monitoring and repair funds and protocols are essential

Proposed Solutions

To address the challenges of implementing NNBF in New York that have been identified, several mechanisms are proposed, including formalizing a community of practice, implementing standardized data collection, creating a visualization tool for project outcomes, and developing a public-facing database that can be utilized by a variety of stakeholders. The following is an initial path towards solutions, but not an exhaustive list; several actions have already begun or are in place.

NNBF Community of Practice

Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.

Some communities of practice — including formal and informal networks of practitioners — already exist in NYS, though not always focused solely on NNBF. Examples include participants in the creation and use of New York's Measuring Success protocols for data collection, the Hudson River Sustainable Shorelines Initiative, and the NYS Adaptation Practitioners Network. Formal networks of organizations working within this sector exist across the country and even internationally, including N-EWN and the Natura network.

By encouraging participation in these networks and formalizing a state-wide community of practice, information sharing about NNBF successes and lessons learned can increase, potentially resulting in more implementation of projects that result in increased coastal resilience. Increasing communications both regionally and state-wide to share NNBF information and case studies is encouraged. Ideally, one group or a few organizations will lead and coordinate this network that can meet on a regular basis.

Standardized Data Collection

One challenge that New York is currently facing in regard to the implementation of NNBF projects is the lack of data from implementation sites. This is creating a negative feedback cycle: because the data do not exist, regulators are inhibited from permitting projects. One way to address this is by encouraging the proposal and permitting of pilot projects and requiring regular, long-term data collection, monitoring, and maintenance of those sites.

In 2020, NYS DOS, with input from multiple state agencies and partners, released a comprehensive monitoring framework for shoreline features across the state that would collect comparable data through consistent monitoring to inform future design and management of NNBF shorelines. This monitoring framework has been in use for several years at specific sites, but is not yet widely used or accessible. Continued outreach to bring awareness to the framework, review and assessment of protocols and its applicability, and required implementation could enhance the utility of the framework and build a robust dataset to inform NNBF project selection.

Visualization of Data

Many factors influence data visualization of NNBF in NYS, including the project type, goal of visualization, target audience, and utilization of the developed tool. Data visualization can span a technical range from carefully designed, multi-phase frameworks that evaluate NNBF sites to community science photo monitoring stations or ArcGIS Story Maps. By utilizing the appropriate method, the collection and use of data visualization can ease challenges or concerns when considering a novel approach to shoreline stabilization.

In NYS, one data visualization method being used is photo monitoring of NNBF projects through CoastSnap stations, integrated into MyCoast NY, to crowd-source images of change over time. This program not only collects data to inform decision making about NNBF implementation but also engages the public and increases education and outreach about innovative shoreline management solutions. Current NNBF CoastSnap Stations include Shorefront Park (Patchogue), Bush Terminal Piers Park (NYC), Center for the Urban River at Beczak (Yonkers), Sandy Island Park (Pulaski), Fair Haven Park (Sterling), and Beaver Island Park (Grand Island). **Access CoastSnap at: Mycoast.org/ny**

Comprehensive NNBF Database

Information about NNBF projects, including case studies and results from monitoring and assessment, must be easy to locate if it is intended to affect policy and practice. NYS does not currently have a comprehensive database of NNBF projects where this information can be accessed. This database could serve multiple audiences, including practitioners, regulators and policy makers, landowners, and the public. Creating a comprehensive database requires an organization to assume responsibility for keeping it updated, which requires financial resources and staff time. Some databases exist but do not fully address the need. They include:

Data map of NNBF CoastSnap Stations.

- Internal databases maintained by funding or permitting authorities: Entities such as governmental agencies may keep databases of existing projects that were internally funded and/or implemented, but these exclude unaffiliated projects and may not be widely accessible.
- Spreadsheet database developed by the SRIJB and NY Sea Grant: This is publicly available and paired with a Google map of NYS to visually depict different types of existing NNBF projects and any associated data.
- Measuring Success Database maintained by NYS DOS that holds data collected with the Measuring Success protocols. Access to the database is restricted, and registered users of the database have reported difficulty in accessing and downloading data for analysis. The database also lacks both data visualization and a data synthesis framework.
- ArcGIS Story Maps: NYS DEC Region 1 (i.e., Marine District) will be launching a Story Map that displays permitted living shoreline projects.

- Comprehensive websites: The Hudson River National Estuarine Research Reserve (HRNERR) hosts information about the Sustainable Shoreline Initiative, including an interactive map of 14 demonstration sites that showcase the efficacy of a variety of NNBF.

It is recommended to build upon these existing efforts to develop a comprehensive database that serves end-user needs as determined by thorough state-wide engagement.

Future Work

To continue momentum towards implementing the proposed solutions, NYSG, along with regional partners including SRIJB, will lead the formalization of a NYS NNBF Community of Practice. This group of practitioners will expand upon this project by hosting regular regional and state-wide forums, meetings, and workshops to promote information sharing and discussions. A community of practice will achieve the required work to refine an agenda that addresses the proposed solutions presented here in future years. Furthermore, the leaders and participants will identify potential resources to support both the continuation of the NYS NNBF Community of Practice and necessary steps to achieve the goal of increasing successful NNBF project implementation in NYS.

Conclusion

The use of NNBF is a key focus across NYS as a strategy to stabilize shorelines and enhance community resilience. While numerous projects have been successfully implemented, significant challenges remain. These include gaps in knowledge, difficulties in standardizing approaches across diverse geographic regions, and limited data accessibility. However, these barriers can be addressed through targeted solutions, most notably the development of a robust community of practitioners who actively share information, data, and educational resources.

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About SRIJB (srijb.org): The Science and Resilience Institute at Jamaica Bay (SRIJB) is a CUNY-wide institute created through a partnership amongst the National Park Service, the City of New York, and the City University of New York (CUNY). Our mission is to produce integrated knowledge that increases biodiversity, well-being, and adaptive capacity in coastal communities and waters surrounding Jamaica Bay and New York City. The Institute is hosted and supported by Brooklyn College and works closely with member organizations including NYSG, the Jamaica Bay Rockaway Parks Conservancy, and the Jamaica Bay Ecowatchers.

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