



Towards a Salt Marsh Management Plan for NYC: Recommendations for Restoration and Protection



NYC Parks

City of New York Parks & Recreation
Forestry, Horticulture, and Natural Resources
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NYC Parks



Salt Marsh Management Plan Executive Summary

Salt marshes, like this one in Richmond Creek, Staten Island, were once a dominant feature of New York City's shoreline and provide essential habitat, wave attenuation, and water filtration.



Over 80 percent of New York City's tidal wetlands have been lost and the remaining marshes continue to degrade. Rising sea level exacerbates shoreline erosion (Udall's Cove in Queens, left), and drowns marsh vegetation (Idlewild Park, Queens, right).

With 520 miles of coastline, New York City's historic landscape was shaped by water. Salt marshes were once a dominant feature of the city's shoreline, but filling, industrialization, and development has resulted in the loss of over 80 percent of these tidal wetlands. The coastal wetlands that remain today provide essential refuge, breeding grounds and food for fish, birds and wildlife, as well as a unique open space in a dense urban environment. Salt marshes also provide services for the city by reducing wave energy, withstanding flooding, and filtering debris and pollutants from the water. Yet despite decades of regulatory protection, salt marshes continue to be threatened by poor water quality, rising sea levels, encroaching development, illicit dumping, and erosion. Prioritizing wetland management with limited resources in the face of these urban threats can be challenging.

RECOMMENDED ACTIONS

Protect and create pathways for migration

In order to reduce constraints to salt marsh migration, we recommended protecting land in tidal wetland buffers through transfer of public property to NYC Parks, acquisition of private property or conservation easements, and enforcement of regulations aimed at protecting wetland adjacent areas. A majority of migration area adjacent to the 25 study sites falls on NYC property, totaling over 200 acres of future wetland. However, with sea level rise, an additional 53 acres of wetland will migrate on to other public and private parcels. We identified 18 public properties and 44 private properties where salt marsh is likely to develop in the future. Ideally, we would transfer, acquire, or place easements on all of these properties. Due to the significant cost of such a recommendation, however, we identified four priority public properties for transfer and eight priority private properties for acquisition.

These priority areas are all located in Staten Island, adjacent to relatively healthy marshes that are otherwise not highly vulnerable. We will share maps of these properties and engage with the New York State Department of Environmental Conservation to make sure that property owners abide by the 150-foot buffer regulated by Article 25 of the New York State Environmental Conservation Law. We also identified 43 acres of paved surfaces adjacent to our study sites that are projected to be flooded with rising sea level in the future. Most of these paved surfaces are roadways, parking lots, and paved paths that are actively used. We aim to work within NYC Parks and with other agencies to include these future flooded areas in the strategies to adapt to sea level rise, including the strategy, where appropriate, of removing paved surface and reclaiming these areas for potential salt marsh migration.



To develop a citywide strategy for marsh protection and restoration, we assessed the health and threat of the 25 largest salt marsh complexes. Above is Udall's Cove in Queens.

Of the approximately 4,000 acres of marsh that remain, almost half are managed by NYC Parks. Our goal is to preserve and protect this vital resource for the next generation. One of our partners in achieving this goal is the Natural Areas Conservancy (NAC), a non profit partner to NYC Parks that was started in 2012 and is committed to advancing the field of urban ecology and to providing data-driven approaches to the management of natural areas in NYC.

Together with NAC, we conducted a salt marsh assessment in 2013 and 2014 as part of a citywide assessment of all city-owned natural habitat. That wetlands assessment provided the foundation for an analysis of threats and potential management responses that are described in this report. NYC Parks will use this document as a building block in long-term planning to conserve and manage salt marshes in the city.

OBJECTIVE AND APPROACH

Our objective was to develop recommendations for how to protect, restore, and manage salt marsh on NYC parkland. To do this, we focused on the 25 largest salt marsh systems distributed across the city's boroughs and waterways in the Parks system.

We assessed the condition (or health) and vulnerability of (or threats to) these sites by collecting data on specific indicator metrics in the field and through desktop analyses. We collected information on vegetation, soil, breeding birds, the physical shape of the marsh and how it has changed, and projections of salt marsh migration or the movement of marsh habitat to higher elevations as sea levels rise. We determined that NYC marshes have, on average, lower health compared to rural marshes in other mid-Atlantic regions. When comparing marshes within the city to one another, we found larger sites with minimal fragmentation were in better condition and less vulnerable to threats than smaller, more fragmented marshes, which exhibited poorer condition and higher vulnerability to threats.

We focused on three main threats to salt marsh longevity: limited area for migration, failure to build up in elevation at the same pace as sea level rise, and ongoing erosion along the water's edge. In response to these threats, we identified specific actions that would help sustain the presence of the marshes. These actions fall within two overarching strategies for maintaining salt marsh in the city. One is to protect and create pathways for salt marsh migration inland. Another is to protect and restore existing marsh. We prioritized sites with higher health and lower threats for migration protection, and we prioritized sites with lower health and moderate to high threats for restoration.

Protect and restore existing marsh

In order to address the threats to salt marsh of not keeping pace with sea level rise and erosion on the water's edge, we recommend restoring existing marsh where appropriate, using two pilot techniques. One is the application of a thin layer of sediment to elevate the marsh surface. Almost 300 acres of marsh across the 25 study sites can be categorized as low marsh, or marsh that is lower in elevation and more frequently flooded by tides. We identified 17 acres across five study sites that are priority for increasing marsh surface elevation through thin layer sediment application. The other technique is the restoration of lost shoreline salt marsh by re-constructing the eroded marsh edge. In the past 40 years, 160 acres of salt marsh have been lost across the 25 study sites. We identified 28 acres across eight sites that are priority for marsh edge restoration based on their historic marsh loss. We will pursue funding to implement these proposed restoration efforts to increase the health and longevity of these threatened marshes.

Other ongoing restoration opportunities, action, and recommendations

While we are making recommendations for future marsh protection and restoration, NYC Parks currently conducts restoration work in wetlands across the city. Current restoration work focuses on the removal of debris and trash as well as the excavation of historic landfill on marshes. We conduct large debris removal projects and fill excavation projects through construction contracts and we use volunteer groups and clean smaller and more accessible areas of debris as well as to plant salt marsh species and maintain protective fencing. These restoration projects will continue to be implemented and they will be included in the management plan for NYC salt marshes.

Of the 4,000 acres of marsh that remain, almost half are managed by NYC Parks.

CONCLUSION AND NEXT STEPS

To ensure that the next generation of New Yorkers experiences the benefits of our coastal natural heritage, we need a long-term commitment to protecting and restoring salt marshes in NYC. As development encroaches into buffer zones, sea levels rise, and marsh edges erode, we have to enlist new strategies and try a variety of approaches to reduce the vulnerability of tidal wetlands to threats. We need to protect pathways for salt marshes to migrate in the future, restore existing marshes that are eroding and subsiding, and continue to try to better understand the factors that contribute to salt marsh loss. In this document, we outline an approach for assessing the health of marshes and their vulnerability, for identifying how some key threats can be addressed, and for determining where there are opportunities to take action to restore marshes and make them more resilient. This report builds off existing documents (PlaNYC 2009, OneNYC 2015, etc.) and provides a foundation for natural resource plans that contribute to a more sustainable and resilient NYC.



To protect the remaining salt marshes, it is important to both conserve salt marsh buffers and restore degraded marshes. We can continue with standard restoration techniques like removing fill from historic marshes (done at Marine Park in Brooklyn, left) or pilot new techniques such as adding clean sand to elevate the marsh (as shown at Alley Creek in Queens, right).

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INTRODUCTION

Salt marshes in New York City (NYC) are essential tidal wetland habitat that sustain vibrant ecosystems in our highly developed environment while also enhancing the open space opportunities for adjacent communities. There are approximately 4,000 acres¹ of salt marsh remaining in NYC today, representing less than twenty percent of the extent of historic tidal wetlands around New York Harbor. Nearly 1,500 acres of the remaining salt marsh are owned and managed by the New York City Department of Parks & Recreation (NYC Parks). These tidal ecosystems fringe the city, and the salt marshes included in this study alone occupy about 17 miles of the City's shoreline. The largest of these salt marsh complexes are found in the outer boroughs, where they provide buffers to wave action and sea-level rise; improve water quality by filtering pollutants and excess nutrients, and by catching large marine debris; provide natural habitat for a diversity of plants, fish, and wildlife. Salt marsh complexes also create rare expansive vistas and places for education and inspiration for New Yorkers. However even our largest marshes continue to be threatened by sea level rise, coastal erosion, encroachment, and other human impacts in our densely urban environment. New York City must think strategically about these coastal resources and act to safeguard their long-term survival so they can provide the environmental benefits that are critical for community health, sustainability, and resilience.

The purpose of this document is to lay a foundation for a long-term NYC tidal wetlands conservation plan and inform short and mid-term restoration and management priorities. The recommendations we make to protect and restore our largest salt marsh complexes under NYC Parks management derive from the synthesis of our field data and desktop analyses of the threats and health of these habitats. The recommendations can be considered by planners, resource managers, and community advocates from public and private entities when they are considering projects along the city's coastline. This report will inform and support efforts to create a more sustainable waterfront city and build upon other City planning documents such as *PlaNYC (2009)*², *the Wetland Transfer Task Force (2007)*³, *the NYC Wetlands Strategy (2012)*⁴, and *OneNYC (2015)*⁵.

STUDY OBJECTIVES AND APPROACH

The overall goal of this study was to develop recommendations that would guide planning for the protection, restoration, and management of the remaining salt marsh habitat in NYC.

To this end, we focused on the 25 largest naturally occurring salt marshes on NYC Parks property, which constitute over two-thirds of the total tidal marsh area on parkland. First, we assessed the existing conditions at these salt marsh complexes (Figure 1) and evaluated their vulnerability to various stressors through field data collection and desktop analysis. Next, we selected metrics that best represented marsh condition and the threats faced, so we could compare metrics across salt marsh sites. Finally, we identified a select set of actions that we considered best for addressing these threats and preserving existing vitality. These actions are not all-inclusive, but innovative forms of interventions that can realistically be implemented by NYC Parks. The Natural Areas Conservancy (NAC), a non-profit that works closely with

¹ O'Neil-Dunne, J.P.M., S.W. MacFaden, H.M. Forgione, and J.W.T. Lu. (2014) Urban ecological land-cover mapping for New York City. Final report to the Natural Areas Conservancy. Spatial Informatics Group, University of Vermont, Natural Areas Conservancy, and New York City Department of Parks & Recreation. 22 pp.

² New York City, Mayor's Office of Long-term Planning & Sustainability (NYC OLTPS). (2009) PlaNYC. New York City Wetlands, Regulatory Gaps and Other Threats. <http://www.nyc.gov/html/om/pdf/2009/pr050-09.pdf>

³ New York City Department of Parks & Recreation (NYC Parks). (2007) Recommendations for the Transfer of City-Owned Properties Containing Wetlands. Prepared by the New York City Wetlands Transfer Task Force <https://www.nycgovparks.org/greening/natural-resources-group/wetlands-transfer-task-force>

⁴ New York City, Mayor's Office of Long-term Planning & Sustainability (NYC OLTPS). (2012) Wetlands Strategy. http://www.nyc.gov/html/planyc2030/downloads/pdf/nyc_wetlands_strategy.pdf

⁵ New York City, Mayor's Office of Recovery & Resiliency (NYC ORR). (2015) One New York the plan for a strong and just city. <http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf>

NYC Parks on the conservation of our natural areas, provided NYC Parks staff technical advice and expertise. The Nature Conservancy (TNC) helped develop indices for salt marsh condition and vulnerability, which informed our recommendations for protection and restoration.

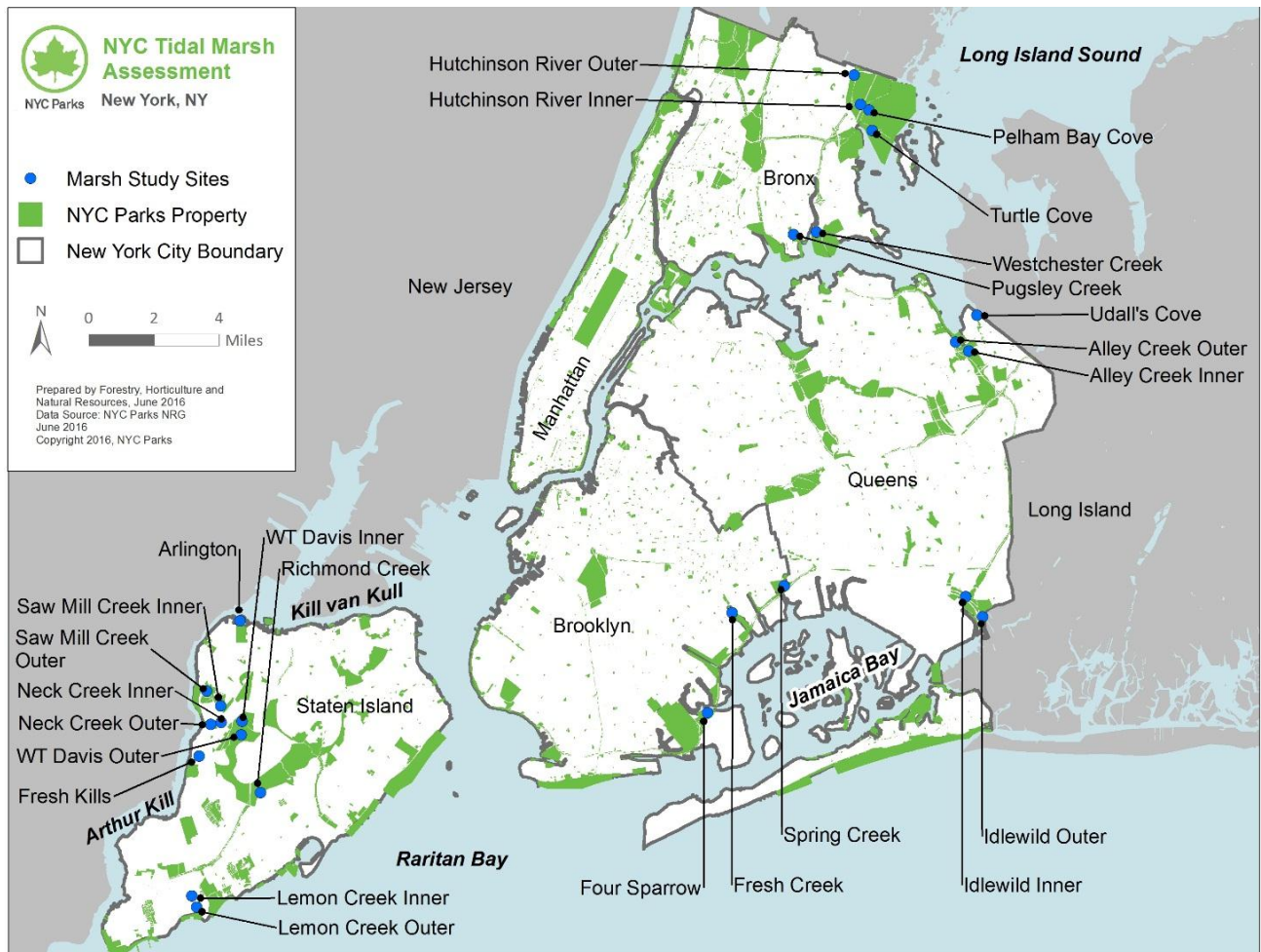


Figure 1. Map of 25 NYC naturally occurring salt marsh complexes. Sites are located in the Bronx, Queens, Brooklyn and Staten Island with receiving water bodies of Long Island Sound, Jamaica Bay, Arthur Kill, and Raritan Bay.

Field Assessments

The salt marsh field assessments were conducted as part of 10,000 acre baseline assessment of city-owned parkland. Staff visited each complex to collect vegetation and soil data to study the marshes in three different ways. First, we used standard rapid assessment methods⁶ so we could compare NYC marshes to marshes in other regions in the Mid-Atlantic. Second, we developed a new protocol⁷ that involved more extensive measurements to allow comparisons across sites within NYC. Finally, we layered a long-term monitoring protocol, at six of the sites⁸. A detailed description of this work can be found in the NYC Salt Marsh Conditions Assessment Report⁹.

⁶ Rogerson, A., McLaughlin, E., & Havens, K. (2010) Mid-Atlantic tidal wetland rapid assessment method version 3.0. Delaware Department of Natural Resources and Environmental Control. 50pp

⁷ Natural Areas Conservancy Salt Marsh Assessment (NAC SMA) (2013) in Partnership with City of New York, Division of Forestry Horticulture, and Natural Resources

⁸ Partnership for the Delaware Estuary. (2012) Development and Implementation of an Integrated Monitoring and Assessment Program for Tidal Wetlands. PDE Report No. 12-03. 77 pp

<https://s3.amazonaws.com/delawareestuary/sites/default/files/Quirk%20PDE%20Jan%202013.pdf>

⁹ New York City Department of Parks & Recreation (NYC Parks). (2016) NYC Salt Marsh Conditions Assessment Report

Historic and Landscape Analysis

Desktop analyses were conducted to assess historic change at the marshes and to use as indicators of salt marsh condition and vulnerability. The analysis of salt marsh loss focused on the change in vegetated marsh area from 1974 (the year of the first regulatory tidal wetlands maps in NYC) to 2012 using aerial photographs. Overlaying the past and recent salt marsh boundaries allowed calculations of total area, average width, and percentage of salt marsh area loss over time. Other landscape-level indicators include density of mosquito control ditching at each marsh, marsh perimeter to area ratio, presence or absence of breeding bird species at each marsh since 2000, and the percentage of development within a 200 meter buffer adjacent to the marsh. These indicators help assess the fragmentation, potential neighboring land use threat, and ecosystem services.

Future Inundation Modeling

Information from a spatial model called Sea Level Affecting Marshes Model (SLAMM) was used to predict the impacts of future sea levels on salt marshes and the adjacent upland area¹⁰. SLAMM provided an estimate of how land cover and vegetation cover types would change over time with sea level rise. Upland areas next to salt marsh likely to be flooded according to SLAMM were identified as areas for salt marsh migration. Upland areas that are currently developed, and probable to be flooded by sea level rise were also considered, separately, as sites that could be reclaimed for salt marsh. The model output was used to develop indicators of vulnerability and to identify locations where salt marsh buffer should be protected and where salt marsh could expand in the future.

Conditions and Vulnerability Indices

The field and spatial data collected in the approach described above was used to develop a conditions index and a vulnerability index for NYC salt marshes¹¹. Nine metrics were chosen to represent the condition, or health, of a salt marsh. Six different metric were selected that served as indicators of how vulnerable the salt marsh was to various threats (Figure 2). Values for each of the metrics were used to develop scores that were then normalized so that each metric for condition and vulnerability could be compared across sites. Summary scores were generated so that sites could be plotted in a general matrix of condition versus vulnerability (Figure 2). Conceptually, this matrix provides a framework to prioritize sites for protection and restoration: sites in better health and with lower vulnerability are the highest priority for protection since they are the most likely salt marshes to be self-sustaining in the long-term (Figure 3). Sites with lower condition and moderate to higher vulnerability are highest priority for restoration, because some intervention is likely needed to increase their viability.

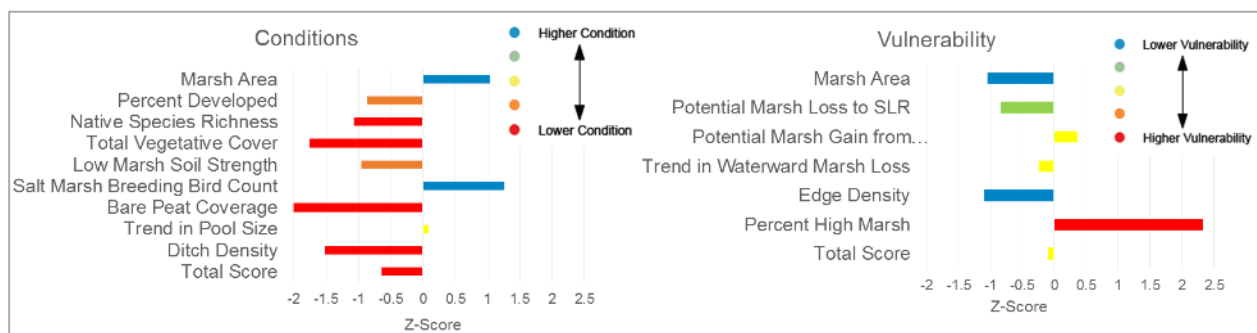


Figure 2. Conditions and vulnerability metrics and scores for Idlewild Marsh Outer, Queens, NY. This site has a low total condition score driven by low scores across multiple conditions metrics (red and orange bars). It has a moderate total vulnerability score driven

¹⁰ Clough, J., M. Propato, A. Polaczyk. (2014) Application of Sea-Level Affecting Marshes Model (SLAMM) to Long Island, NY, and New York City. Final Report. New York State Energy Research and Development Authority (NYSERDA), Albany, New York. <http://www.warrenpinnacle.com/prof/SLAMM/NYSERDA/>

¹¹ Maher, N., Lloyd, S. & Alleman, L. (2016) New York City Tidal Marsh Systems Analysis: Conditions, Vulnerability, and Opportunities for Restoration. Prepared by The Nature Conservancy for the City of New York Department of Parks & Recreation Division of Forestry, Horticulture, and Natural Resources.

by low scores across multiple vulnerability metrics (blue and green bars) and a high score in percent high marsh, indicating that the site is low elevation and at risk of drowning with sea level rise.

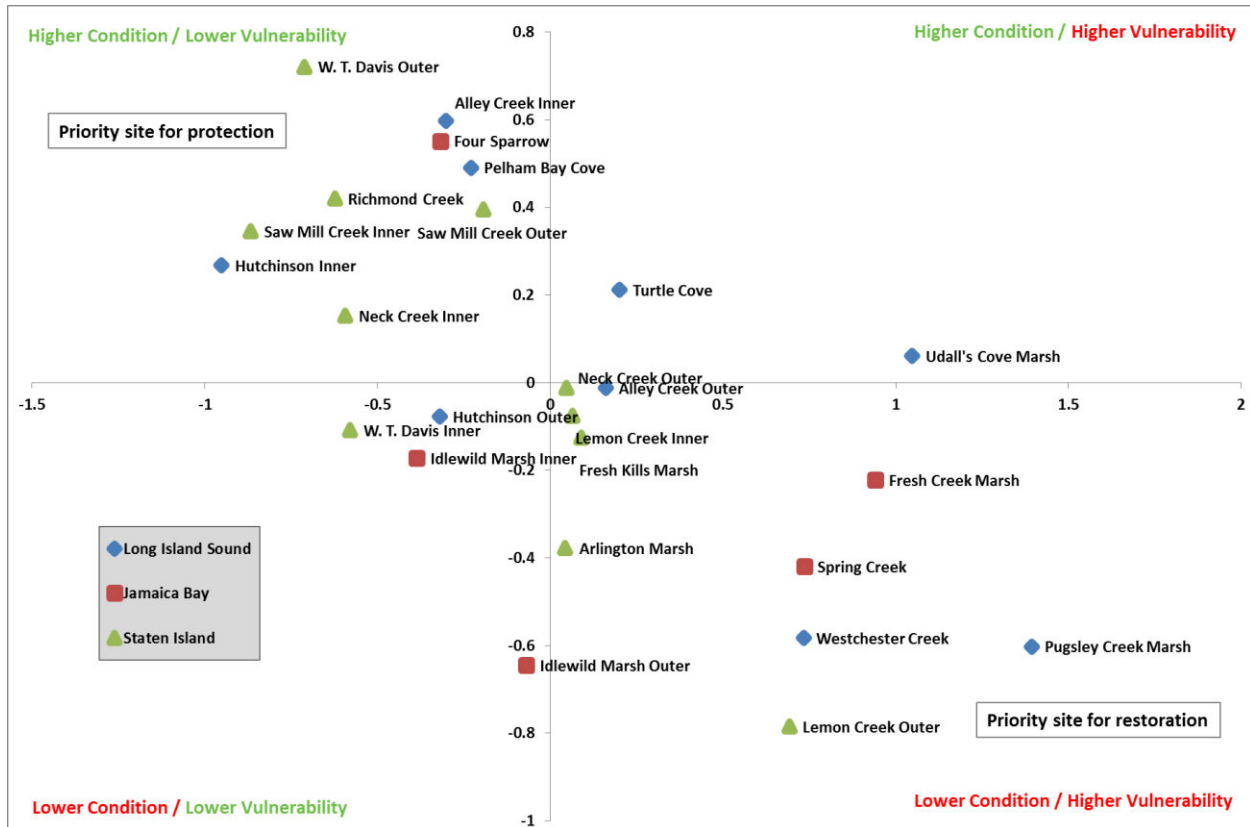


Figure 3. The distribution of study sites across the condition and vulnerability gradient. Sites in the top left quadrant have higher condition and lower vulnerability and are priority sites for protection to keep the status quo, if not increase health via sound conservation. Sites in the bottom right quadrant have lower condition and higher vulnerability and are priority sites for restoration to improve their condition and lower their vulnerability.

SALT MARSH ASSESSMENT RESULTS

The Condition of Our Wetlands

The overall health of salt marshes in NYC is lower compared to larger and more rural salt marshes in the Mid-Atlantic region based on rapid assessment findings. The healthiest NYC marshes, however, potentially provide ecological functions comparable to those of similar size in other developed watersheds. The smallest salt marshes in the study are the most stressed and limited in the ecological and environmental services they provide, but these marshes still provide forage, nursery habitat, and refuge for fish and wildlife. They also offer an opportunity for New Yorkers to observe and experience a remnant ecosystem that has largely been replaced by an armored shoreline.

Within NYC, the highest condition salt marshes are found on Staten Island. These marshes are also the most resilient, in part because they are large, have the highest marsh, and have the greatest potential area for landward migration as sea level rises. This high quality habitat provides breeding and foraging grounds for species of rare bird, fish, and other wildlife. Salt marshes along Jamaica Bay are in poorer condition and are less resilient, as indicated by the relatively large areas of bare ground. Fringe salt marshes along Jamaica Bay are essential habitat to breeding bird species, such as the salt marsh sparrow, but they have low total cover of vegetation and lower number of native plant species. Long Island Sound salt marshes, in the Bronx and northern Queens, vary widely in their condition. On average, sites in the Sound are smaller

in size, surrounded by a higher level of development, and have higher cover of invasive *Phragmites australis*. However, they have higher total cover of vegetation and a higher diversity of native plant species compared to Jamaica Bay sites.

The Threats to Our Wetlands

Threats to NYC salt marshes are multiple and pervasive, but some of our marshes are more vulnerable than others. In this study we focus on those threats directly related to or exacerbated by sea level rise. Development pressure is the greatest threat to salt marshes in Staten Island as this is the least developed borough and has a large amount of privately owned undeveloped land adjacent to wetlands. Soil and water contamination are also threats to these marshes, particularly along the Arthur Kill and Kill van Kull where oil refineries and shipping operation along the New York/New Jersey shoreline result in a legacy of contaminated soil from industry and frequent oil spills.

The Jamaica Bay fringe marshes have the lowest elevation of all marshes in the city and therefore have the greatest risk of losing interior and shoreline vegetated marsh area due to drowning or excessive inundation. These sites are surrounded by dense development and some marshes have altered hydrology and large areas of fill and marine debris because of it. Also, many of these marshes are in close proximity to combined sewage outflow (CSO) pipes, causing major impacts on water quality and nutrient levels, especially with chronic exposure.

The greatest threat to the marshes along the Sound appears to be from shoreline erosion. Salt marsh loss at the water's edge has been significant across NYC. The 25 wetland marsh complexes in the study have lost a total of 160 acres (or 15 percent of their total area) between 1974 and 2012. Staten Island marshes had the greatest area of loss. However, Long Island Sound marshes had the greatest proportion of loss at 21 percent. The continued conversion of vegetated marsh to mud flat is likely a result of a combination of factors that include wave action, boat wake, increased inundation due to sea level rise, reduced root density and peat accumulation, predation by herbivorous crabs, and changes in soil chemistry and plant biology due to high nutrient loads. Similar to Jamaica Bay sites, Long Island Sound marshes are surrounded by extensive development, have large areas of fill and marine debris, and are in close proximity to CSO pipes. Another potential threat in Long Island Sound is the crab species *Sesarma reticulatum*, which is attributed to extensive marsh vegetation loss through herbivory in Massachusetts and Rhode Island.^{12, 13} The crab has been found at sites in Pelham Bay Park, however their abundance and impact to marshes in NYC is not known.

STRATEGIES FOR ADDRESSING WETLAND THREATS

Our ability to influence the long-term viability of salt marshes in NYC depends on a number of factors. These include:

- The degree and extent of the threats to the salt marsh systems
- How well we understand the causes and processes of marsh degradation
- The ability to create or adapt strategies based on sound assessment of their effectiveness
- Our ability to take timely action at a significant scale

The scale at which we need to take action is large because shoreline salt marsh loss and threats to salt marsh sustainability, such as sea level rise, affect all NYC marshes to some degree or another and are increasing in intensity.

To approach this problem, we identified and focused on three main threats to the long-term viability of salt marsh in NYC (Figure 4):

- Lack of locations to migrate inland

¹² Bertness MD, Brisson CP, Bevil MC, Crotty SM (2014) Herbivory Drives the Spread of Salt Marsh Die-Off. PLoS ONE 9(3): e92916. doi:10.1371/journal.pone.0092916

¹³ Coverdale, T.C., Altieri, A.H., Bertness, M.D. (2012) Belowground herbivory increases vulnerability of New England salt marshes to die-off. Ecology, 93(9), 2085-2094

- Inability of the marsh surface elevation to keep up with sea level rise
- Erosion of the marsh edge since 1974

Based on our best understanding of condition and the factors influencing it, we focused on a narrow set of actions and strategies to address threats. These actions and strategies do not necessarily address the causes or processes of degradation, but they are ones the City has the capacity to undertake, will provide some level of protection, and will allow us to learn important lessons about what measures will be most effective and feasible at different sites, therefore refining and expanding our “arsenal” moving forwards.

Our first overarching strategy is to protect pathways for landward migration of salt marsh in the future and restoring salt marsh buffer or adjacent areas. This strategy is critical for the survival of salt marshes as sea levels rise and development pressure increases on areas adjacent to the marsh. Migration pathways can be protected through land transfer to NYC Parks, acquisition by NYC Parks or establishment of an easement that NYC Parks would manage, and use of existing regulations. Pathways should be ecologically restored and existing and future marsh protected by reclaiming hard surfaces such as paved trails and parking lots that will be regularly flooded in the future.

Our second broad strategy is to restore and protect existing marshes to reduce further degradation and shoreline erosion. There is a risk of marsh loss to drowning and erosion where there is a predominance of low marsh with relatively low sediment supply, historic high rates of shoreline erosion, and/or expansion of mudflat within interiors.

Our actions are twofold as they relate to this strategy:

1. Selective addition of sand to increase marsh surface elevation
2. Building out of the marsh edge with a sill or protective toe anchor, where needed, to regain and stem further loss of vegetation along the marsh edge

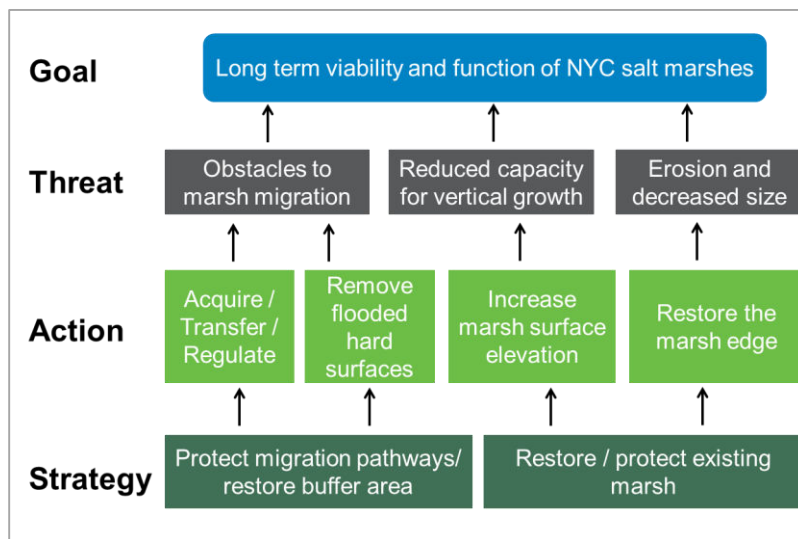


Figure 4. Goal, Threats, Actions, and Strategy for marsh protection and restoration.

PRIORITIZATION OF RESTORATION AND PROTECTION STRATEGIES

To implement our strategies and actions at all salt marshes across the city would be extremely costly. It would also be risky, since some of the restoration actions are still relatively untested, and some actions are likely more effective and time sensitive at some sites than others. Within our two broad strategies, to create and protect buffers around tidal wetlands and to restore marshes in place, we developed an approach to help prioritize restoration or protection action across sites. This approach required identifying metrics associated with the site that served as an indicator of the most appropriate action as follows:

METRIC

Area of land adjacent to marsh that SLAMM projected to be flooded by 2085

Area of hard surface land adjacent to marsh that SLAMM projected to be flooded by 2085

Proportion of the marsh dominated by low marsh species and bare ground

Proportion of the marsh and area of vegetated marsh loss since 1970s

ACTION

Acquire or transfer property to prevent development in potential marsh migration areas through property acquisition or regulations

Remove hard surfaces that will be flooded (to allow for migration)

Increase marsh surface elevation through sediment application

Restore and protect the marsh edge

A score derived from z-score methods which allowed comparisons between sites was created for each action at each site. Each site was then ranked according to its score. Scores were summarized by water body and region to determine if some actions appear more suited in those areas than others (Figure 5). The results suggest that different actions are more suitable in different areas. Sites in Staten Island have the greatest need for protection of salt marsh migration pathways (with a z-score of 0.5). Sites in Jamaica Bay have the greatest need for marsh surface elevation increase (with a z-score just over 0.4), Salt marshes in Long Island Sound have the greatest need for restoration of the lost marsh edge (with a z score just over 0.4).

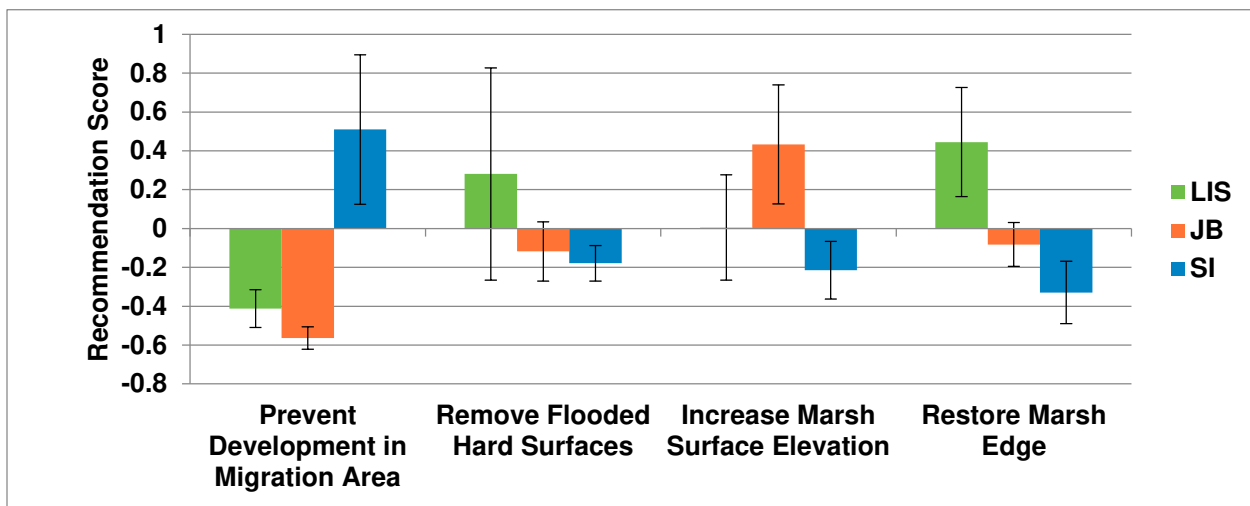


Figure 5. Z-scores for actions to protect or restore salt marshes summarized by NYC marsh region.¹⁴ Regions include Long Island Sound (LIS), Jamaica Bay (JB), and Staten Island (SI).

RECOMMENDED ACTIONS

Below we describe our recommendations, where and why they should be applied, and the constraints and limitations to implementation.

Strategy 1: Protect and create pathways for migration

Action: Protect land in tidal wetland buffer through transfer, acquisition, easements, and regulation

By preventing vegetated uplands adjacent to salt marshes from being developed, salt marshes will have the opportunity to migrate landward, giving them a chance of enduring sea level rise. Protecting land adjacent to salt marsh from development does not ensure salt marsh migration, however it is a necessary first step in facilitating migration. The most effective protection for wetland migration pathways is for land

¹⁴ Maher, et al. 2016, pg6

owned by other city agencies to be transferred to NYC Parks, for NYC Parks to acquire the land if privately owned, or an easement be made on the land that is currently or will become marsh. Simultaneously NYC Parks can advocate for more strictly limiting permits for fill activity within the New York State Department of Environmental Conservation (NYSDEC) jurisdictional adjacent area to wetlands.

To understand where this type of action is most needed and potentially effective, we identified individual properties that will likely contain marsh by 2085 based on SLAMM. The properties identified at each marsh site were classified by ownership type and prioritized based on the proportion of the parcel that is currently wetland or likely to be future wetland. Within a site, the adjacent parcels recommended for transfer, acquisition, or easements were those with the greatest existing wetland area and/or projected additional future flooded area. Whole parcels were identified for acquisition or transfer when much of the parcel was existing and/or projected additional wetland (45% or greater of parcel threshold) and there were no buildings on the parcel. Parcels were identified for easement when buildings were present on the parcel or when less than 45% of a parcel without buildings had existing and/or projected additional future flooded area.

NYC Parks owns most of the property in our study area that is likely to support future salt marsh. But 58 acres of existing wetland are under private and non-parks public ownership, as are 53 acres of projected future wetland (Table 1). Most of these parcels with future wetland also have a large proportion of non-wetland area, especially adjacent to sites in Staten Island (Figure 6). All of the priority higher condition and lower vulnerability sites identified on public and private property are located in Staten Island with a total of 10.4 acres of existing wetland and 13.8 acres of future wetland that warrants increased protection.

Table 1. Acres of current and additional future marsh and number of parcels by ownership.

Owner	Current Marsh (acres)	Future Marsh (acres)	No. of Parcels
NYC Parks	864	+204	228
Private	21	+29	80
Other Govt.	37	+24	18
TOTAL	922	257	326

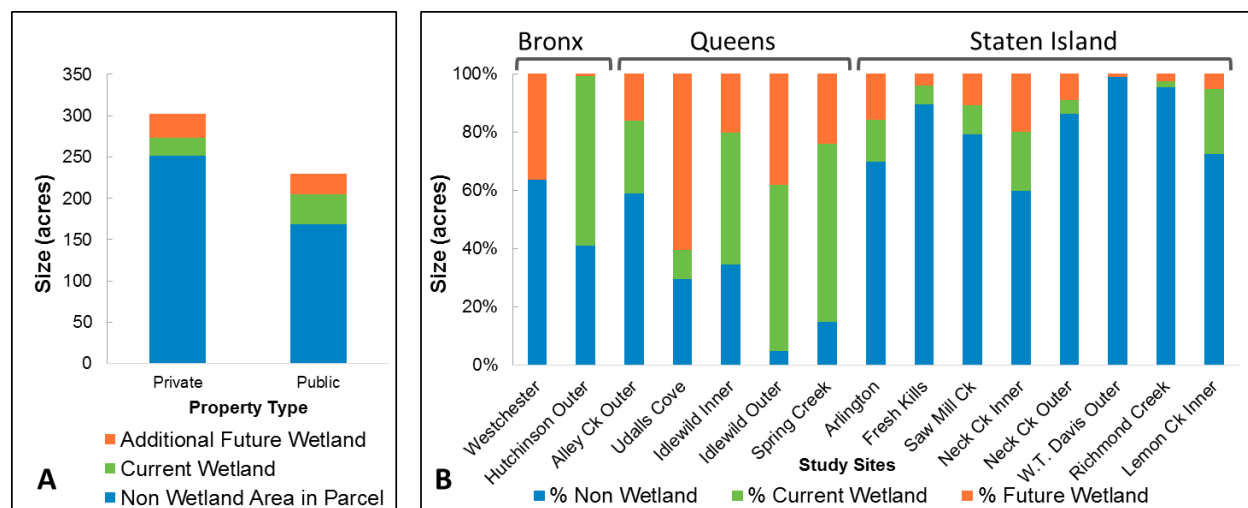


Figure 6. Current and future wetland and non-wetland area in non-NYC Parks parcels. A) Areas summarized by private and public land, B) Proportions of parcels summarized by study sites adjacent to parcels in the Bronx, Queens, and Staten Island NY, no parcels were identified in Brooklyn, NY.

Action: Transfer of public parcels with wetlands to NYC Parks

Properties owned by other city government agencies adjacent to salt marsh that either currently contain marsh or will likely support salt marsh in the future, should ideally be transferred to NYC Parks ownership. Across our study area, 18 parcels owned by other agencies currently support 37 acres of marsh and are likely to support about 24 additional acres of marsh in the future (Table 1 & 2). Of these 18 parcels, we

strongly recommend the transfer of 4 parcels (Identified with (*) in Table 2). These parcels are critical because they are adjacent to high condition and low vulnerability sites and they contain high proportions of predicted future wetland. Some of the identified public parcels were already considered for transfer by the Wetlands Transfer Task Force¹⁵, a temporary interagency task force formed as a result of legislation by the New York City Council (Local Law 83)¹⁶ to inventory city-owned properties containing wetland and determine the feasibility of their transfer to NYC Parks. These parcels were not transferred if they were under special reviews to resolve issues of jurisdiction, long-term leases on the properties, conflicting land-use issues, the presence of building, or other reasons. Because transferring all parcels that will support future salt marsh is not necessarily feasible, we must focus on ensuring maximum regulatory protection in adjacent wetland areas (see Regulation section below).

While transfer costs do not include the cost of the land, they do include the cost of conducting an environmental assessment (e.g. including a site inspection and historic review to assess likelihood of contamination, and if necessary, a site sampling to determine the degree of contamination), remediation or restoration of the site, and installing fencing. We estimated these costs as ranging between \$65,000 and \$2 million per acre depending on the site condition. We assumed that easements on public property cost the same as transfer. Consequently, the cost of transferring all identified parcels would cost \$5 – \$135 million and \$0.1 - \$3 million for the four priority sites we recommend.

A detailed overview of the transfer opportunities across all study sites and cost estimates can be found in Appendix A and C.

Table 2. List of publicly owned parcels recommended for transfer. Property owners include the Division of Citywide Administrative Services (DCAS), Department of Small Business Services (DSBS), NYS Department of Environmental Conservation (NYSDEC), New York State (NYS), US Department of Transportation (USDOT), Economic Development Corporation (EDC), Department of Sanitation (DSNY), and the Port Authority of NY-NJ. Borough abbreviations stand for Bronx (Bx), Queens (Qu), and Staten Island (SI). Four parcels (*) are recommended as highest priority for transfer to NYC Parks.

Borough Block and Lot (BBL)	Property Owner	Study Sites	Parcel Size (acres)	Current Marsh		Future Marsh	
				Acres	% of Parcel	Acres	% of Parcel
2-05611-0084	DCAS	Westchester Ck (Bx)	0.44	0.00	0%	0.13	29%
2-05611-0154	DSBS	Westchester Ck (Bx)	0.11	0.00	0%	0.03	23%
2-05654-0012	NYSDEC	Hutchinson Outer (Bx)	0.41	0.40	98%	0.00	0%
2-05654-0180	NYS	Hutchinson Outer (Bx)	10.50	5.95	57%	0.09	1%
4-13735-0005	DCAS	Idlewild Inner (Q)	0.08	0.03	38%	0.03	41%
4-13735-0013	DCAS	Idlewild Inner (Q)	0.14	0.06	42%	0.08	57%
4-13737-0039	USDOT	Idlewild Inner (Q)	0.12	0.00	4%	0.07	59%
5-01301-0001	DCAS	Arlington Marsh (SI)	38.99	4.29	11%	8.36	21%
5-01306-0014	DSBS	Arlington Marsh (SI)	8.38	4.32	52%	0.49	6%
5-01309-0010	PANYNJ	Arlington Marsh (SI)	32.83	2.96	9%	3.84	12%
5-01801-0125	NYSDEC	Saw Mill Ck Inner (SI)	4.45	1.50	34%	1.52	34%
5-01815-0125*	DSBS	Saw Mill Ck Inner (SI)	0.51	0.00	0%	0.47	92%
5-01815-0135*	EDC	Saw Mill Ck Inner (SI)	1.52	0.00	0%	1.36	89%
5-01815-0375*	EDC	Saw Mill Ck Inner (SI)	1.00	0.00	0%	0.54	54%
5-02685-0100	DSNY	Fresh Kills Marsh (SI)	93.39	9.45	10%	3.69	4%
5-02786-0141*	NYS	Neck Ck Inner (SI)	3.14	0.00	0%	1.41	45%
5-06712-0001	NYSDEC	Lemon Ck Inner (SI)	33.84	7.68	23%	1.74	5%
5-06712-0190	DCAS	Lemon Ck Inner (SI)	0.13	0.04	29%	0.03	25%
Total		8 sites	230.0	36.70	16%	23.89	10%

¹⁵ NYC Parks 2007, pg4

¹⁶ https://www.nycgovparks.org/sub_about/parks_divisions/nrg/wtff/assets/Local_law05083.pdf

Action: Acquisition and establishment of easements

There are a total of 44 parcels of land citywide identified as priority candidates for acquisition or easement. The pieces of land should be either purchased by the city or secured as easements. In both cases, NYC Parks would manage the land as a means to protect current and future marsh. Easements allow protection from development on a sub-section of property while allowing for continued private ownership and management. This mechanism is most effective for parcels with existing buildings that are not appropriate for NYC Parks to own or manage.

There are 20 priority parcels in Staten Island, adjacent to higher condition lower vulnerability sites (Table 3). Protecting these parcels would allow us to protect around 9 acres of future wetland. The highest priority parcels are identified with (*) in Table 3, and protecting these parcels alone would protect six acres of future salt marsh. We recommend pursuing easements on the remaining private parcels. These priority parcels for acquisition or easements in Staten Island represent over half of the current and future marsh that can be protected through acquisition.

The remaining 24 low priority parcels have low development pressure due to owners who have committed to keep their parcels as open space, such as the Douglaston Manor Association in Queens, or because they are entirely existing salt marsh or in close proximity to salt marsh. Acquisition or easement on these 24 parcels of private property is not essential to ensure protection, because even future wetlands fall within the 150 foot wetlands buffer that is protected by existing regulation in NYC (See Regulation section below).

The cost of acquisition was estimated based on the market price of property in NYC and assumed to be \$7 million per acre on the high end and \$1.3 million per acre on the low end. We assumed that easements on private property could cost as much as acquisition, depending on the arrangement with the property owner. Consequently, the cost of acquiring all 20 priority parcels would cost \$30 – \$163 million and \$22 - \$122 million for the eight highest priority parcels at Saw Mill Creek and Neck Creek.

A detailed overview of the acquisition and easement opportunities across all study sites and cost estimates can be found in Appendix A and C.

Table 3. Summary of all private parcels that would ideally be acquired (or have easements). Priority based on the adjacent sites having higher health and lower threats. All of these sites are in Staten Island. Eight parcels (*) highly recommended for acquisition are 50% wetland, or will be in the future.

Borough Block and Lot (BBL)	Owner Name	Study Site	Parcel Size (acres)	Current Marsh		Future Marsh	
				Acres	% of Parcel	Acres	% of Parcel
5-0178-00015*	M & M GROUP, LLC.	Saw Mill Ck Inner	3.40	0.00	0%	1.87	55%
5-01780-0022	I.C. PROPERTIES, LLC	Saw Mill Ck Inner	2.40	0.36	15%	0.11	4%
5-01780-0057	I.C. PROPERTIES, LLC	Saw Mill Ck Inner	1.08	0.00	0%	0.07	6%
5-01780-0250*	I.C. PROPERTIES, LLC	Saw Mill Ck Inner	3.06	2.23	73%	0.34	11%
5-01780-0270*	I.C. PROPERTIES, LLC	Saw Mill Ck Inner	1.54	0.06	4%	1.01	65%
5-01790-0120*	SINGH SATNAM	Saw Mill Ck Inner	0.41	0.05	11%	0.27	65%
5-01801-0075	VANBRO CORP.	Saw Mill Ck Outer	27.41	0.10	0%	0.07	0%
5-01801-0160	VANBRO CORP.	Saw Mill Ck Outer	8.46	0.00	0%	0.03	0%
5-01815-0260	S. SHORE ENTERPRIS	Saw Mill Ck Inner	2.70	0.06	2%	0.01	0%
5-02610-0150	FESLOR LLC	W. T. Davis Outer	2.26	0.00	0%	0.03	1%
5-02776-0003	RAO, AHMAD	Neck Ck Inner	0.24	0.00	0%	0.07	29%
5-02776-0012*	HAYNBERG SVEN	Neck Ck Inner	0.75	0.05	7%	0.54	72%
5-02776-0014	SOENARIE PETER S	Neck Ck Inner	0.23	0.00	0%	0.05	19%
5-02776-0024	MARIANN T RUAS	Neck Ck Inner	0.09	0.00	0%	0.03	32%
5-02776-0152*	CANNON GP NETWORK	Neck Ck Inner	0.30	0.07	22%	0.21	70%
5-02780-0040*	VICTORY-SIMON HOLDING	Neck Ck Inner	1.09	0.16	14%	0.73	67%
5-02780-0110*	VICTORY-SIMON HOLDING	Neck Ck Inner	6.87	3.13	46%	0.81	12%
5-02784-0029	VICTORY-SIMON HOLDING	Neck Ck Inner	15.37	2.53	16%	1.75	11%
5-02785-0141	SETTINIERI JOHN	Neck Ck Inner	1.58	0.02	1%	0.37	23%
5-04447-0109	COLONIAL SQ HOME0	Richmond Ck	4.82	0.10	2%	0.13	3%
Total		5 sites	84.08	8.91	11%	8.48	10%

Action: Compliance with wetland adjacent area regulations

In New York State, Article 25 of the Environmental Conservation Law (ECL) 6 NYCRR Part 661 (Tidal Wetland Land Use Regulation) authorizes State jurisdiction of an adjacent area landward of the tidal wetland boundary. In New York City this area extends 150 feet (ft.), or to the 10 ft. elevation contour, or to roads or other above-ground structures, whichever is shortest. These regulations are implemented by the New York State Department of Environmental Conservation (NYSDEC) and pertain to activities that could substantially impair or alter the natural condition of the jurisdictional wetland adjacent area, including soil removal, fill activity, and construction of new roads or other structures. Most of the projected future wetland areas identified in our study fall within the 150 ft. maximum existing wetland adjacent area and therefore any development activity proposed for these areas will require a permit from NYSDEC. However, it is often difficult to track and regulate actions in the wetland adjacent area across the highly developed landscape of NYC—development in these buffer areas continues today through both permitted and illegal activities, though less frequently than in the past.

All of the property we have identified as priorities for acquisition or easements (privately-owned property), or transfer (publicly-owned property), include wetland adjacent area under State jurisdiction and therefore wetland protection regulations must be followed. NYC Parks will work with NYSDEC at the state level, to strengthen protection efforts in these areas, particularly where there may be existing violations and evidence of encroachment, or when infrastructure construction projects encroach on wetland adjacent areas.

Action: Reclaim future flooded hard surfaces that prevent migration

Hard surfaces that are likely to be regularly flooded in the future should be removed and restored to native plant communities. This action will facilitate salt marsh migration and the long-term viability of the salt marsh. However, in NYC there is very little hard surface adjacent to existing marsh that is not associated with an actively used road or parking lot.

Hard surfaces are defined as pavement such as roads or parking lots as well as other paved surfaces such as pathways and turf fields. Hard surfaces that were identified but cannot be removed include buildings or other structures, or railroad tracks. Removing hard surfaces entails breaking up and excavating pavement, concrete, and fill, adding clean sand-type planting medium after the removals, and planting of appropriate native species.

In order to identify which hard surfaces are feasible to remove, the snow plow priority status from the Citywide Street Centerline¹⁷ database was used to estimate the level of activity associated with those paved surfaces. Roads listed as primary and secondary priority for snow plowing were assumed to have high activity or use and thus more difficult to remove. Roads listed as tertiary priority were assumed to have low levels of use. Roads without snow plow priority designation were assumed to have the same status as the closest adjacent existing status. Within a site, the hard surfaces we recommend for removal, in the short or long-term, are those that are on NYC Parks property and have low activity or use (tertiary snow plow priority status or those without priority). Larger areas of roads and parking lots with higher level of activity were not included.

Across all of the study sites, the greatest amount of future flooding is projected to occur on parking lots, followed by roads and other hard surfaces (Table 4). By far the largest parking lot area to be flooded in the future is the 24 acre lot at Orchard Beach in Pelham Bay Park, the Bronx. This lot is heavily used during the summer months, when the beach is open, and used as an emergency staging area at other times. To address the flooding problems that will be associated with this parking lot, and to protect the surrounding water resources, we recommend long-term planning to consider sustainable ways to re-design or program this paved area, including planning for some expansion of salt marsh habitat.

In total, over 7 acres of road are likely to be flooded in the future adjacent to existing marsh. These roads include residential streets and heavily used traffic arteries, such as Brookville Blvd. in Queens, NY and Travis Ave. in Staten Island, NY. Critical roads, like these, cannot feasibly be removed for salt marsh migration, in the near term, but long-term planning and design at these sites needs to consider approaches that will protect and sustain the salt marsh. NYC is currently designing projects to raise roads in low-lying areas that are increasingly flooded by tides, such as Travis Ave in Staten Island¹⁸. Elevating these roads on piers, for example, could maintain the long-term function of the marsh and viability of the road. Though these measures are extremely costly, they provide the opportunity to design and construct for long-term sea level rise. Where this is not possible, any road raising or flood protection should be sensitive to the potential impacts on adjacent wetlands.

¹⁷ New York City, Department of Information Technology and Telecommunications, Citywide Street Centerline <https://data.cityofnewyork.us/City-Government/NYC-Street-Centerline-CSCL-/exjm-f27b>

¹⁸ For example the Raised Shorelines initiative led by the Economic Development Corporation and the Mayor's Office of Recovery and Resiliency, and the >\$20 million project to raise road elevations in Broad Channel, Queens.

Table 4. Summary of hard surface removal opportunities adjacent to all 25 study sites.

Hard Surface Type	Number of Marsh Sites	Number of Locations of Flooded Hard Surfaces	Area of Flooded Hard Surface (acres)
Parking Lots	4	7	29.36
Roads	17	47	7.38
Other Hard Surfaces	7	21	5.87
Total	18	75	42.61

Just under 6 acres of other hard surfaces were also identified (Table 4). A large portion of these sites are located adjacent to Idlewild Inner, Queens, on a privately owned paved vacant lot, as well as an area adjacent to Brookville Boulevard, Queens, that is owned by DOT. Other hard surfaces include a small area of buildings adjacent to Idlewild Inner that cannot be removed. From this 6 acres of other hard surfaces we identified about 1.5 acres across five salt marsh sites that had no known conflicting use and could be recommended for removal (Table 5). Most of the 1.5 acres are small sections of paved pathways that will require further investigation to verify if removal will be beneficial, and to estimate costs and identify design objectives. Some of the other hard surfaces are so small that they might be accomplished as individual small scale restoration projects rather than a citywide or large-scale effort.

These hard surface removal projects, dispersed across multiple sites, represent only a small proportion of the more than 40 acres of hard surfaces next to our study marsh sites that will likely be flooded over the next half century (see Table 4). The issue of regular flooding of developed land in the coming decades will need to be addressed and all of the locations identified here should be considered as part of the strategy to adapt to sea level rise.

We assumed the cost of removing hard surfaces, including concrete or pavement removal, excavation of fill, placement of clean sand, planting, and all associated construction costs ranges from \$0.5-1 million per acre. Consequently, the cost of protecting all future migration paths adjacent to our salt marsh study sites would be \$20-40 million for all sites, and up to \$2 million for the priority sites we recommend (Table 5).

A detailed overview of the hard surface removal opportunities across all study sites and cost estimates can be found in Appendix A and C.

Table 5. Priority opportunity for removal of future flooded hard surfaces. These are sites where the adjacent wetlands have higher conditions and lower vulnerability, and the hard surface is located on NYC Parks property and is not heavily used (tertiary snow plow priority).

Adjacent Study Site Name	Hard Surface Type	Acres of Flooded Hard Surface	Cost of Hard Surface Removal (\$1 million/acre)
Westchester Creek	Other Hard Surface	0.67	\$0.67
Hutchinson River Inner	Other Hard Surface	0.21	\$0.21
Pugsley Creek Marsh	Other Hard Surface	0.03	\$0.03
Lemon Creek Outer	Other Hard Surface	0.48	\$0.48
Saw Mill Creek Inner	Other Hard Surface	0.06	\$0.06
Total		1.45	\$1.45

Strategy 2. Protect and restore existing marsh

Action: Apply a thin layer of sediment to elevate marshes

To help protect and maintain the function of existing wetlands, we recommend pursuing the addition of sediment to low elevation areas in marshes in target areas. Ideally, there would be sufficient sediment supply in the streams bays and estuaries deposited on the marshes to build up at the same rate as sea level rises. However, NYC is a sediment starved system, especially in Jamaica Bay.^{19,20} Applying clean silt and sand (approximately inches in depth) to a bare or partially bare marsh surface is a way to increase the surface elevation of the marsh so that plants can colonize at a higher elevation to keep from drowning during sea level rise.^{21,22}

Over a quarter of our large marsh systems consist of low marsh. This indicates a great need and opportunity to increase elevation to sustain these ecosystems (Table 6). Marshes where this action should be implemented were prioritized based on percent *Spartina alterniflora* cover and bare ground cover data, presence of breeding sparrow (sparrow are vulnerable to loss of high marsh habitat), future loss due to sea level rise (based on SLAMM results), and feasibility for sediment application (proximity to land or water access points).

Table 6. Summary of all low marsh area across the 25 study sites. Includes the total potential area of where elevation could potentially be increased.

Location	# of Study Marshes	Total Study Marsh Area (acres)	Low Marsh in Study Marshes	
			% of Total	Total Area (acres)
Long Island Sound	9	232.7	21%	48.5
Jamaica Bay	5	254.7	61%	154.4
Arthur Kill, Kill van Kull, Raritan Bay	11	529.8	14%	73.1
Citywide	25	1017.3	27%	275.0

We recommend Jamaica Bay fringe salt marshes for thin layer sediment application, because these marshes have the greatest proportion and area of low marsh in NYC (Figure 5). Although sediment applications may not be able to fully counteract the lack of sediment available for deposition in Jamaica Bay,^{23 24} we believe the investment in such a pilot project is warranted at these marshes, in part since doing nothing will seal the fate of the low marshes here. Two other marshes, Turtle Cove in the Bronx and Lemon Creek in Staten Island, are also particularly vulnerable to inundation and offer opportunities for piloting this technique. These sites are doubly suitable in part because access for sediment deposition may be possible by land, when access by boat is not feasible (Table 7).

¹⁹ Gateway National Recreation Area, National Park Service, US Department of the Interior (2007) An Update on the Disappearing Salt Marshes of Jamaica Bay, New York. Jamaica Bay Watershed Protection Plan Advisory Committee http://www.nytimes.com/packages/pdf/nyregion/city_room/20070802_FinalJamaicaBayReport.pdf

²⁰ Jamaica Bay Watershed Protection Plan Advisory Committee (2007) Planning for Jamaica Bay's Future: Final Recommendations on the Jamaica Bay Watershed Protection Plan.

²¹ Frame G.W., M.K. Mellander, & D.A. Adamo. (2006) Big egg marsh experimental restoration in Jamaica Bay, New York. *In People, places and parks: proceedings of the 2005 George Wright Society conference on parks, protected areas, and cultural sites*, ed. D. Harmon, 123–130. Hancock: The George Wright Society

²² Ray, G. L. (2007). Thin layer disposal of dredged material on marshes: A review of the technical and scientific literature. *ERDC/EL Technical Notes Collection (ERDC/EL TN-07-1)*, Vicksburg, MS: U.S. Army Engineer Research and Development Center.

²³ Gateway National Recreation Area et al. 2007, pg. 18

²⁴ Jamaica Bay Watershed Protection Plan Advisory Committee 2007, pg. 18

Table 7. Summary of priority marsh sites for thin layer sediment applications. The water bodies associated with these salt marshes are given in parenthesis: JB = Jamaica Bay; LHB= Lower Hudson Bay; HR = Hutchinson River.

Priority Study Sites	Accessible Area for Thin Layer Sediment Application (acres)	Estimated Cost of Increasing Elevation (assuming \$0.5 million per acre)	Accessibility
Turtle Cove (HR)	0.7	\$0.4	Land access only
Idlewild Inner (JB)	31.0	\$15.5	Land access only
Idlewild Outer (JB)	8.9	\$4.5	Land or water access
Spring Ck (JB)	2.1	\$1.1	Land access only
Lemon Ck Outer (LHB)	4.8	\$2.4	Land access only
Total	17.2	\$23.9	

Although thin sediment layer application will be subject to rigorous permit review under the Clean Water Act and NYS ECL,²⁵ there are several precedents for this technique being used in NYC. This approach was approved by NYSDEC in 2003 at Big Egg Marsh, Queens, NY. NYSDEC also approved the use of clean dredge silt and sand to reconstruct eroded salt marsh in Jamaica Bay on National Park Service property. The U.S. Army Corps of Engineers (USACE), NYSDEC, New York City Department of Environmental Protection (DEP), National Park Service (NPS), and the Natural Resource Conservation Service (NRCS) placed clean sand across 155 acres to expand or rebuild five Jamaica Bay marsh islands from 2007 to 2012. The USACE used various planting and seeding techniques to re-establish salt marsh vegetation after the sand was placed.

We were awarded a grant from the NYS Department of State's Environmental Protection Fund Local Waterfront Revitalization Program to pilot a sediment placement project in Idlewild Park, Queens, NY (Figure 7). This project will give insight as to whether the strategies and actions formulated through our analyses of the data in this report work on the ground.

To estimate costs for these proposed actions, we assumed a unit cost of \$500,000 per acre for the thin layer sediment application, which includes the cost of clean sediment placement, planting, installation of herbivory fencing, and erosion control measures. This was also the budgetary assumption for the recently awarded grant. At this rate, conducting thin sediment application across five sites would cost approximately \$24 million dollars (Table 7).

A detailed overview of thin layer sediment application opportunities across all study sites and cost estimates can be found in Appendix B and C.

²⁵ 6 CRR-NY 661.8

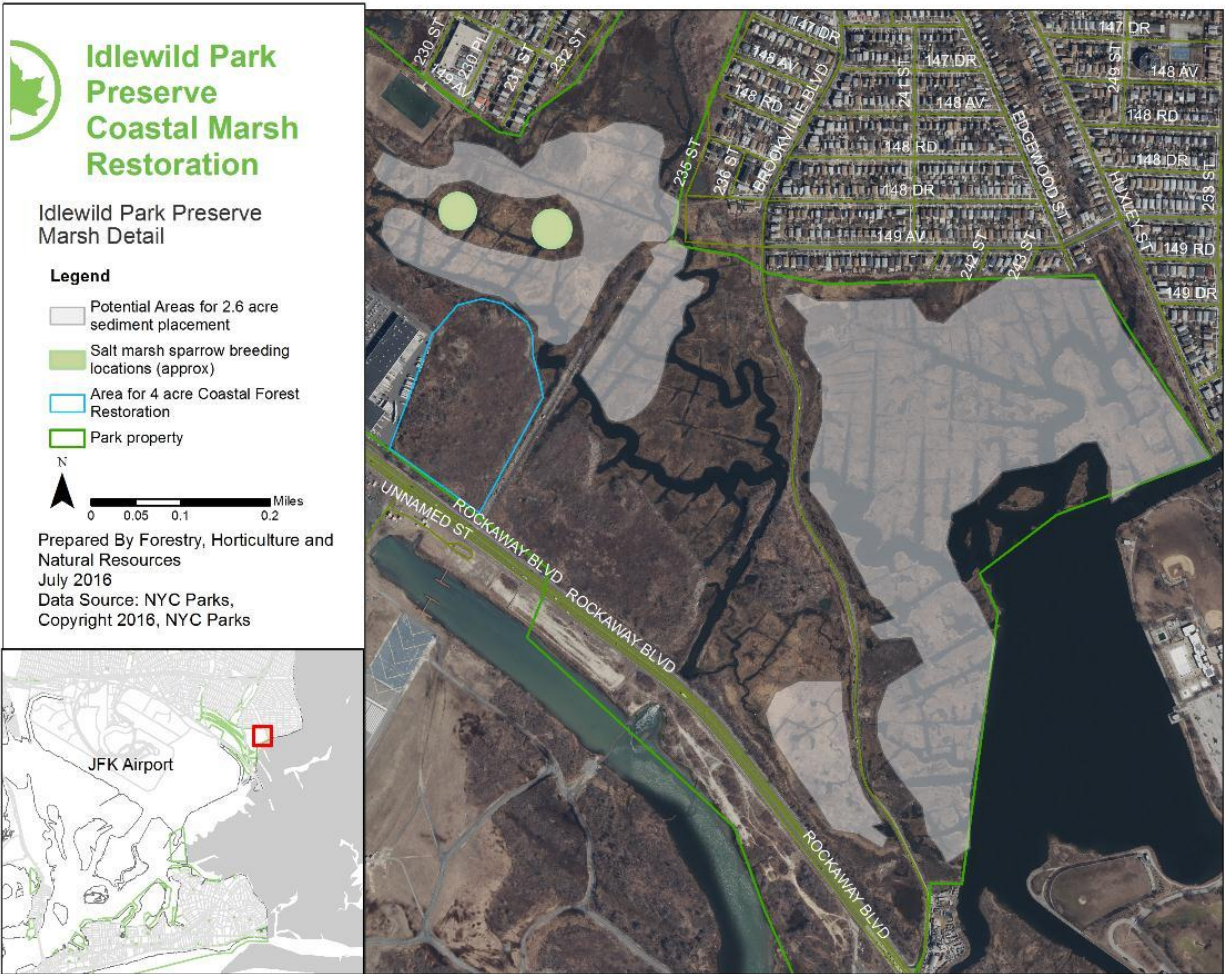


Figure 7. Proposed thin layer sediment application project for Idlewild Park in Queens. Part of a funding application submitted to the Department of State’s Environmental Protection Fund Local Waterfront Revitalization Program by NYC Parks. Only a fraction of the potential area of sand placement would actually receive sand. This area would be determined by site access and the techniques available for sediment placement.

Action: Restore eroded marsh edge

In addition to thin layer sediment application, we recommend restoring marsh edge through design techniques, including the placement of sand fill to existing marsh elevation behind an armored sill or breakwater. NYC marshes have lost a total of 160 acres (15% of total area) from 1974 to 2012, indicating a great need and opportunity for marsh edge restoration (Table 8). Sites in the Bronx, Queens, and Brooklyn on Long Island Sound and Jamaica Bay experienced the highest proportion of loss and thus have the greatest need for restoration. We identified priority areas within 8 sites that were accessible for sand application to restore almost 27 acres of marsh and over 10,000 feet of shoreline (Table 9).

The area, proportion, and width of marsh loss along the water’s edge from 1974-2012 were used to identify sites and locations for projects. Sites that experienced the greatest area, proportion, and width of salt marsh loss are assumed to be in the greatest need of restoration. Within sites that have experienced loss, those with lower condition and moderate to higher vulnerability were prioritized for marsh edge restoration. Additional priority criteria include sites with high marsh loss that are at least one acre in area and at least 100ft wide, that have lower levels of exposure to wind/wave action, and that can be accessed by land or water for sediment application.

Table 8. Summary of all marsh edge restoration opportunity by borough across the 25 study sites.

Study Site Location	Number of Study Sites	Total Study Site Acreage	Acres of Salt Marsh Loss Since 1974	Percent of Salt Marsh Loss Since 1974	Average Width of Salt Marsh Loss Since 1974 (ft.)
Bronx	6	158	35	19%	48
Queens	6	286	51	17%	65
Brooklyn	2	43	7	17%	37
Staten Island	11	530	67	12%	25
Citywide	25	1017	160	15%	45

Table 9. Summary of priority sites, area of opportunity, and shoreline length for marsh edge restoration.

Priority Sites for Salt Marsh Edge Restoration	Priority Area for Restoration (acres)	Priority Area Edge Length (ft.)	Estimated Cost of Restoration (\$0.6 million/acre)
Hutchinson Outer	1.5	825	\$0.9
Pugsley Creek	1.5	1815	\$0.9
Turtle Cove	8.4	2717	\$5.04
Alley Creek Outer	5.7	2073	\$3.42
Udall's Cove	2.7	767	\$1.62
Spring Creek	1.2	408	\$0.72
Four Sparrow	1.2	50	\$0.72
Fresh Creek	5.6	1791	\$3.36
Total	27.8	10446	\$16.68

We recommend pursuing pilot projects at the eight sites identified in Table 9 to test techniques that can help reduce on-going loss of fringe marshes. Restoring and expanding marsh edge acts both to protect existing marsh and improve ecosystem health by creating habitat for marine life such as oysters and ribbed mussels.

Shoreline protection techniques piloted thus far include fibrous logs secured and planted into the shoreline and the reintroduction or expansion of live oysters, used in Fresh Kills along Main Creek in Staten Island in 2013, or gabion baskets that accumulate sediment and create a growth medium for plants and ribbed mussels, used in Fresh Kills along Main Creek in 1997. Other examples of successful salt marsh shoreline protection projects in NYC include the Bronx Kill marsh on Randall's Island and the Pier 1 marsh in Brooklyn Bridge Park, both of which have riprap breakwaters.

We were awarded grants from the NYSDEC's Climate Smart Cities Program and the Long Island Sound Futures Fund for pilot projects in Alley Creek to restore the shoreline edge and will continue to pursue funding to implement pilot projects at other priority sites citywide.

We estimate that the restoration of vegetated marsh shorelines costs at least \$600,000 per acre, including the cost of clean sediment placement, planting, installation of herbivore fencing, erosion control measures, and applicable shoreline protection measures (e.g. riprap breakwaters or sills armored toe, or coir logs). By this estimate, restoring marsh edge across eight sites would cost approximately \$17 million dollars (Table 9).

A detailed overview of the marsh edge restoration opportunities across all study sites and cost estimates can be found in Appendix B and C.

Other Ongoing Restoration Opportunities, Actions, and Recommendations

Although this study has focused on future restoration needs and piloting new interventions at our largest marsh complexes, NYC currently conducts restoration work throughout our wetland properties using similar decision-making approaches. We map opportunities for restoration in the field and use spatial and tabular data to keep an updated inventory of restoration needs across NYC, this is referred to as the Restoration Opportunities Inventory (ROI)²⁶.

Action: Remove debris and trash

Small and large floatable trash and marine debris collects in our coastal wetlands with the ebb and flow of the tide. This material, along with illegally dumped domestic or industrial garbage, can accumulate in large areas, smother marsh vegetation, and compact soil. NYC Parks employs contractors to remove large objects such as boats or cars. We also hold clean up events with volunteer groups to remove smaller items such as residential garbage, tires, or small marine debris. NYC Parks is currently implementing a project funded by National Oceanic and Atmospheric Administration and the Federal Emergency Management Agency to remove large marine debris from salt marshes across NYC deposited during Hurricane Sandy. Additionally, NYC Parks removes debris with volunteer groups across the city year-round. The ROI contains information regarding debris removal opportunities, which is used to identify projects, resources, and pursue funding for project implementation.

Action: Excavate Historic Fill

We also restore marshes by removing historical landfill from marsh habitat. Many marshes across NYC were filled during the construction of bridges, roadways, and housing developments in past decades. In some locations, this fill can be excavated to elevations where the tidal hydrologic regime can be re-established to support salt marsh vegetation. Sometimes the substrate exposed by excavation is historical marsh peat, but sometimes it is still more contaminated fill, in which case the material is over-excavated and back-filled with clean sand to the appropriate elevation. Some projects may also remove tidal barriers, such as berms, and reconnect tidal flow behind the barrier. NYC Parks has been implementing these projects over the past 30 years. We use the ROI to identify opportunities for salt marsh restoration through fill excavation and to determine when and where it is best to use this strategy.

SUMMARY AND NEXT STEPS

Restoring and protecting the remaining salt marsh in NYC is essential for making a more resilient and livable city in the face of climate change. Salt marsh habitat specifically provides refuge for wildlife, captures and stores carbon, reduces the impact of continuous wave action, and improves water quality. It also provides essential open space for the highly urbanized NYC landscape and an important resource for engagement with the natural world through recreation, education, and research. A NYC tidal wetlands conservation plan is critical for the long term vitality and function of our salt marshes. The strategies and recommendations in this report are building blocks for this plan.

For any given marsh site, it is essential to understand the existing and historical conditions, the near and long-term threats, and, to the full extent possible, the degree to which the factors or causes of degradation can be mitigated. Once the environmental feasibility, cost and community support for any given interventions have been established, it is easier to decide which protection or restoration strategies to pursue. We believe that in the face of threats associated with sea level rise, particularly in the New York City region, protecting pathways for migration, and restoring existing marshes in place, through pilot projects and new techniques, is critical. We intend for our recommendations to contribute to a future NYC

²⁶ Natural Areas Conservancy (2016). Inventory of Coastal Wetland Restoration Opportunities in NYC http://naturalareasnyc.org/content/3-in-print/2-research/roi-project-summary-august-2016_final.pdf

tidal wetlands management plan that helps us to ensure communities and future generations will get to experience the ecological and cultural heritage of the once vast salt marsh systems of New York City.

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APPENDICES

Appendix A. Opportunities to Protect and Create Pathways for Migration

Appendix B. Opportunities to Restore Salt Marsh Through Thin Layer Sediment Application and Marsh Edge Restoration

Appendix C. Cost Estimates