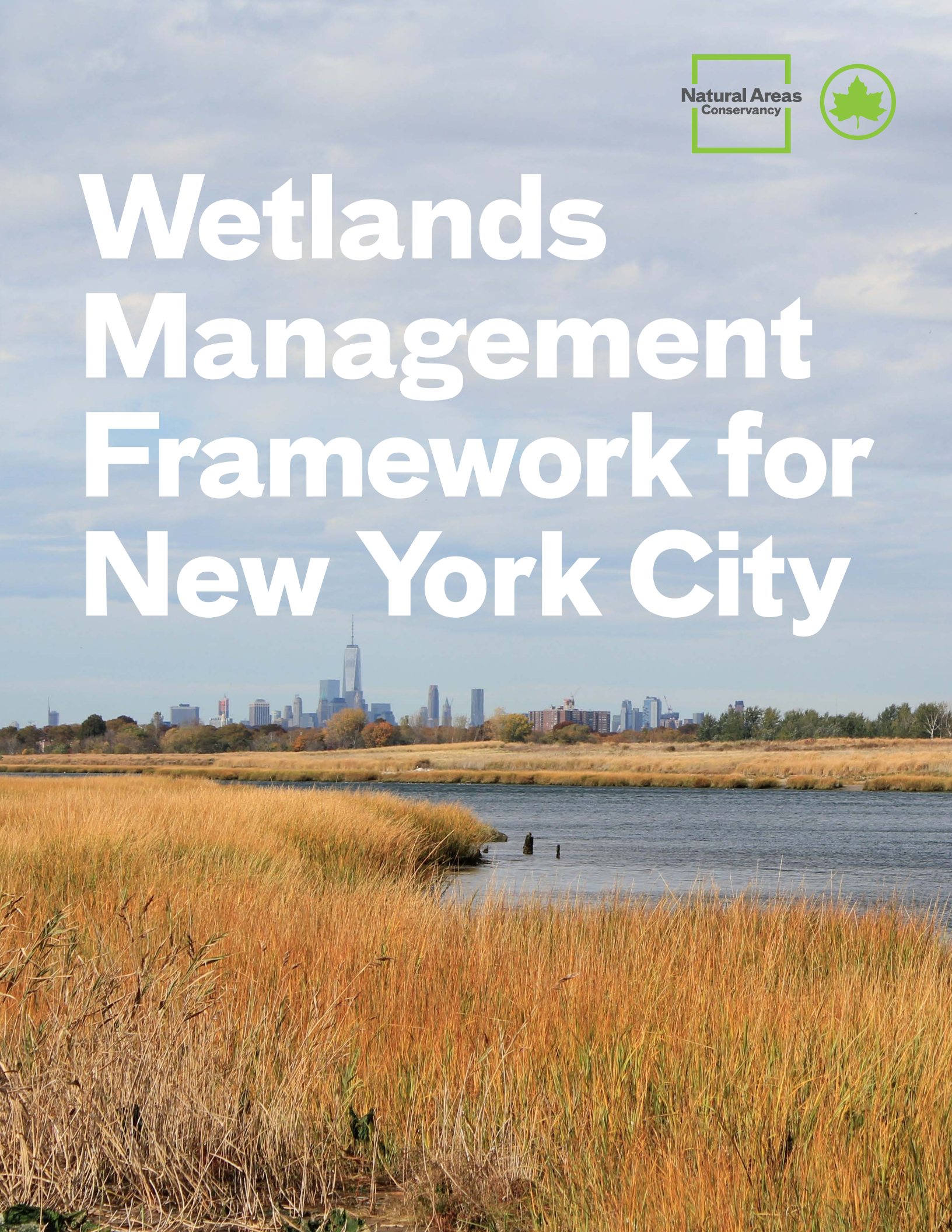
Natural Areas Conservancy

Wetlands Management Framework for New York City



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COVER
White Island and Gerritsen Creek Marshes, Marine Park, Brooklyn.

BACK COVER
Last Chance Pond Park, Staten Island.

All photos by NYC Parks or NAC unless otherwise credited.

Contributions to this document were provided by numerous people at NYC Parks and other agencies. In particular, valuable guidance was provided by Alyssa Cobb Konon, Jesse Krauss, Sarah Nielson, and Zoe Piccolo.

Created in 2012, the Natural Areas Conservancy is a nonprofit organization devoted to restoring and conserving New York City's 20,000 acres of forests and wetlands in close partnership with the New York City Department of Parks and Recreation.

Wetlands Management Framework for New York City

Natural Areas Conservancy

Natural Areas Conservancy

1234 Fifth Avenue | New York, NY 10029

Dear New Yorkers,

The Natural Areas Conservancy is proud to present a bold new vision for the restoration and long-term care of our city's wetlands with our partners at NYC Parks. The *Wetlands Management Framework for New York City* emphasizes the extensive role that salt marshes, streams, and freshwater wetlands managed by NYC Parks play in safeguarding biodiversity, making our city resilient, and providing New Yorkers with access to nature. We present a plan for a sustained investment in the management and restoration of these valuable resources and steps to make these goals a reality.

Despite being the most densely populated city in the nation, New York City continues to be defined by the natural features that originally made it an ideal location for human settlement. Our city is a city of water—boasting an astounding 520 miles of shoreline and retaining over 100 miles of streams. Each of our five boroughs is home to large swaths of natural areas, including swamps and freshwater marshes.

New York City's wetlands provide many benefits, including protection against storms and flooding, cleaner waters, lower summer temperatures, and carbon storage. Wetlands are also great places to spend time in nature, which can reduce stress, improve fitness, and refresh the spirit.

The *Wetlands Management Framework for New York City* comes at just the right time: recent years have shown the importance of our city's natural areas for recreation, renewal, and resilience—especially in the face of climate change. Building on more than thirty years of wetland restoration and management, this framework uses valuable data on the health and condition of our wetlands from the Natural Areas Conservancy and NYC Parks to make recommendations to manage wetlands for the future.

We hope this framework will inspire you to join us in our call to action: **to protect and expand New York City's wetlands.**

Thank you,

Sarah Charlop-Powers
Executive Director, Natural Areas Conservancy

NYC Parks

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Dear Friends,

About half of New York City's wetlands and streams can be found in our parks. From salt marshes in Pelham Bay Park to freshwater wetlands in the Greenbelt, these natural areas are vital resources that support wildlife and provide environmental benefits and recreational opportunities for nearby communities. Like our hiking trails and basketball courts, our city's wetlands strengthen the health and wellbeing of New Yorkers, and it's important that we care for them now and for future generations.

NYC Parks is pleased that the Natural Areas Conservancy partnered with us to produce *Wetlands Management Framework for New York City*. The *Framework* illustrates the existing vulnerabilities of our wetlands as well as the meaningful benefits of their preservation, restoration, and management. Thanks to improved water quality, the Bronx River supports a new generation of fish and enables Bronx residents and visitors to paddle through its shady corridor. Freshwater wetlands in Alley Pond Park in Queens attract hikers and birdwatchers, and the salt marsh in Marine Park in Brooklyn is a favorite location for bird-watching, fishing, and kayaking.

This new framework is a significant step forward in improving management and resources for our wetlands and streams. It builds on decades of work by NYC Parks and our many local, regional, and state partners by outlining ways to understand, restore, and manage these natural areas. By providing key insights into the state of our wetlands and recommendations to improve their long-term health, this framework has the potential to enhance these important resources throughout our parkland. I look forward to seeing how this comprehensive roadmap informs wetland management, not only here in New York City but in cities across the country and around the world.

Mitchell J. Silver, FAICP, Hon. ASLA
Commissioner, NYC Parks

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Executive Summary

There are 5,650 acres of wetlands in New York City (NYC) today. Approximately half of that total is managed by NYC Parks—1,540 acres of salt marsh, 850 acres of freshwater wetlands, and 60 miles of streams. But these wetlands and streams extend across only a small fraction of their historical area. New York City has lost 85 percent of its salt marsh area[1] and stream miles[2] and 99 percent of freshwater wetland habitat[3] since Europeans arrived. The remaining wetlands are vulnerable to sea-level rise, development, and pollution. Nevertheless, our city's wetlands provide natural beauty, support diverse wildlife, and offer recreational opportunities for New Yorkers and visitors. They contribute to climate resilience by reducing flood risk, mitigating heat impacts, and storing carbon.

This *Wetlands Management Framework for New York City* provides a 30-year roadmap for the preservation, restoration, and management of all wetlands and streams in New York City with particular focus on those under the care of NYC Parks. This framework outlines steps that will:

1. Protect and improve the health of wetlands and streams
2. Create new wetlands and allow space for wetlands to migrate
3. Fund wetland management and protection
4. Expand public access and engagement

In order to achieve these long-term goals, we call for increased investment in wetlands restoration and management as well as funding for land acquisition for conservation. The framework identifies a variety of actions and dozens of potential projects that would increase the footprint of wetlands in New York City, and bring 7,000 acres of wetlands and surrounding area into active management.

Together with partners, we can pursue the following actions and strategies:

Across habitat types:

- Remove fill and debris within historical salt marshes, freshwater wetlands, streambanks, and floodplains
- Remove invasive species and reestablish native vegetation
- Monitor habitat quality and identify emerging threats

In and adjacent to salt marshes:

- Reconstruct eroded marsh edges
- Add sediment to vulnerable marshes
- Ensure parkland is adaptable to sea-level rise and uses are compatible with flooding

In streams:

- Rehabilitate degraded stream reaches
- Increase connectivity between stream reaches

To better protect wetland resources:

- Complete wetland mapping on NYC Parks' property
- Remove illicit stream discharges and sources of floatable debris
- Install stormwater green infrastructure throughout the watershed
- Identify land acquisition and transfer opportunities to protect current wetlands and facilitate marsh migration
- Expand community engagement programs to improve access and promote stewardship

Much has been accomplished over the last several decades, during which government and nonprofit partners have made significant investments in our city's wetlands—including restoring 355 acres of salt marsh for fish and wildlife habitat,[4] piloting a wetland mitigation bank to improve restoration outcomes, and reconstructing freshwater wetlands and streams to better manage storm and floodwaters.

However, assessments conducted from 2012 to 2018 and supplementary research show that wetlands are at risk. For example:

- Salt marshes managed by NYC Parks are projected to lose several acres per year as vegetated marsh is eroded, and they face the threat of drowning under climate change
- Streams are degraded by stormwater and loss of adjacent protective vegetation
- Freshwater wetlands face degradation from adjacent development, invasive species, stormwater pollution, and loss of connection to water sources

Implementing this framework will yield benefits beyond the wetlands and streams themselves. It will create new green jobs and improve access to New York City's green spaces, especially for the half a million New Yorkers who live within walking distance of wetlands within NYC Parks. Finally, in this report, we highlight the importance of government policy in caring for wetlands and streams. Success depends on coordination, commitment, and funding from all levels of the public sector and cooperation with non-governmental partners—both to protect our remaining wetlands and streams and to ensure that degraded habitat will be restored. This investment will ensure New York City's wetlands continue to benefit future generations.

Introduction

New York City's landscape was originally shaped by water and ice. Glaciers and meltwater formed the city's hills, thousands of acres of interconnected freshwater wetlands, lakes, ponds, and salt marshes, in addition to hundreds of miles of streams. Today, New York City has 520 miles of coastline, an estuary teeming with life, and a busy working harbor. Our city's wetlands provide natural beauty, support diverse wildlife, and offer recreational opportunities for New Yorkers and visitors. They contribute to climate resilience by reducing flood risk, mitigating heat impacts, and storing carbon. In recognition that wetlands are fundamental to the health of New York City, we developed the *Wetlands Management Framework for New York City* to summarize the management and restoration needed to preserve and protect these resources over the next 30 years.

Rattlesnake Creek,
Seton Falls Park, The Bronx

Overview of New York City's Wetlands

FIGURE 1

NYC's Land Cover: 41% of NYC Is Green

Source: Natural Areas Conservancy Ecological Covertype Map, 2014.

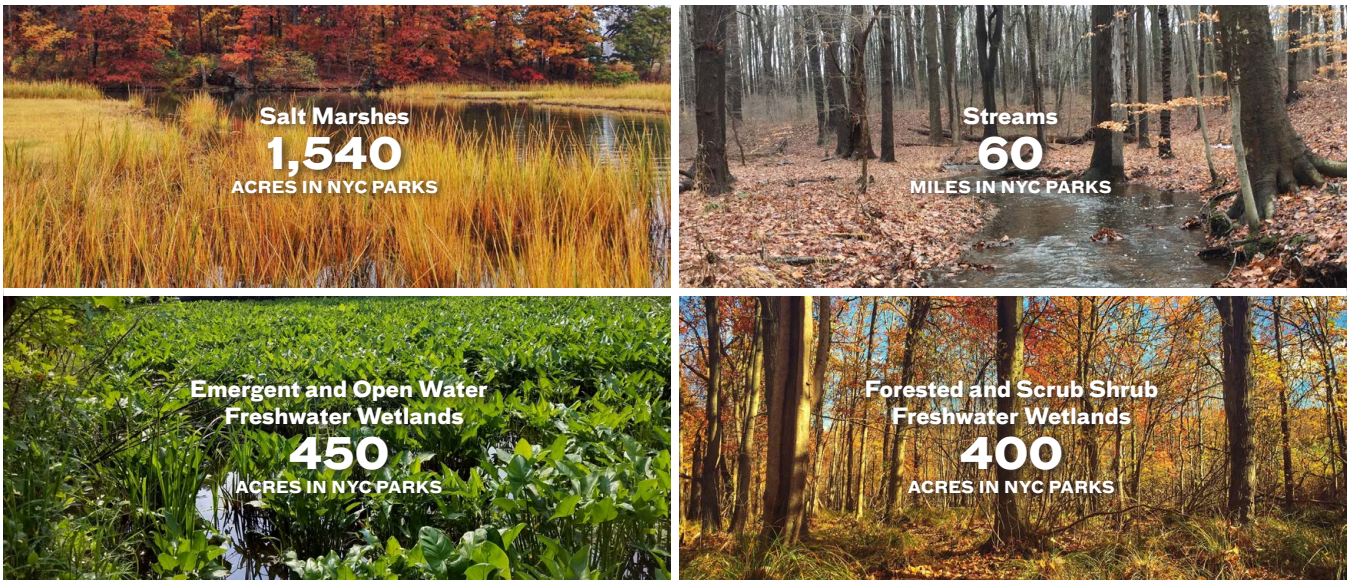
FIGURE 2

NYC's Natural Areas Make Up 12% of the City

Source: Natural Areas Conservancy Ecological Covertype Map, 2014.

FIGURE 3

Half of NYC's Wetlands and Streams Are in NYC Parks



NYC Parks wetlands extent is based on National Wetlands Inventory (NWI), 2004 and NYC Parks Freshwater Streams Hydrography, 2018. NWI data has been edited to reflect known conditions. Note: Citywide totals are: 4,020 acres of tidal wetlands (predominantly salt marshes, NYC Wetlands Strategy, 2012), 1,630 acres of freshwater wetlands (NWI, 2004), and 110 miles of streams (NYC Parks Freshwater Streams Hydrography, 2018). NWI and Ecological Cover Type Map data differ due to differing methodologies.

A New Vision for Streams and Wetlands

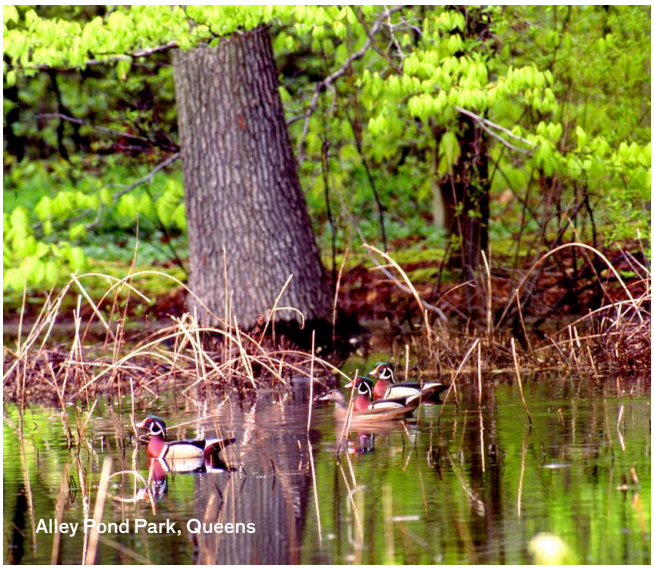
We envision a city and harbor where wetlands and streams thrive, are resilient, and contribute to the economic, cultural, and social health of our vibrant and diverse metropolis. In this vision of the future, the city's wetland ecosystems support abundant and diverse wildlife. Fisheries are healthy. Wetlands and streams provide access to and engagement with nature. People increasingly spend time recreating on-water—including whale watching, kayaking, fishing, and sailing. Diverse communities steward wetlands and streams and advocate for their protection. Local and regional planning, as well as infrastructure development, reflect the connectivity of wetlands and waterways, their sensitivity to disturbance, and the importance of their protection. Planning, protection, and restoration are funded to provide on-going ecological and social benefits—including green jobs. We envision a city that supports its wetlands and streams to safeguard these resources for future generations of New Yorkers.

Lemon Creek,
Staten Island

Wetlands Management Framework Goals

Protect Existing Wetlands and Create New Wetlands

- Prevent additional wetland loss and restore lost wetlands
- Plan for climate change by ensuring every wetland and stream has adjacent natural land for storm-related flooding and for migration when sea-levels rise



Alley Pond Park, Queens

Improve Wetland and Stream Health

- Capture stormwater runoff at its source to reduce the frequency and volume of contaminated water flowing into our city's waterways
- Prevent new runoff to NYC Parks' wetlands and streams from roads, streets, and parking lots
- Add structural complexity, increase connectivity, and reduce invasive species and fragmentation

Marine Park, Brooklyn

Fund Wetland Management and Protection

- Increase city, state, and federal investment in wetland protection, restoration, acquisition, management, and monitoring
- Increase city and state investment in stormwater green infrastructure construction and maintenance

Expand Policy Support

- Include natural shoreline protection and land acquisition for wetland migration in future city planning efforts, and develop policies to support associated open space preservation
- Increase inter-agency coordination to identify barriers to and opportunities for expanding implementation, maintenance, and stewardship of green infrastructure
- Maintain integrity of wetlands within NYC Parks by supporting opportunities to strengthen conservation of small wetlands that are hydrologically connected

Saw Mill Creek Marsh, Staten Island

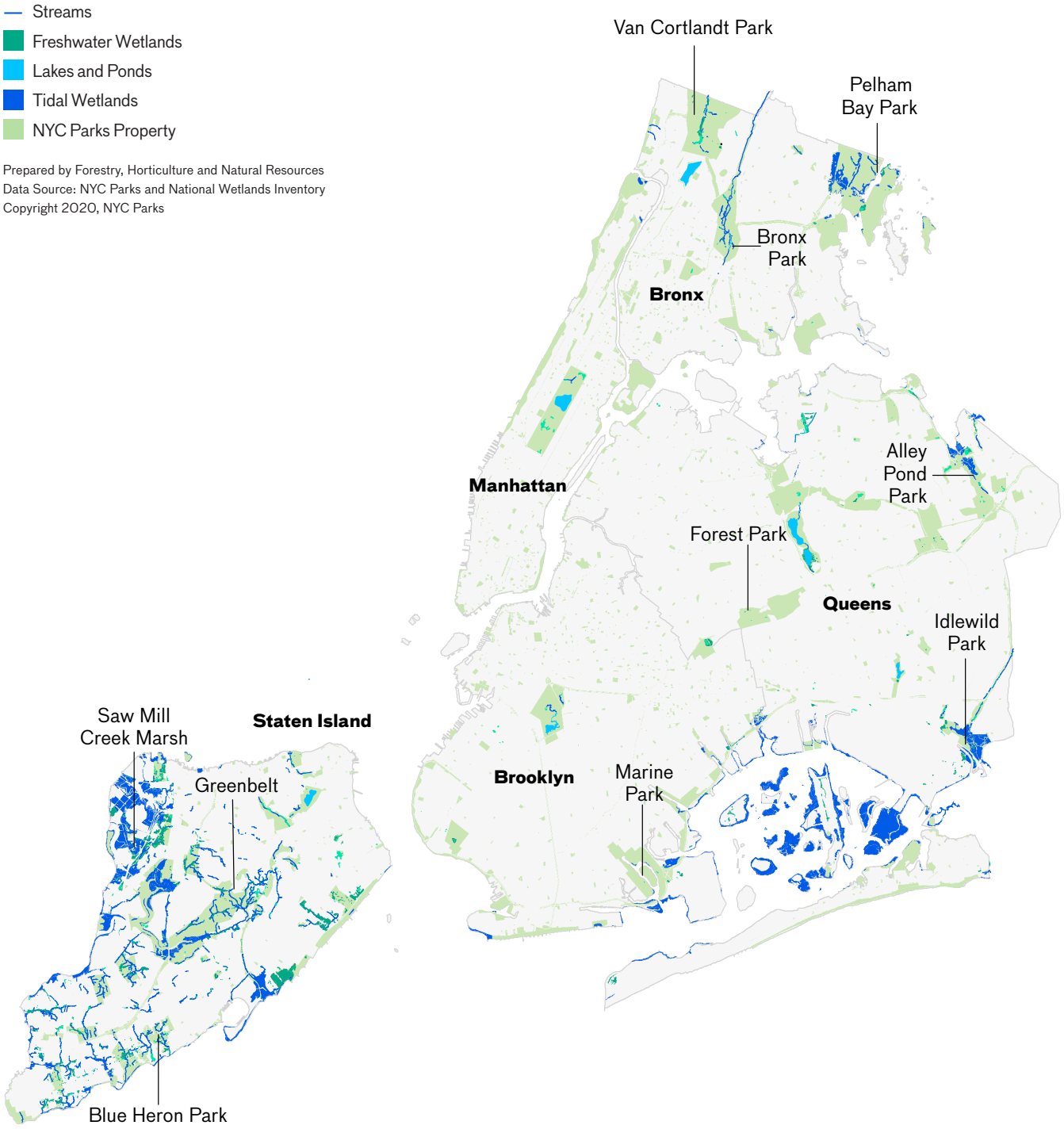
Expand Public Access

- Increase support for stewardship and education for wetlands
- Improve access for all New Yorkers, prioritizing underserved communities
- Provide green jobs

FIGURE 4

NYC's Streams and Wetlands

Approximately 4,020 acres of tidal wetlands, 1,630 acres of freshwater wetlands, and 110 miles of streams remain in NYC today, approximately half of which are on NYC Parks property. Tidal wetlands, which include salt marshes, are found where the land meets the sea, and are flooded by tides. Many of the lower extents of beaches along the coastline are technically tidal wetlands under today's regulatory definitions. The majority of freshwater wetlands and streams are found on Staten Island.



Prepared by Forestry, Horticulture and Natural Resources
Data Source: NYC Parks and National Wetlands Inventory

FIGURE 5

NYC's Watersheds

Five main watersheds span New York City: The Hudson River-East River, Long Island Sound, Arthur Kill-Upper Bay, Raritan Bay-Lower Bay, and Jamaica Bay watersheds. Each of these watersheds is connected to the Atlantic Ocean. A watershed is the entire surrounding land area from which water may flow into a watercourse or waterbody.

- Streams
- Wetlands
- Watersheds
- NYC Parks Property

Prepared by Forestry, Horticulture and Natural Resources
Data Source: NYC Parks and National Wetlands Inventory

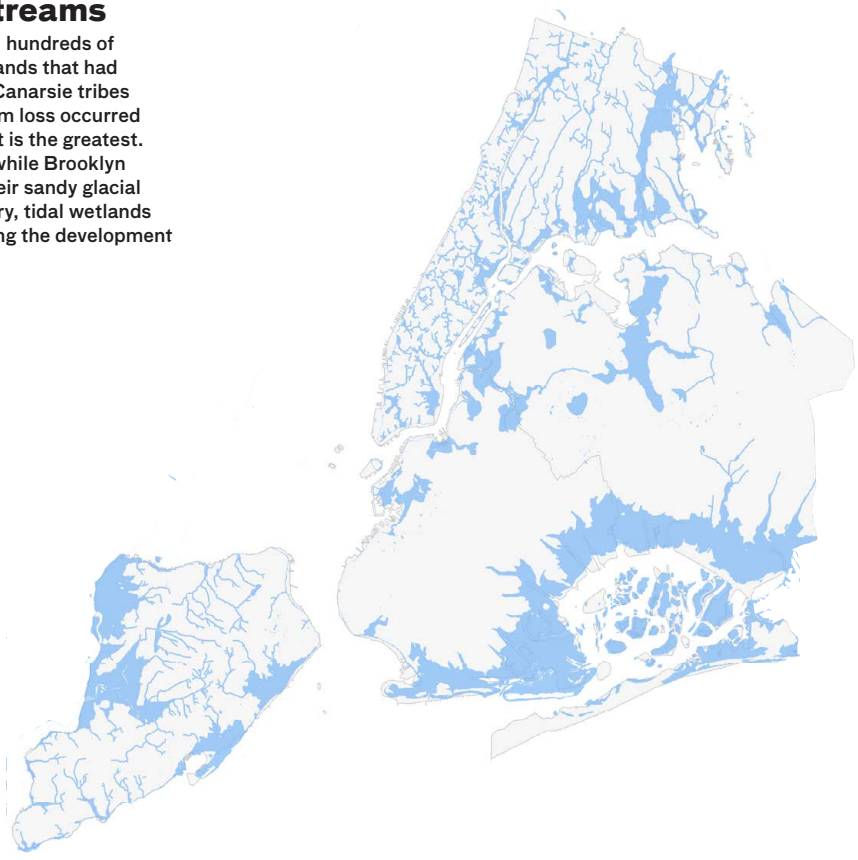
FIGURE 6

Historical Wetlands and Streams

In the 1600s, when Europeans arrived, NYC had hundreds of miles of streams and thousands of acres of wetlands that had been stewarded by the Lenape, Rockaway, and Canarsie tribes for centuries. Since that time, the greatest stream loss occurred in the Bronx and Manhattan, where development is the greatest. Staten Island has the most remaining streams, while Brooklyn and Queens naturally had few streams due to their sandy glacial soils. Based on historical maps and aerial imagery, tidal wetlands were filled largely in the early to mid-1900s during the development of New York Harbor.

- Historical Wetlands and Streams

Prepared by Forestry, Horticulture and Natural Resources
Data Source: Regional Plan Association



Wetlands and Streams: Essential to the City

Wetlands provide profound benefits to New York City. Healthy, functioning wetlands help clean water, which is essential to a thriving estuary. They provide breeding and foraging habitat for fish and birds. People seek wetlands to recreate and find respite. Because of their proximity to over eight million residents and millions of visitors, New York City's wetlands provide value that outweighs their size. For example, every year more people visit Jamaica Bay in Queens than Yellowstone National Park.[5]

Home to Nature

New York City's wetlands support more than 325 species of birds,[6] over 315 species of plants,[7] and over 200 species of fish and shellfish.[8] Wetlands and streams act as forage grounds and nurseries for many sportfish and are critical refueling stops for tens of thousands of migratory birds and insects along the Atlantic flyway.

Playgrounds for People

Wetlands provide opportunities for recreation, education, contemplation, wonder, and renewal. Research confirms the common wisdom that access to nature improves our physical and mental health.[9] Spending time in nature provides significant cognitive and emotional benefits.[10] Indeed, studies show that visual access to water has even greater benefits than traditional green space,[11] and that the beneficial health effects of spending time in urban wetlands may be even greater for underserved communities.[12]

Community Identity

For many New Yorkers, wetlands are part of the fabric of their communities and families. Residents of neighborhoods including City Island (the Bronx) and Gerritsen Beach (Brooklyn) have connections to their local waterways that span generations. Following decades of restoration, the Bronx River is increasingly visible from shore, accessible by water, and now supports the upstream migration of spawning alewife for the first time in hundreds of years. In Flushing Meadows Corona Park in Queens, people fish and race dragon boats in fierce competitions on Meadow Lake. In Staten Island's Greenbelt, hikers can follow numerous streams that are home to eels, minnows, dragonflies, salamanders, and frogs. Neighborhood residents flock to the parks around Coney Island Creek in Brooklyn, to fish, walk along the shore, and simply enjoy a moment of peace and quiet by the water.[13]

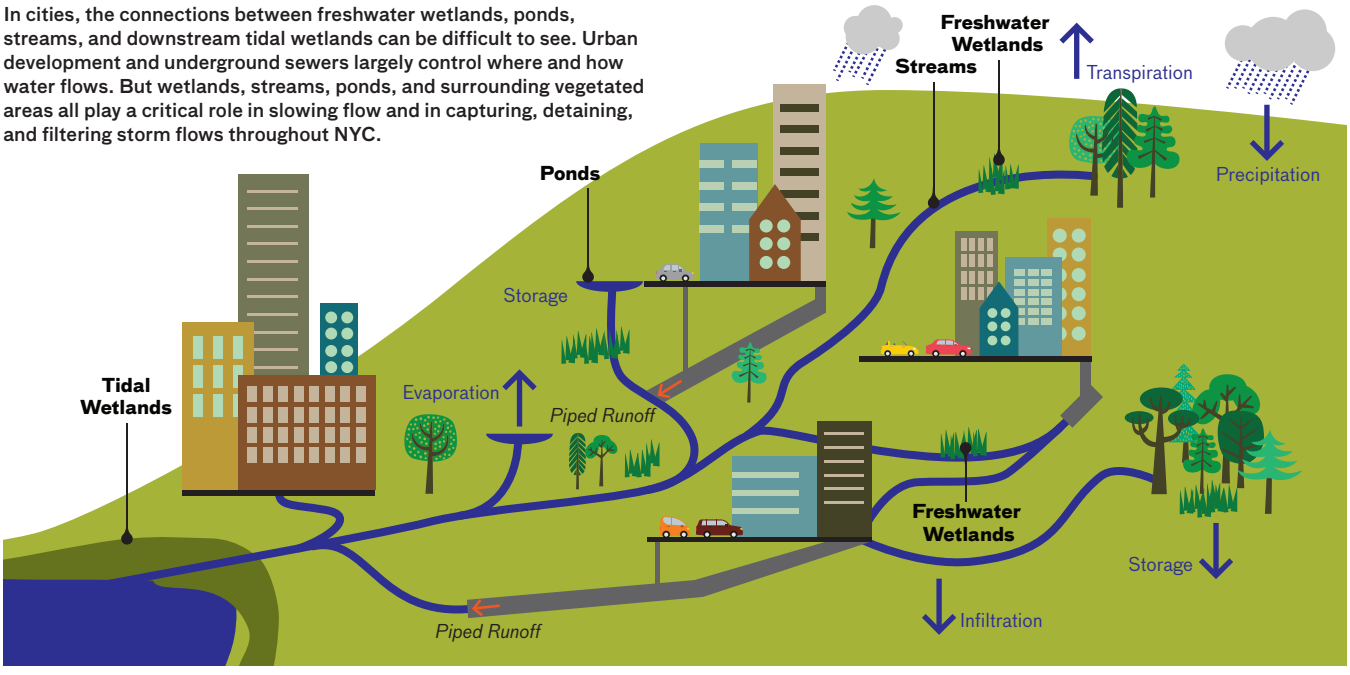
Enhance NYC's Resiliency to Climate Change

For coastal communities, salt marshes mitigate the impacts of storm surges and coastal flooding by detaining floodwaters. They help buffer wave energy and capture and store carbon. Forested freshwater wetlands, streams, lakes, and ponds sequester carbon, filter water, cool our city, and reduce the impacts of the urban heat island.[14]

FIGURE 7

How Are NYC's Wetlands Connected in Urban Watersheds?

In cities, the connections between freshwater wetlands, ponds, streams, and downstream tidal wetlands can be difficult to see. Urban development and underground sewers largely control where and how water flows. But wetlands, streams, ponds, and surrounding vegetated areas all play a critical role in slowing flow and in capturing, detaining, and filtering storm flows throughout NYC.



Rare and Threatened Wetland Species in NYC

New York City is home to 212 species of mammals, birds, reptiles, amphibians, fish, and insects that have state legal protection status (e.g., threatened, endangered, or special concern). Of these, 156 species (almost three quarters) use wetlands for foraging, breeding, or for shelter.[15] New York City's wetlands are also home to 69 rare, threatened, or endangered plants, and wetland plants make up 30 percent of the extirpated plant species in the City.[16] Here is a short introduction to a few special plant and animal species that can be found in New York City's wetlands.

Atlantic Coast Leopard Frog

(Rana kauffeldi)

Scientists first described this species as distinct from the wide-ranging southern leopard frog (*Rana sphenocephala*) in northwest Staten Island in 2014. This little frog, about 2.5 inches in length, favors open wet meadows, typically in freshwater near the coast. Large groups congregate during a short, early-spring breeding season and produce a noisy chorus.

Horseshoe Crab

(Limulus polyphemus)

These marine invertebrates are living fossils—the species has existed for over 400 million years. Every spring, horseshoe crabs come onto the beach within bays and coves to spawn during high tides, and their eggs are critical food for migratory birds. In NYC, they are often found on sandy shores and tidal inlets across the city, including wetlands near Pelham Bay Park in the Bronx, Calvert Vaux Park in Southern Brooklyn, and Great Kills Park in Staten Island.

Diamondback Terrapin

(Malaclemys terrapin)

Diamondback terrapins are the only turtle species in North America that live in estuarine habitats where fresh and salt waters meet. Adult females grow to be about 9 inches long, males to 6 inches. Diamondback terrapins live the majority of their life in the salt marsh, but females come onto land to nest in sandy uplands in the late spring. These turtles gained some local notoriety in 2011, when nesting females caused JFK Airport to shut down a runway after they came on land to nest.

Saltmarsh Sparrow

(Ammodramus caudacutus)

These small, unassuming birds, about 5 inches in length, are salt marsh specialists. Due to threats from sea-level rise and habitat loss, scientists estimate they will go extinct by 2050 without intervention. Saltmarsh sparrows are predominantly found in large expanses of high marsh, such as in Four Sparrow Marsh in Brooklyn. When in low marsh, such as in Idlewild Park in Queens, saltmarsh sparrows often must renest when spring tides flood their nests.

PHOTO: ALEX COOK

Northern Dusky Salamander

(Desmognathus fuscus)

Northern dusky salamanders are wide-ranging and can be found as far north as New Brunswick, as far south as North Carolina, and as far west as Ohio and Tennessee. They prefer wooded habitats with trickling sources of water like springs or seeps. A population of northern duskies live in Highbridge Park in northern Manhattan.

Little Bluet

(Enallagma minusculum)

Little bluets are small, light-blue and black damselflies about one inch long found in coastal freshwater wetlands. Designated as threatened by New York State, little bluets have been found in only three locations in the state—including one in Queens. Their persistence is threatened by water quality degradation.

Black-crowned Night Heron

(Nycticorax nycticorax)

These stocky black-and-white waterbirds reach about 2 feet in length and are distinctive for their hunched posture. Black-crowned night herons nest in colonies in NYC's harbor and often forage in bodies of freshwater. Designated as a species of greatest conservation need by New York State, they are vulnerable due to habitat loss.

PHOTO: DICK DANIELS

Slender Blue Flag Iris

(Iris prismatica)

This rare wetland wildflower is 1 to 3 feet in height. It blooms in the late spring, with showy blue-purple flowers with a yellow center. Thin leaves come up from a basal cluster. In NYC, they are threatened by habitat degradation and overgrazing by deer.

Wetlands and Streams at Risk

New York City's wetlands and streams were once regarded as a nuisance—most suitable for dumping and filling to make way for development. The legacy of this treatment is significant. Streams are piped underground, and salt marshes are buried under landfills. Water access is blocked by highways and train tracks. These impacts are compounded by the effects of climate change, including rising water levels and severe storms. Despite decades of progress in protection and restoration, wetlands face new and ongoing risks.

Sea-Level Rise

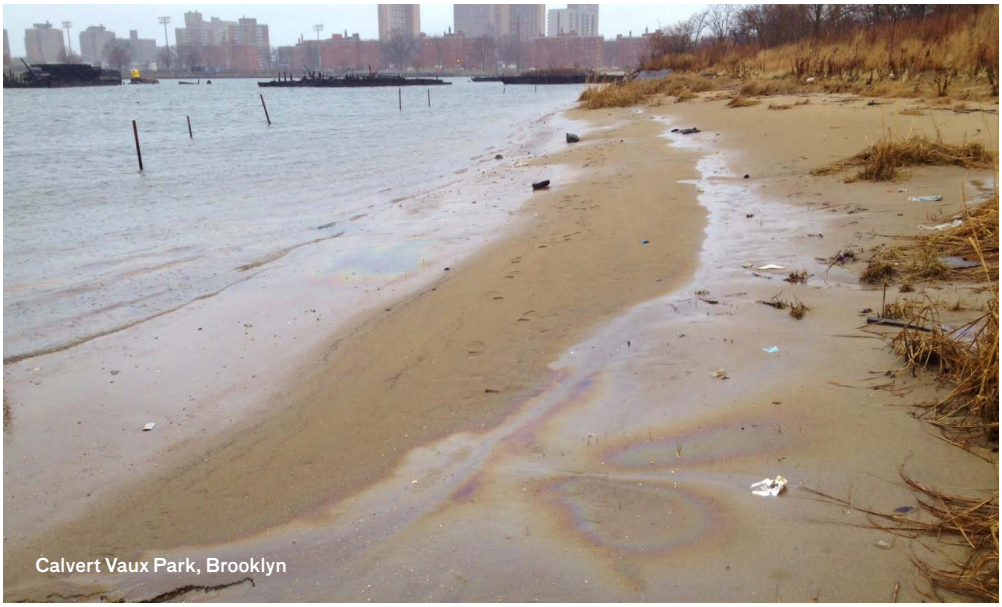
By the 2050s, New York City will experience sea-level rise by as much as 2.5 feet.[17] Rising water levels stress salt marsh plants by limiting oxygen and effectively drowning them. Where conditions allow, salt marshes will migrate landward to a higher elevation as today's dry land becomes more frequently inundated. But in New York City, that movement is often restricted by low-lying coastal development.

Storm flooding at Brookville Boulevard, Idlewild Marsh, Queens

Sediment Starvation

Salt marshes can increase in elevation naturally, but that process depends on a regular supply of natural sediment. Channel dredging, dams on streams, and hardened shorelines deplete the sediment supply that would otherwise build up on our marshes and prevent erosion and drowning. Sea-level rise makes this lack of natural sediment supply a greater threat to the future of coastal wetlands in New York City.

Idlewild Park, Queens



Calvert Vaux Park, Brooklyn

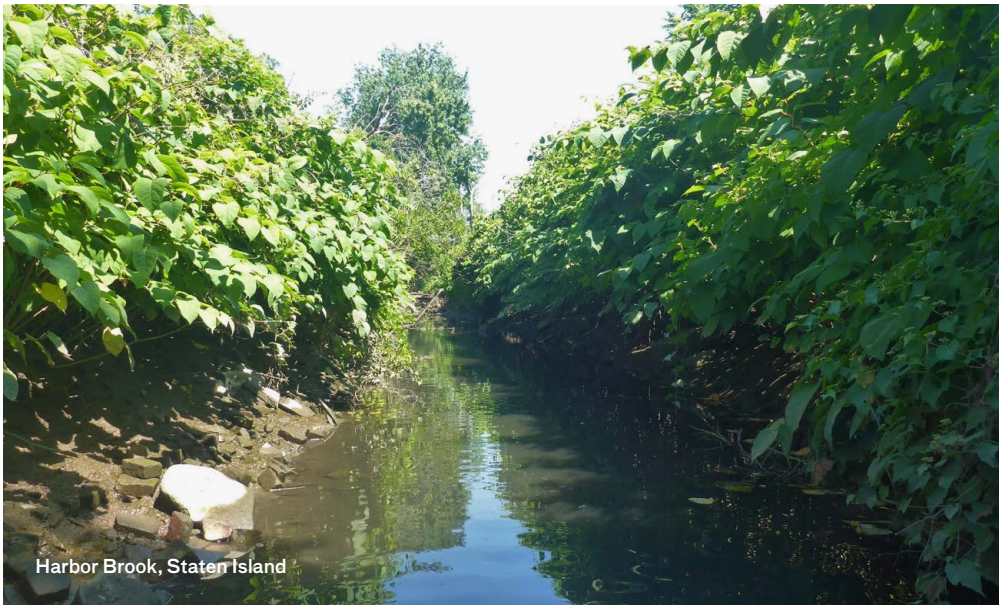
Pollution

Oil spills, accidental and illicit pipe discharges, and plastic waste present ongoing risks to wetland wildlife. Nutrients from urban stormwater and combined sewer overflows exacerbate marsh drowning by inhibiting root growth and causing plant matter to decompose more rapidly, weakening marsh soils.[18]

Egbertville Ravine, Staten Island

Excessive Runoff

The replacement of vegetation and soil with concrete and buildings means that rainfall is no longer intercepted by greenery nor absorbed into the ground. Instead, stormwater runs off roads, parking lots, and lawns and is piped directly to streams, causing flash flooding, excessive erosion, and increased levels of pollutants. More frequent and intense rainstorms caused by climate change will intensify these impacts.



Harbor Brook, Staten Island

Invasive Species

Invasive plants, such as Japanese knotweed, often outcompete diverse native plant communities, degrading habitat for native fish and wildlife. In our lakes and ponds, higher temperatures year-round due to global warming, and high levels of nutrients, have caused more frequent and longer periods of harmful algae blooms, which can limit recreational opportunities and deplete oxygen, which leads to fish kills.

FIGURE 8

Timeline of Stream and Wetland Regulations, Plans, and Restoration

Pre-1990 | 1995 | 2000

Regulations

1972
The federal Clean Water Act established regulation for the filling of wetlands and the discharge of pollution to streams, wetlands, and other water bodies.

1974
The New York State Tidal Wetlands Act resulted in protection of 7,388 acres along New York City's shoreline, establishment of a 150-foot adjacent area buffer, and regulatory maps.

1975
The New York State Freshwater Wetlands Act resulted in protection of 2,746 acres, establishment of a 100-foot adjacent area buffer, and regulatory maps.

1996
The federal Water Resources Development Act, Section 206 authorized the U.S. Army Corps of Engineers to restore aquatic ecosystems resulting in cost sharing for wetland restoration projects.

Planning

1992
The New York City Department of City Planning issued the City's first *Comprehensive Waterfront Plan.* This plan described opportunities for reclaiming New York City's waterfront, including the creation of new parks. The plan was updated in 2011 to include strategies for climate resiliency. A subsequent update will follow in 2021.

2001
NYC Parks put forward *Forever Wild* guidelines to protect natural areas across 10,000 acres of parkland.

New York / New Jersey Harbor Estuary Program Habitat Workgroup Status Report outlined restoration and acquisition priorities and standardized restoration design and monitoring approaches.

Restoration

1990
An Exxon tanker leaked one million gallons of oil into the Arthur Kill, which impacted Saw Mill Creek on Staten Island, one of New York City's healthiest wetlands, and resulted in natural resource damages funding for salt marsh restoration and the city's first salt marsh restoration, completed in 1993.

1990s
The New York City Department of Environmental Protection's Bluebelt Program initiated use of wetlands and stream corridors for stormwater management at 12 parks across 17 acres (e.g., Mill Creek, Richmond Creek, Wolfe's Pond).

1996
The New York State Clean Air Clean Water Bond Act provided over $8 million in funding to restore streams, freshwater wetlands, and salt marshes in New York City across nearly 40 acres, including projects such as Gerritsen Creek, the Bronx River Floodplain, Pugsley Creek, and Strack Pond.

2005 2010 2015 2020

2009
New York City Local Law 31 resulted in the creation of a preliminary updated wetlands map based on satellite data and a wetlands strategy that identified funding, legal, management, enforcement, and other requirements for wetland protection.[19]

2007
NYC Interagency Wetlands Transfer Task Force recommended the transfer of more than 363 acres of wetlands to NYC Parks and other agencies and recommended an additional 373 acres for review.[20] To date, 162 acres have been transferred to NYC Parks.[21]

2009
NYC Wetlands: Regulatory Gaps and Other Threats, produced by the Mayor's Office, reported that small freshwater wetlands lack protection.

The U.S. Army Corps of Engineers' *Comprehensive Restoration Plan* established a consensus vision for restoration opportunities in New York Harbor, resulting in over 268 acres of wetland restoration. [22]

2010
Bronx River Intermunicipal Watershed Plan was the first watershed plan in New York City and identified priority restoration and green infrastructure projects.

2012
NYC Wetlands Strategy, produced by the Mayor's Office, identified protection strategies and priority projects, such as the first pilot wetland mitigation bank in New York City.

The New York City Department of Environmental Protection initiated a long-term control planning process to abate combined sewer overflows in priority watersheds.

2016
NYC Parks and the Natural Areas Conservancy's *Inventory of Coastal Wetland Restoration Opportunities in NYC* identified 275 acres for salt marsh restoration.

2017
Towards a Salt Marsh Management Plan for NYC: Recommendations for Restoration and Protection NYC Parks described conditions and recommended actions for managing NYC Parks' largest salt marshes.

Design and Planning for Flood Resiliency: Guidelines for NYC Parks provided guidance for developing and renovating resilient waterfront parks.

2018
NYC Salt Marsh Restoration Monitoring and Design Guidelines, produced by NYC Parks, updated the 2001 salt marsh restoration guidelines.

2020
Strategies for Managing NYC's Streams by NYC Parks identified the condition of New York City's streams and made recommendations to protect them.

2002–2012
Wildlife Conservation Society-National Oceanic and Atmospheric Administration Community Restoration Grants for the Bronx River funded wildlife studies, restoration, and monitoring through stewardship and partnership building, and led to the construction of the first fishway at 182nd Street allowing river herring to migrate upstream. In 2017, the first alewife in 400 years accessed the freshwater reach of the river via the fishway.

2006–2012
The U.S. Army Corps of Engineers Ecosystem Restoration partnerships agreements leveraged restoration funding between city, state, and federal agencies.

2014–2020
Department of the Interior National Fish and Wildlife Foundation Grants funded over $10 million in post-Hurricane Sandy coastal resilience at Sunset Cove, Spring Creek, and other sites.

2018
Saw Mill Creek Mitigation Bank piloted by the New York City Economic Development Corporation was completed and released the first wetland mitigation credits for city projects.

Wetland and Stream Protections Today

Strengths

State and federal protections limit destruction from filling and development.

Federal regulations provide for robust protections of navigable streams, coastal wetlands, and freshwater wetlands that are hydrologically connected by streams or tributaries to navigable waters, no matter their size.[23] If impacts are unavoidable, regulations require mitigation to counteract those impacts.

The New York State Department of Environmental Conservation (NYS DEC) regulates all coastal wetlands and 150 feet of adjacent area surrounding coastal wetlands (or to the 10 foot elevation contour, whichever is shorter),[24] as well as freshwater wetlands 12.4 acres or larger, including a 100-foot adjacent area.[25] NYS DEC also mapped and regulates some smaller wetlands (approximately 40 locations[26]) that are of unusual local significance—totaling about 278 acres.[27]

Local environmental review guidance is more stringent than state-level requirements and can be used to protect small unregulated wetland resources within or adjacent to NYC Parks.

New York City has local policies that review environmental impacts and development (City Environmental Quality Review, Uniform Land Use Review Procedure, and the Waterfront Revitalization Program). The guidance provided to quantify and disclose impacts to natural resources is detailed and comprehensive. This process can lead to reduction of impacts through the consideration of alternatives.

NYC Parks policies and programs encourage protection.

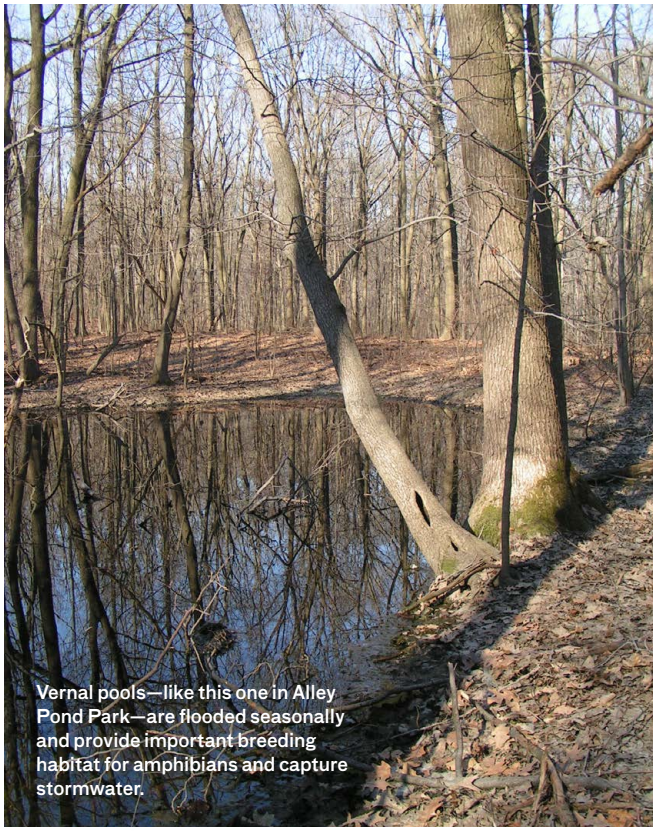
New York City's parks are protected. Development on NYC Parks property is protected by virtue of the public trust doctrine. NYC Parks' Forever Wild program includes a set of guidelines and best practices for each division of NYC Parks, including practices in and around wetland areas. The Forestry, Horticulture, and Natural Resources division of NYC Parks reviews the program regularly to ensure it remains timely and effective in protecting natural resources on parkland.

Weaknesses

Not all wetlands are currently protected by law or policy. Existing regulations that fail to address pressing threats, such as sea-level rise, and out-of-date maps leave New York City's wetlands at risk. When wetlands and their adjacent habitats are located on private property, protection is limited to large wetlands and those connected to navigable waters by streams and creeks. While overt filling of wetlands and illegal damaging activities occur much less frequently than in the past, development continues to encroach upon critical wetland habitats and is occasionally permitted by regulators. For example, in the industrial areas of northwest Staten Island, unregulated wetlands and future wetlands are still being developed.

Wetland maps are outdated and insufficient given climate change.

New York State's tidal wetland maps were created in 1974 and freshwater maps in the mid-1980s. Since that time, some wetlands have been filled and shifted in response to development, leaving wetlands and their regulated adjacent uplands inadequately represented. Sea-level rise associated with climate change has caused changes in coastal wetland extent, leaving tidal regulatory maps particularly inadequate (see example in Figure 9) and likely to become increasingly inaccurate over time.



Vernal pools—like this one in Alley Pond Park—are flooded seasonally and provide important breeding habitat for amphibians and capture stormwater.

Coastal wetland regulations do not consider future sea-level rise.

Current regulations do not protect areas that will become flooded as sea-levels rise. With current sea-level rise projections, the fixed 150-foot regulatory distance from the 1974 tidal wetland boundary and the 10-foot elevation threshold will both become increasingly ineffective tools to conserve New York City's wetlands (see Marsh Migration sidebar).

Small freshwater wetlands remain unprotected.

Because New York State's 12.4-acre threshold limits protection for small wetlands, hundreds of acres of freshwater wetlands across the city that were mapped by the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) in the 1990s are vulnerable to development. These include vernal pools, which are small isolated depressions in forests, that do not have surface connections to streams, and are essential habitat for locally-rare salamander populations. Small wetlands totalling 530 acres intersect public property and may be at risk for development.[28] Over 100 additional acres intersect private property (over 1,000 tax lots) and receive no regulatory protection. Since the 1990s, a citywide spatial analysis showed that up to 20 percent of those wetlands on private property have been legally filled and developed and 10 percent of freshwater wetlands remain vulnerable to development.

Streams that do not flow year round have no protection.

Roughly 30 percent of streams in New York City are ephemeral, flowing in response to snowmelt and rainfall. They are critical for cleaning water, detaining storm flow and decreasing local flood risk, delivering sediment to salt marshes, and supporting biodiversity. Despite their value, these streams may be filled and piped legally.*,[29] Remotely sensed data showed that three ephemeral stream channels in Staten Island, with a combined length of one mile, were filled on private property between 2010 and 2018.[30]

* In addition to state laws that limit protection for ephemeral streams, federal protections were rolled back in 2018. While this has a larger nationwide impact, NYC's streams are still left increasingly vulnerable.

Wetland adjacent areas have weak protections.

New York State law only requires a 30-foot setback from regulated tidal wetlands for buildings, and requires no setbacks for freshwater wetlands or streams.[31] Thus, while the state can regulate activities in the area surrounding wetlands, the law does not preclude construction in these areas or require mitigation. Federal regulations do not regulate any areas surrounding wetlands.

Wetlands mitigation is often inadequate.

Most wetland mitigation project permits include monitoring to ensure 85-percent survival of all plantings, but requirements are inconsistent and often not enforced. Furthermore, mitigation failures are rarely addressed. The NYC Mitigation Bank addresses these failings by requiring long-term protection and maintenance agreements and funding, but cannot accommodate all mitigation needs in the city.

Stormwater management remains insufficient.

Stormwater runoff from impervious areas continues to impact water bodies, because regulations do not ensure adequate analysis and design, nor performance standards, to prevent increases in volume and frequency of runoff, which leads to continued disturbance of downstream wetlands and streams.

Tulip Creek, Alley Pond Park, Queens

Updating NYC Wetland Maps

The *New York City Wetlands Strategy* (2012) called for an update of wetland maps using remote sensing technology, such as Light Detection and Ranging (LiDAR). LiDAR provides precise elevation data that can be used to detect land use and topographic changes, and subsequently is a critical tool for evaluating the extent of wetlands. While local updated maps would not have regulatory authority, they would provide more accurate locations and extent of our wetland resources to help ensure we can better protect and manage them.

In 2016, NYC Parks partnered with the University of Vermont Spatial Analysis Lab to update wetland and stream hydrography mapping of the city using 2010 LiDAR and other field and remote sensing data. The geographic information system methodology aimed to correct the problem of underestimating freshwater wetlands, particularly under forest canopy.[32] This work resulted in a preliminary map that is reliable for tidal wetlands but requires significant field verification and quality control for freshwater wetlands. We will provide this new map information to USFWS for use in the next, yet unscheduled, NWI map update, and to NYS DEC for a future update to the state regulatory maps, also not yet planned.

FIGURE 9

Wetlands Change Position Over Time

Tidal wetlands at McGuire Fields Park in Mill Basin, Brooklyn occupied a much different footprint in the 1974 aerial photos used in the regulatory maps (yellow) than what was delineated in the field in 2019 (blue). The more recent boundary extends much farther inland. Updated maps would extend the regulated wetlands and adjacent area inland significantly.

- State Regulated Wetland Boundaries (1974)
- Delineated Tidal Wetland (2019)
- 150' State Regulated Wetland Buffer (1974)
- 150' Delineated Wetland Buffer (2019)

Prepared by Forestry, Horticulture and Natural Resources
Data Source: NYC Parks, NYS DEC

Zoning Protection for Wetlands

Zoning is a tool that can be used to buffer NYC Parks-managed wetlands from negative impacts on adjacent private property.[33] In the 1970s and 1980s, the Department of City Planning (DCP) created three special districts in the Bronx and Staten Island—Special Natural Area District, Special Hillsides Preservation District, and Special South Richmond Development District. The regulations that govern development in these special districts have preserved and fostered the tree-lined streets and the biologically diverse wetlands and forests that are part of what make these districts special.

Other American cities have also successfully used zoning regulations to protect natural resources. For instance, Austin, Texas regulates development on steep slopes and in riparian corridors and limits the amount of impervious surfaces.[34] Zoning in Duluth, Minnesota incorporates a natural resources overlay, which requires all applicants to consider wetlands, floodplains, and riparian zones in permit applications.[35] Portland, Oregon also uses environmental overlay zones to protect sensitive areas—particularly rivers, streams, and wetlands.[36] New York City could join these other cities in using zoning to better protect wetlands.

Condition of Wetlands and Streams

Assessment of New York City's Wetlands

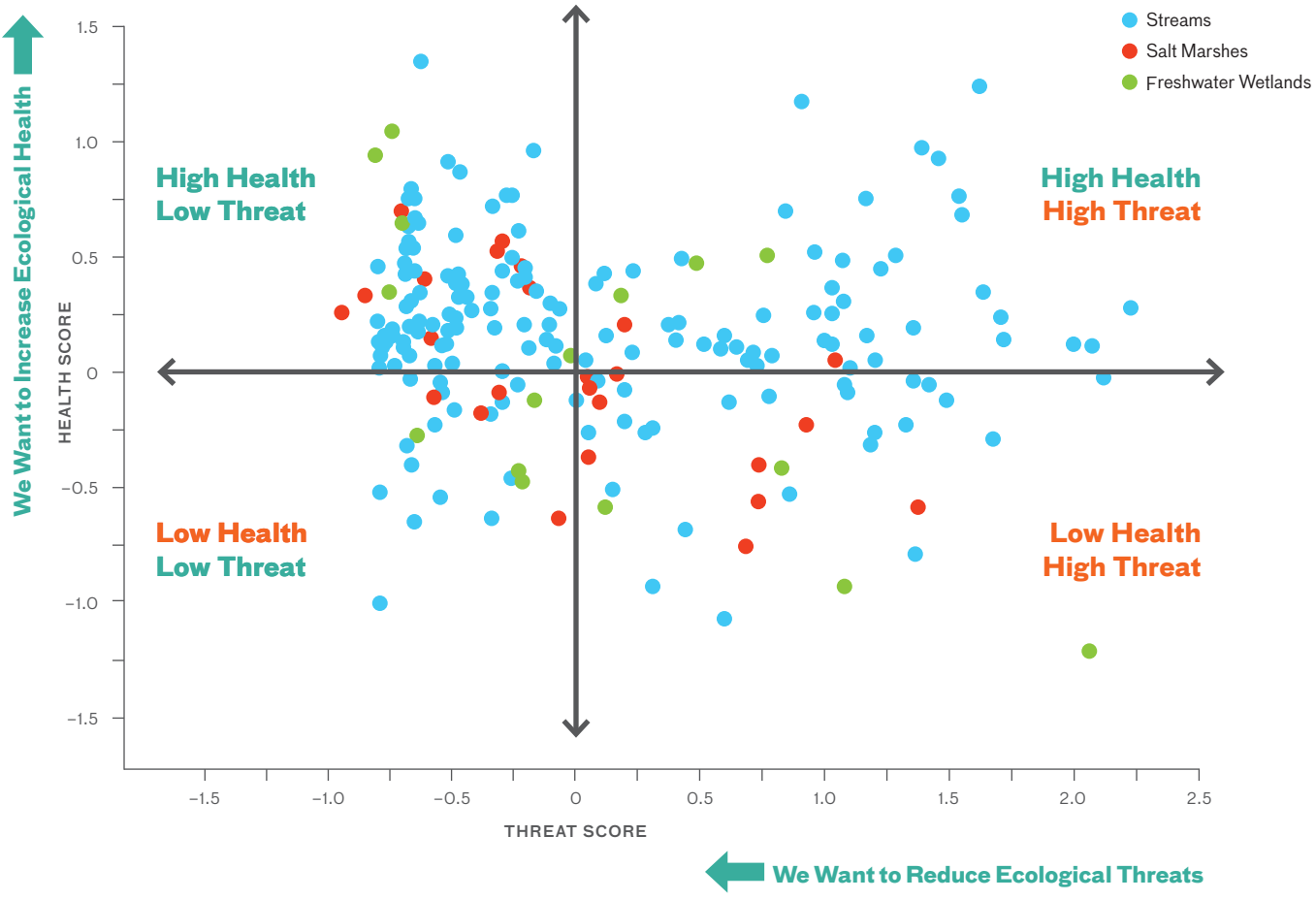
From 2013 through 2017, NYC Parks and the Natural Areas Conservancy (NAC) assessed the condition of over 1,300 acres of tidal and freshwater wetlands and 26 miles of streams in NYC Parks. Data included information on size and location of wetlands, plants and animals, vegetation cover and structure, erosion, and soil condition. The results are summarized in this section and provide the basis for this management framework.[37, 38]

With the ecological assessment data, staff developed relative condition scores indicating ecological health and threat for wetlands and streams across the city. We categorized each wetland and stream based on these scores (Figure 10).

FIGURE 10

Relative Stream and Wetland Health and Threat Scores

Each wetland or stream reach received a condition and impact score based on the metrics evaluated. The position of the site along the spectrum of scores allowed us to compare their relative health and vulnerability to threats.



Salt Marsh

Current Conditions

Salt marshes occupy the edges of the city within the zone of tidal inundation where the water meets the land. New York City's coastline once included over 30,000 acres of tidal wetlands[39] that supported thriving fisheries and clean water (Figure 6). Because of filling and dredging for industry and development, today only about 4,000 acres of salt marsh remain across the city—less than 15 percent of their historical extent.[40] NYC Parks and the National Park Service each manage nearly 2,000 acres of salt marshes in the city.[41]

A study of the 25 largest salt marshes on parkland (totaling 1,011 acres) showed that our remaining salt marshes are in moderate-to-poor health compared to those throughout the mid-Atlantic region.[42] However, these marshes still provide critical habitat and ecological functions. All of New York City's remaining salt marshes provide forage and rearing habitat for fish and water birds, over 70 percent are dominated by native wetland grasses, and approximately 400 acres of our largest marshes provide habitat to threatened and rare saltmarsh sparrows.

At the water's edge, salt marshes managed by NYC Parks are projected to lose about 6 acres per year as vegetated marsh converts to unvegetated mudflat based on studies of a subset of marshes. The interior is subsiding in many large marshes as well—over 275 acres are at a low elevation and at risk of drowning or converting to mudflat. In these areas, sea-level rise outpaces the sediment deposition and organic matter build-up that is needed to maintain the marsh's elevation.

About 250 acres of low-lying natural areas could become salt marsh, if conditions allow, due to increased tidal inundation by 2085 as sea-levels rise. This newly inundated area would help reduce, but not prevent net salt marsh loss. Next to our largest marshes, 43 acres of the surrounding low-lying area is developed and not likely to become marsh. These developed areas include buildings, paved surfaces, and transportation infrastructure, such as roads and railroads.[43]

Pugsley Creek, The Bronx

TABLE 1

Salt Marsh Condition Index

Index representing overall salt marsh health and threat, created using data collected across NYC Parks' salt marshes.

	Ecological Attribute	Measurable Indicator
Health	Well-vegetated marsh	Higher vegetation cover, lower presence of bare soil
	Contiguous, stable habitat	Lower ditch density, less change in open water area over time
	Habitat supportive of wildlife	Presence of breeding saltmarsh sparrows
	Marsh soil resilient to erosion	Higher soil shear strength
	Well-vegetated buffer	Smaller amount of development adjacent to marsh
Threat	Susceptibility to sea-level rise	Lower amount of high marsh
	Susceptibility to erosion	Higher shoreline vegetation loss
	Barriers to marsh migration	Adjacent future flooded area more developed

FIGURE 11

Salt Marsh Health and Threat

Each of the 25 salt marshes assessed received a health and threat score based on key metrics evaluated. The position of the marsh along the relative spectrum of health and threat scores corresponds to the recommended management actions.

Goose Creek Marsh , Pelham Bay Park, The Bronx

High Health / Low Threat

- Large, dominated by native plants, higher vegetation cover, higher elevation
- Priority for protection, more likely to persist under sea-level rise

Udall's Cove, Queens

High Health / High Threat

- Large, signs of transition, high rate of marsh loss, little space for marsh migration
- Requires interventions, such as sediment addition to raise elevation

WT Davis Wildlife Refuge, Staten Island

Low Health / Low Threat

- Higher invasive plant cover, high rate of marsh erosion, some space for migration
- Manage wetland-adjacent vegetation for habitat value and to allow marshes to migrate

Spring Creek, Queens

Lower Health / High Threat

- Small, low vegetation cover, high erosion rates, future anticipated conversion to mudflat
- Requires significant reconstruction to improve function

What is Marsh Migration?

Salt marshes can retain their structure and function in the face of sea-level rise by growing vertically and by migrating inland. Marshes grow vertically as sediment from storms and plant organic matter builds up on the marsh surface. If this sediment and organic accumulation is less than the rate of sea-level rise, marshes will drown. Marshes migrate horizontally as adjacent higher land becomes regularly inundated by the tide and suitable for salt marsh plants—unless physical barriers, including naturally steep slopes, bulkheads, roads, and buildings, prevent movement.

Allowing for and facilitating marsh migration is an important strategy for conserving coastal wetlands. This can happen in some locations if New York City 1) proactively acquires and preserves low lying land as open space and 2) removes barriers to inland migration by removing fill and restoring upland habitats surrounding salt marshes. These efforts can be a cost-effective way to preserve wetland habitats as marshes are allowed to migrate and help increase the resilience of coastal communities to climate change.

Ensuring marshes have the space to migrate and adapt under sea-level rise is not without challenges. These efforts require consideration of ecological, coastal protection, socioeconomic, and environmental justice factors. Coordination must happen across a broad range of governmental agencies, non-governmental agencies, and communities, and policy mechanisms must be adaptable and creative.[44]

Ramblersville, a small coastal community between Howard Beach and JFK airport in Queens, provides one successful example. Following Hurricane Sandy, the City developed a program to give homeowners the option to sell homes in areas heavily damaged by Hurricane Sandy. At Ramblersville, homes across several acres were bought and demolished with the goal of returning the lots to natural open spaces in the community. NYC Parks will accept ownership of these parcels in 2021 and manage their restoration to coastal wetlands and preservation for future marsh migration. Programs like these are models for how cities can adapt to climate change by protecting residents and wetland habitats.

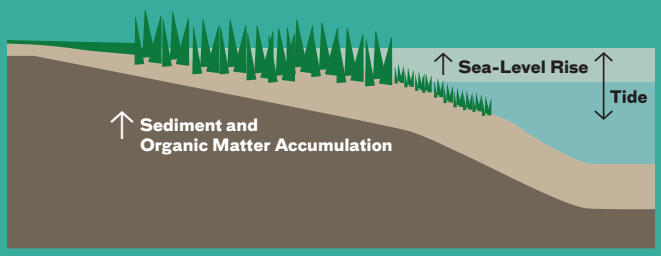
FIGURE 12

How Salt Marshes Respond to Sea-Level Rise

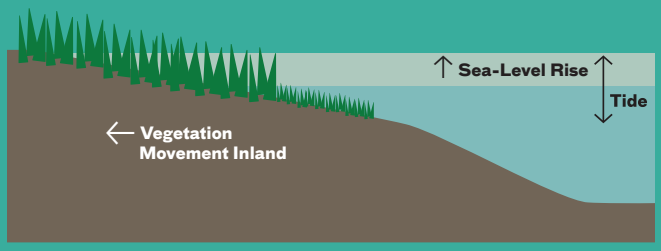
Adapted from Scenic Hudson, Protecting the Pathways, 2016.

Salt Marshes Can Keep Pace with Sea-Level Rise

Vertical Growth

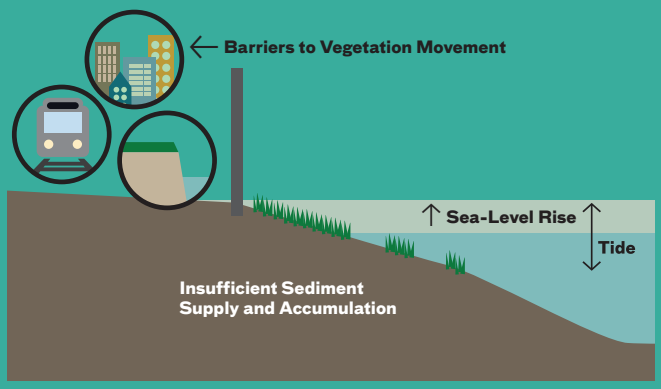


Horizontal Migration



Challenges Within an Urban Context

Marsh Drowning



Vernam Barbadoes,
Queens

Long Pond Park,
Staten Island

Freshwater Wetland

Current Conditions

Today, only about 1,100 acres of historical freshwater wetlands remain in New York City, approximately 1 percent of our historical wetlands.[45] Of the remaining freshwater wetlands, about 40 percent are protected by state regulations,[46] and nearly half are found within New York City's parks.[47] Freshwater wetlands include swamp shrublands and forests, marshes, and seasonal pools. Despite their small extent, freshwater wetlands have outsized benefits for biodiversity since there are many wildlife and plant species that are wetland dependent, such as birds and rare frogs, salamanders, or dragonflies. In addition, given adequate protection of surrounding habitat, freshwater wetlands protect surrounding residents from stormwater flooding. In our study of 18 freshwater wetlands across 300 acres, we found that our freshwater wetlands are surprisingly healthy; for example, in more than 85 percent of forested, partially forested, or scrub-shrub freshwater wetlands studied, more than 80 percent of the canopy is native.[48] Yet New York City's freshwater wetlands are highly threatened and at risk of loss and decline from development, invasive species, poor water quality from stormwater inputs, and loss of connection to water sources.[49]

TABLE 2

Freshwater Wetland Condition Index

Index representing the relative health of and threat to freshwater wetlands, created using data collected in a subset of NYC Parks' freshwater wetlands.

	Ecological Attribute	Measurable Indicator
Health	Native plant diversity	Higher percent cover of native species, higher proportion of wetland indicator species
Health	Habitat supportive of wildlife	Presence of rare amphibians, dragonflies, or damselflies; higher water quality
Health	Diversity in habitat structure	Highly variable topography
Health	Stable wetland dynamics	Less variability in the hydroperiod
Threat	Disturbance from stormwater runoff	Higher percent development in watershed
Threat	Invasive plant species	Higher cover of invasive species

Clove Lakes Park,
Staten Island

Lakes and Ponds

The 40 lakes and ponds across NYC Parks, totaling over 850 acres,[50] provide rare open space for animals and people. Most were constructed for water storage, flood control, or recreation. Many are found at sites of historical wetlands and streams and are outside of natural areas. Meadow Lake, in Flushing Meadows Corona Park in Queens, is the largest, at 95 acres. Meadow Lake is an historical salt marsh that became a coal ash dumping ground in the late 1800s and was then excavated to provide a major attraction for the 1939–40 World's Fair. Natural ponds (or kettle ponds), such as those formed by retreating glaciers, are found in Queens and Staten Island.

New York City's constructed lakes and ponds pose some management challenges due to their landscape context and characteristics. A 2015 NYC Parks study assessed characteristics and conditions of lakes and found that they are typically shallow, with partially armored shorelines that receive nutrient-laden stormwater runoff from surrounding development. Some are augmented with drinking water, which contains the nutrient phosphorus. During warmer times of the year, high levels of nutrients in these shallow lakes and ponds can lead to harmful algal blooms, which can contain toxic cyanobacteria that make canoeing and fishing unsafe, and lead to oxygen deprivation for fish. With warming temperatures due to climate change, these harmful algal blooms will likely occur more often and persist for longer periods throughout the year.

Maintaining the health of these water bodies requires ongoing management—including reducing nutrient sources, expanding native shoreline vegetation, controlling invasive species (such as *Phragmites australis,* common reed), increasing habitat diversity, and controlling geese to reduce herbivory and nutrients from feces. Each lake is different, from its location and characteristics, to the source of its water and water chemistry. The variation in these factors and our inability to control them makes it challenging to manage these bodies of water. In order to better manage lakes and ponds, NYC Parks will continue to prioritize public education to promote safe enjoyment and stewardship.

LaTourette Park, Staten Island

Streams and Riparian Corridors

Current Conditions

Historically, nearly 250 miles of freshwater streams flowed through the five boroughs of New York City (Figure 6).[51] Most of these streams have been filled or buried in pipes. A study of the 60 miles of streams in NYC Parks found that only about 40 miles of the historical streams exist today, with the balance being newly constructed or formed by stormwater erosion.[52] Virtually all of these remaining streams have been modified in some way, either directly or through changes in the watershed. In addition to these streams, dozens of miles of new channels to convey stormwater have been constructed or eroded into the landscape, directing untreated stormwater into parks and downstream water bodies. The origin and fate of streams in NYC Parks can be hard to trace, as the water flow often emerges through pipes and disappears into culverts under roads and private property.

The condition of New York City's streams varies, but healthier streams are generally found in the least developed watersheds. Healthy streams are bordered by predominantly native vegetation, creating valuable habitat and providing shade and protective value for the stream itself. Streams are home to a diverse assemblage of invertebrates, such as stoneflies and mayflies, and fish, including minnows, darters, and river herring.

In New York City, these healthy conditions are rare and difficult to attain. Streams that are in poor condition have been impacted by extensive modifications in the channel and watershed. In their current diminished state, these streams are highly unlikely to provide habitat for local or diverse fauna typical of healthy streams.

Small ephemeral streams receive no regulatory protection. About 17 miles of streams in NYC Parks are headwater streams, where the stream network begins, water and nutrients accumulate, and amphibians find refuge. NYC Parks' streams are unlikely to be filled, but there are an additional 14 miles of streams (including headwaters) on private property. They can be filled and re-routed without permits or penalties.

The most impacted streams are difficult to restore due to the degree to which they have been fragmented, straightened, dammed, and armored. Ongoing impacts from the surrounding urbanized watershed are difficult to mitigate. These impacts include loss of floodplains and riparian habitat and development in the watershed, which removes vegetation and soil cover and alters the hydrology, leading to frequent and high stormwater flows that cause erosion, sedimentation, and increased delivery of contaminated runoff into our streams.

TABLE 3

Stream Condition Index

Index representing stream wetland health and threat, created using data collected across streams in NYC Parks.

	Ecological Attribute	Measurable Indicator
Health	Well vegetated riparian area	Higher vegetation cover in area adjacent to stream
Health	Diversity in habitat structure	More canopy cover over stream
Health	Absence of invasive species on stream bank	Lower invasive plant cover
Health	Connection to floodplain	Lower degree of entrenchment
Health	Water quality	Presence of pollution intolerant species
Threat	Disturbance from stormwater runoff	Higher percent development in watershed
Threat	Potential pollution from stormwater runoff	Higher number of outfalls

FIGURE 13

Stream Health and Threat

Examples of representative streams in each health and threat category across New York City. Each stream reach received a relative health and threat score based on the metrics evaluated at the field and landscape level. The position of the stream reach across the range of health and threat scores corresponds to the recommended management actions.

Rattlesnake Creek, Seton Falls Park, The Bronx

High Health / Low Threat

- Dominated by native plants and pollutant intolerant wildlife
- Priority for protection and long-term monitoring

Deadmans Creek, Blood Root Valley, Staten Island

High Health / High Threat

- Moderate native plant and wildlife habitat
- Requires stormwater management to improve water quality and stress from erosion

Horseshoe Spring Brook, Silver Lake Park, Staten Island

Low Health / Low Threat

- Higher invasive plant cover and poor native plant structure
- Priority for managing surrounding riparian vegetation

Willowbrook, Willowbrook Park, Staten Island

Low Health / High Threat

- High erosion and sedimentation rates
- Requires significant reconstruction to improve function

Enhanced Green Streets in Queens

Restoring Watershed Hydrology Through Green Infrastructure

In natural, undeveloped watersheds, most precipitation is intercepted and absorbed by vegetation and soil. In urban environments, where there is relatively little vegetation and soil, most rainfall becomes stormwater runoff that flows across streets and other impervious surfaces, carrying sediment and pollutants into the sewer system and downstream waters. Grime from the street including oil, metals, and trash is piped into wetlands and streams contaminating those habitats. The increased frequency and volume of this stormwater also cause erosion and result in persistent stress on these aquatic systems.

One approach to mitigating this stress in urban watersheds is to reduce the generation of runoff at its source on hard surfaces by increasing opportunities for plants to intercept rain, and for runoff to be trapped and infiltrated through soil. This can be accomplished using green infrastructure (GI)—a stormwater management approach that uses constructed soil and vegetative systems, such as rain gardens, bioswales, and green roofs to detain and retain stormwater and thus help restore more natural hydrologic processes.

The design, construction, and maintenance of these systems can be costly in densely developed cities, with highly variable neighborhoods and land uses, but GI provides co-benefits such as greener streets, neighborhoods, and parks.

GI is being used as a strategy to help reduce the volume of runoff to combined sewer systems in New York City, and thus help reduce the frequency of combined stormwater and sewer discharge to the harbor.[53] However, more GI is needed in our Municipal Separate Storm Sewer System areas as well as unsewered areas in order to protect our streams and wetlands. The areas outside combined sewer watersheds cover over half the area where New York City's remaining streams are found. To protect these aquatic resources, City agencies need to incorporate GI into road and sewer infrastructure upgrades and new development to retain stormwater in the landscape. GI can also be retrofitted at sites to reduce the runoff from existing impervious areas. On Staten Island, for example, we have identified dozens of acres of impervious surface where bioswales and rain gardens could reduce runoff that discharges into New York City's healthiest streams.

Wetland and Stream Restoration Approaches

From decades of experience, we know that restoring the health of wetlands in a dense urban city like New York City is possible, despite the challenges of high costs and ongoing stressors. The least disturbed wetlands are usually used as a reference, or guide, to establish restoration goals. The major causes of degradation inform the restoration actions.

Over the last 30 years, NYC Parks has implemented dozens of wetland restoration projects, totaling nearly 130 acres, and has worked with partners to implement dozens more. NYC Parks improved some of the most degraded sites while responding to local concerns, funding opportunities (e.g., the NYS Clean Air Clean Water Bond Act), and operational imperatives, including flooding (e.g., Strack Pond restoration in Forest Park in Queens and the Cricket Pitch in Bronx Forest Park in the Bronx). NYC Parks restored many salt marshes by removing fill placed on historical wetlands and by partnering with the U.S. Army Corps of Engineers.

Here are examples of completed projects that illustrate some of the most common restoration approaches. Figure 14 provides a map of where these types of actions may be possible in the future.

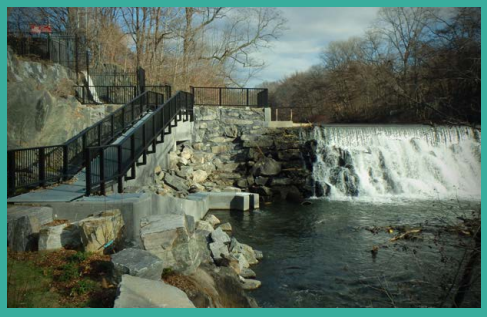
Place sediment on an existing marsh that is drowning due to sea-level rise and inadequate natural sediment deposition (Alley Creek, Alley Pond Park)

Reconstruct a wetland shoreline and expand the marsh waterward where it recently eroded (Bronx Kill, Randall's Island Park)

Remove fill placed on historical wetlands or ponds (former ballfield, Strack Pond, Forest Park)

Remove historical landfill on former salt marsh to re-establish tidal hydrology (Gerritsen Creek, Marine Park)

Increase connectivity by removing obstacles to fish migration or creating passageways (Bronx River, 182nd Street Dam Fish Ladder, River Park)



Stabilize eroding stream banks using rock or wood to enhance or restore stream function (Bronx River, Bronx Park)

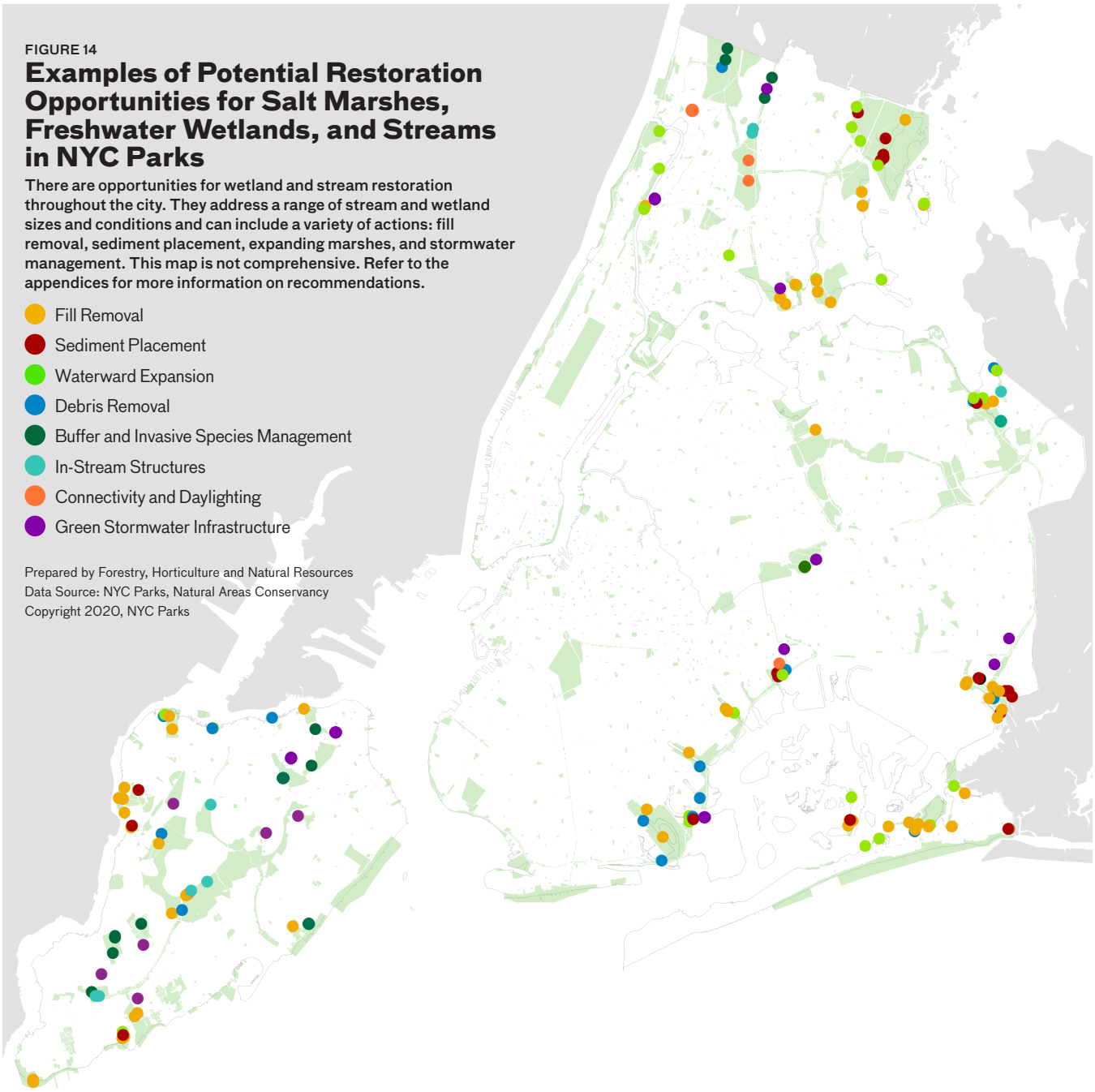
Remove marine debris smothering marsh vegetation (Rodman's Neck, Pelham Bay Park)

Manage invasive species in and surrounding wetlands, where appropriate, to improve habitat structure (Indian Lake, Crotona Park)

FIGURE 14

Examples of Potential Restoration Opportunities for Salt Marshes, Freshwater Wetlands, and Streams in NYC Parks

There are opportunities for wetland and stream restoration throughout the city. They address a range of stream and wetland sizes and conditions and can include a variety of actions: fill removal, sediment placement, expanding marshes, and stormwater management. This map is not comprehensive. Refer to the appendices for more information on recommendations.



Prepared by Forestry, Horticulture and Natural Resources
Data Source: NYC Parks, Natural Areas Conservancy

Recommendations

The ecological assessments of salt marshes, freshwater wetlands, and streams provide a basis for restoration, management, and protection recommendations. The recommendations are informed by 30 years of lessons learned, an acknowledgment that these systems are interconnected, new data, and knowledge about the risks from climate change and ongoing land development. The recommendations do not represent a wholesale change in approach, but rather a renewed effort in light of threats from climate change, with some new elements: a focus on **protecting healthy wetlands**, not just restoring the most damaged places; an emphasis on the **connections between streams and wetland resources** within watersheds; and recognition that success depends on **extending work beyond the water** to include buffers and stormwater management within the built landscape.

Action on the Ground

Our management recommendations consider the various causes of degradation, including historical fill, soil disturbance and invasive plant species in the adjacent areas, and outfalls or diffuse sources of untreated stormwater. Table 4 estimates the extent and cost of these actions, based on specific restoration opportunities.

Restoration

- Remove fill within historical salt marshes, freshwater wetlands, streambanks, and floodplains
- Reconstruct eroded marsh edges
- Add sediment to vulnerable existing marshes
- Remove marine debris
- Rehabilitate or reconstruct degraded stream reaches
- Increase connectivity between stream reaches by:
  - removing obstacles to fish and wildlife movement
  - "daylighting" streams
  - appropriately resizing pipes and culverts

Management

- Remove invasive species and establish structurally diverse native vegetation adjacent to freshwater wetlands, salt marshes, and streams, and within riparian forests
- Improve management practices upstream (e.g., minimize use of fertilizer and salt)

Protection

- Follow *NYC Parks Flood Zone Guidelines* to ensure parkland is adaptable to climate change and development is compatible with future flooded areas, including water access and marsh migration
- Complete wetland mapping in NYC Parks
- Continue to investigate and remove illicit stream discharges and sources of floatable debris
- Install stormwater green infrastructure throughout the watershed

Property Acquisition and Transfer

Land acquisition for conservation is a critical strategy for protecting wetlands, particularly for small wetlands and seasonal streams. In 2007, a Wetlands Transfer Task Force of public and private agencies reviewed hundreds of parcels with wetlands and water on public property for transfer to NYC Parks and NYC Department of Environmental Protection. Including those remaining parcels, as well as new parcels that were identified as priorities for marsh migration, approximately 93 acres of publicly-owned property are recommended for transfer to NYC Parks jurisdiction.[54] Another 50 acres under private ownership are adjacent to NYC Parks' salt marshes that could be acquired and managed as wetlands and buffers. Funding is needed to acquire these priority private parcels, and additional funding may be needed to restore and manage some of these properties once they have been acquired. In addition, acquiring parcels that are not adjacent to Parks' properties through buy-outs or similar programs could accommodate marsh migration in future flooded areas. Specific actions include:

- Identify priority sites (e.g., those with willing sellers) and seek funding for acquisition of low-lying land likely to become salt marsh, as well as acquisition of priority freshwater wetlands
- Streamline the process for acquisition of properties in flooded land
- Transfer City property with future flooded land likely to become salt marsh, and with priority freshwater wetlands, to NYC Parks, making transfer decisions based on conservation value
- Consider the role of private land conservation organizations in acquisition

Implementing the Wetlands Management Framework: What Do We Need?

Drawing on our evaluation of current site conditions, sea-level rise predictions, and our decades of restoration experience, we project that hundreds of millions of dollars are needed over the next 30 years to restore, manage, and protect New York City's wetlands and streams. Capital funding, most of which will likely come from mitigation requirements and from the federal and state governments, represents about two thirds of the needs identified in this framework. The remaining third will underwrite staff to support small-scale restoration initiatives, manage volunteers, monitor progress, and implement adaptive management. While City, State, and Federal agencies invested approximately $200 million to restore wetlands and streams over the last 20 years, this funding has been episodic, unreliable, and inadequate for the needs we demonstrate here.

Capital Funding

What characterizes capitally funded wetland restorations? A capital project creates or extends the life of any element of infrastructure. Among other criteria, the project must cost over $50,000 and provide or enhance an asset that endures for more than five years.[55] The capitally-funded restoration projects that we have identified require heavy machinery, earth moving, and other major construction activities. They include daylighting streams, creation of living shorelines, substantial fill removal and grade alterations, connecting streams to floodplains, and the installation of in-stream structures.

In New York City's dense urban environment, the typical cost for wetland restoration at highly degraded sites is between $1.5 million to $2 million per acre. Stream restoration costs vary widely, but measures such as in-stream habitat structures and upslope green infrastructure to control stormwater can vary greatly from tens to hundreds of thousands of dollars per installation. With over 300 acres of wetland and stream restoration opportunities in NYC Parks alone, conducting this restoration work over the next 30 years would require a significant capital investment, much of which can be provided by required mitigation associated with waterfront projects, as well as by funding designated for ecological restoration and clean water. Table 4 provides an estimate of potential costs associated with proposed restoration actions. By prioritizing and implementing projects in specific target areas, restoration will be more effective and efficient. Priority projects proposed for the first 10 years are listed in Table 5.

Agency Staff

Planning, managing, and implementing the restoration and protection strategies outlined in this framework requires a staff of technical experts and project managers from a variety of fields, including ecologists, hydrologists, environmental engineers, landscape architects, contract managers, field crews, and outreach and engagement staff (Table 6). Under this plan, we will create dozens of new green jobs.

Monitoring

For ecological restoration and management, monitoring plays an essential role in determining whether our management strategies are achieving their intended outcomes. Regulatory permits typically require three to five years of annual vegetation monitoring to evaluate project success. More intensive and long-term monitoring with academic and other research partners is needed to evaluate the response of wetland function to specific stressors, such as climate change, or to management interventions, such as re-introducing a native plant or animal species. Monitoring is essential for adaptive management, which is an iterative process of identifying problems, setting objectives, taking action, monitoring again, and adjusting management actions to be more effective based on analysis of the information collected.[56]

Management Crews

NYC Parks crews are needed now to manage and improve the condition of our wetlands and streams as well as to manage new parcels with wetlands that are transferred to the agency. In-house crews are effective where sites or projects are small in scale and require only small machinery or hand tools. Ongoing maintenance work includes removing debris and invasive species that are intermixed with native vegetation and stabilizing gullies or erosion problems along stream banks using specialized erosion control techniques. We estimate that over 100 acres of wetlands need management each year.

Volunteer Engagement

In addition to relying on in-house crews, engaging local volunteers and non-governmental partners is critical for long-term wetland protection and management. Community stewards and nonprofit educational partners are critical for implementing restoration, providing safe access, educating communities about the value of wetlands and streams, and expanding partnerships. Though NYC Parks staff is needed to ensure volunteer work is coordinated and effective, community engagement will increase the likelihood that our wetland resources will be advocated for and cared for in the long-term.

TABLE 4

Estimated Capital Costs for Wetland Restoration Across NYC Parks

Capital restoration costs differ based on the ecosystem and action needed to address the problem. As such, the cost of these actions and the extent of opportunities vary widely. Estimates are based on 2020 costs. The location of selected restoration opportunities can be found in Figure 14.

Ecosystem	Restoration Approach	Estimated Average Cost	Extent of Known Opportunities
Salt Marsh	Fill Removal	$2,200,000 / acre	86 acres
	Waterward Expansion	$2,000,000 / acre	75 acres
	Sediment Placement	$1,300,000 / acre	78 acres
	Invasive Species Management	$100,000 / acre	21 acres
	Debris Removal	$70,000 / acre	24 acres
Freshwater Wetlands	Fill Removal	$1,900,000 / acre	11 acres
	Invasive Species Management	$200,000 / acre	33 acres
Streams	Stream Enhancement	$100,000 / structure	10 structures
	Connectivity and Daylighting	$2,000-90,000 / linear foot	4 miles
	Reconstruction	$6,356,000 / mile	2 miles
	Green Stormwater Infrastructure	$162,000 / site	100 sites

TABLE 5

Priority Projects

This list represents a subset of potential restoration projects. Priorities align with existing or planned projects, feasibility, stakeholder support, mitigation needs, and restoration or conservation benefit. Cost estimates are approximate, based on past projects, and will be refined in design.

	Site: Restoration Approach	Acres	Cost Estimate
Priority 1	Bridge Park, BX: Fill Removal and Waterward Expansion	0.6	$2,200,000
	Four Sparrow Marsh, BK: Waterward Expansion and Sediment Placement	1.0	$1,000,000
	Snug Harbor—Harbor Brook, SI: Fill Removal	2.5	$4,000,000
	Idlewild, QN: Sediment Placement	4.3	$3,600,000
	Rice Fields—Pelham Bay Park, BX: Fill Removal	0.4	$700,000
	Soundview Lagoon South, BX: Fill Removal and Waterward Expansion	2.3	$4,800,000
Priority 2	Alley Pond Park, QN: Fill Removal	4.5	$9,700,000
	Brandt Point, QN: Fill Removal	2.6	$6,100,000
	Broad Channel, QN: Fill Removal	0.1	$130,000
	Bronx River, BX: Fish Passage	—	$14,000,000
	MARSHES Phase 2—Saw Mill Creek, SI: Fill Removal	5.0	$10,000,000
	Ramblersville—public lots, QN: Fill Removal	5.0	$4,800,000
Priority 3	Alley Pond Park, QN: Waterward Expansion and Sediment Placement	6.6	$12,300,000
	Clove Lakes Park, SI: Stormwater Management	—	$600,000
	Deadmans Creek—Blood Root Valley, SI: Stormwater Management	—	$200,000
	Fresh Creek Park, BK: Fill Removal and Waterward Expansion	4.0	$12,600,000
	Goose Pond—Broad Channel Wetlands, QN: Elevation Enhancement	3.6	$6,400,000
	Lemon Creek Park, SI: Elevation Enhancement	2.7	$3,600,000
	Tibbetts Brook, BX: Stream Daylighting *	—	$63,000,000

***** Led by NYCDEP

TABLE 6

Estimated Staffing Needs to Implement the *Wetlands Management Framework*

Current positions as of November 2020. Additional positions are needed to implement this plan.

Team / Area of Focus	Staff	Current Staff	Additional Needed	Total Needed
Program Supervision	**Senior Program Manager**	1	0	1
	Program Coordinator	0	1	1
Design and Construction Supervision for Contractor Restoration	**Senior Design Manager**	1	0	1
	Landscape Architect	0	2	2
	Engineer	0	1	1
	Construction Manager	0	3	3
Contract Administration	**Project Administrator**	0	1	1
Project Assessment, Monitoring, and Management	**Permitting Coordinator**	0	2	2
	Senior Ecologist / Project Manager	4	2	6
	Field Technician	0	4	4
	Hydrologist / Project Manager	1	1	2
In-House Restoration and Adaptive Management	**Supervisor for Wetland Field Operations**	0	1	1
	Crew Leader	0	4	4
	Crew Member	0	12	12
Volunteer Engagement	**Outreach Coordinator**	0	1	1
	Stewardship Crew Leader	0	1	1
	Stewardship Field Crew	0	4	4
	TOTAL	**7**	**40**	**47**

Access, Engagement, and Stewardship

The public needs to experience and interact with wetlands and streams in order to value them. Furthermore, active engagement with wetlands and streams enhances the health and well-being benefits that people derive from these ecosystems. NYC Parks and its partners provide these opportunities for engagement in numerous ways. Outreach and environmental groups engage schoolchildren and adults through outdoor recreation, environmental education, and interpretation. Hundreds of stewardship groups across the City[57] care for wetlands and streams through shoreline cleanups, plantings, and invasive plant removal. Stewardship and outreach programming by NYC Parks and its partners activates wetland ecosystems[58] and develops long-term advocates for wetland protection.

Stewardship and outreach groups also play an important role in facilitating and promoting safe and appropriate access to wetlands and streams. Direct, unlimited public access is not always best, given unstable surfaces and changing water levels, as well as the risk of erosion, siltation, and disturbance from too much human activity. Parks with wetlands, like Marine Park in Brooklyn, often feature a range of access to different areas (Figure 15). Direct access to the water is encouraged where visitors are unlikely to damage habitat or encounter hazards. Visual access via a bridge or lookout point is most appropriate for the casual visitor.

In other locations, given safety and sensitive species concerns, limiting public access to guided tours is best. At Marine Park, the Urban Park Rangers facilitate this kind of access, for example using canoes on guided tours. White Island, in the middle of Marine Park, was restored to provide habitat for declining grassland birds such as grasshopper sparrows, short-eared owls, and bobolinks, and thus public access has been restricted. Stewardship and outreach groups help to guide the public to areas where their presence will not be destructive or dangerous and enrich that experience through education, restoration activities, and community building.

The range of activities at any given site serves to meet community needs, cultivate long-term stewards, and build partnerships with the thousands of existing waterfront stewardship groups. Public access and engagement in wetlands can also attract residents and visitors from across the city to experience and interact with New York City's nature firsthand. NYC Parks and its partners lead nature walks, kayak or canoe paddles, community science efforts, trash clean-ups, invasive plant removal projects, fence repairs, and planting events. Engaging, educating, and empowering the public to enjoy wetlands and streams—as well as to participate in their maintenance and restoration—are central to a more sustainable future and environment for all New Yorkers.

Overlook in Marine Park, Brooklyn

Planting in Alley Pond Park, Queens

FIGURE 15

Wetland Access Points at Marine Park, Brooklyn

Prepared by Forestry, Horticulture and Natural Resources
Data Source: NYC Parks, Natural Areas Conservancy

Conclusion

Investment in and focus on New York City's wetlands and streams have fluctuated over the past 35 years. Today, despite our understanding of the importance of wetlands to human health and to mitigating climate change, New York City loses dozens of acres of wetlands each year.

Now is a critical time to adopt a proactive approach to managing historically under-resourced wetlands. This framework celebrates the importance of our wetlands for their value to society and communities, while also recognizing them as essential to protecting and restoring biodiversity and buffering the impacts of climate change. In addition to guiding the work of the NAC and NYC Parks' Forestry, Horticulture, and Natural Resources division, the framework can guide the incorporation of wetlands and streams into a broad range of future planning. If we commit to activating the full breadth of the Wetlands Management Framework today, the next 30 years will bring more effective capital investments, more green job opportunities, more meaningful public engagement, and more resilient, healthy wetlands to our city.

Planting in Four Sparrow Marsh, Brooklyn

Appendices

APPENDIX A

Stream and Wetland Resources by Council District

Borough	Council District	Watershed	Wetland Area Acreage	Wetland Types	Parks
Bronx	11	Hudson-East River, Long Island Sound	87	F L S	Jerome Park, Van Cortlandt Park, Bronx River Parkway, Bronx Park
	12	Long Island Sound	285	F L S C	Bronx River Parkway, Seton Falls Park, Hutchinson River Parkway, Pelham Bay Park
	13	Long Island Sound	277	F L S C	Hutchinson River Parkway, Pelham Bay Park, Ambrosini Field, Ferry Point Park, Locust Point Marina, Palmer Inlet
	15	Long Island Sound	36	F L S	Bronx Park, Bronx River Parkway, River Garden, West Farm Rapids
	16	Hudson-East River	—	C	Bridge Park
	17	Long Island Sound	4	L S C	Concrete Plant Park, Crotona Park, South Brother Island, Starlight Park
	18	Long Island Sound	12	S C	Bronx River Parkway, Pugsley Creek Park, Soundview Park, Harding Park Beautification Project
Brooklyn	32	Jamaica Bay	16	F L C	Spring Creek Park, Belt Parkway/Shore Parkway
	35	Jamaica Bay	1	L	Brooklyn Botanic Garden
	39	Jamaica Bay	48	L	Prospect Park
	42	Jamaica Bay	24	F L S C	Spring Creek Park, Fresh Creek Nature Preserve, Belt Parkway/Shore Parkway
	43	Jamaica Bay	16	F L C	Bensonhurst Park, Dyker Beach Park, Belt Parkway/Shore Parkway
	46	Jamaica Bay	76	F L S C	Four Sparrow Marsh, McGuire Fields, Paerdegat Basin Park, Marine Park, Belt Parkway/Shore Parkway
	47	Raritan Bay-Lower Bay, Jamaica Bay	156	F L C	Coney Island Creek Park, Kaiser Park, Coney Island Beach and Boardwalk, Belt Parkway/Shore Parkway
	48	Raritan Bay-Lower Bay, Jamaica Bay	179	F L S C	Holocaust Memorial Park, Manhattan Beach Park, Belt Parkway/Shore Parkway, Marine Park, Coney Island Beach and Boardwalk
Manhattan	6	Hudson-East River	136	L S	Central Park
	10	Hudson-East River	19	C	Inwood Hill Park, Sherman Creek

F Freshwater L Lake S Stream C Coastal

Borough	Council District	Watershed	Wetland Area Acreage	Wetland Types	Parks
Queens	19	Long Island Sound	341	F L S C	Bowne Park, Clearview Park Golf Course, College Point Fields, Crocheron Park, Fort Totten Park, Francis Lewis Park, Little Bay Park, Powell's Cove Park, Udall's Park Preserve, Flushing Meadows Corona Park, Grand Central Parkway Extension, Alley Pond Park, Cross Island Parkway
	20	Long Island Sound	187	F L S C	Kissena Corridor Park, Kissena Park, Flushing Meadows Corona Park
	21	Long Island Sound	176	F L S C	Flushing Meadows Corona Park, Grand Central Parkway Extension
	22	Long Island Sound	1	F C	Grand Central Parkway Extension
	23	Long Island Sound	147	F L S C	Cunningham Park, Douglaston Park Golf Course, Grand Central Parkway, Alley Pond Park, Cross Island Parkway
	24	Long Island Sound	177	F L S C	Captain Tilly Park, Flushing Meadows Corona Park, Grand Central Parkway Extension
	27	Jamaica Bay, Long Island Sound	32	F L S C	Roy Wilkins Recreation Center, St. Albans Park, Laurelton Parkway, Cross Island Parkway
	28	Jamaica Bay	30	F L S	Baisley Pond Park, Belt Parkway
	29	Jamaica Bay, Long Island Sound	3	F L C	Forest Park, Grand Central Parkway Extension
	30	Jamaica Bay	22	F L	Highland Park, Forest Park
	31	Atlantic Ocean, Jamaica Bay	400	F L S C	Beach 17 Playground, Beach 9 Playground, Brant Point Wildlife Sanctuary, Brookville Park, Dubos Point Wildlife Sanctuary, Hook Creek Park, Idlewild Park, Jamaica Bay Park, Mentone Playground, Rockaway Beach and Boardwalk, Rockaway Community Park, Seagirt Ave Wetlands, Springfield Park, Vernam Barbadoes Peninsula, Laurelton Parkway, Belt Parkway
	32	Atlantic Ocean, Jamaica Bay	199	F L C	Bay Breeze Park, Broad Channel American Park, Broad Channel Neighborhood Wetlands, Broad Channel Wetlands, Gemini Fields, Rockaway Beach, Rockaway Beach Boardwalk, Spring Creek Park Addition, Belt Parkway
	37	Jamaica Bay	2	F L	Forest Park

F Freshwater L Lake S Stream C Coastal

Stream and Wetland Resources by Council District (cont.)

Borough	Council District	Watershed	Wetland Area Acreage	Wetland Types	Parks
Staten Island	49	Arthur Kill-Upper Bay, Kill Van Kull, Arthur Kill, Raritan Bay-Lower Bay	182	F L S C	Alice Austen Park, Allison Pond Park, Arlington Marsh Park, Clove Lakes Park, Eibs Pond Park, Forest Grove, Goodhue Park, Graniteville Swamp Park, Heritage Park, Mariners Marsh Park, Richmond Terrace Park, Shooters Island, Silver Lake Park, Snug Harbor Cultural Center, Willowbrook Parkway
	50	Arthur Kill, Raritan Bay-Lower Bay, Arthur Kill-Upper Bay	1,077	F L S C	Blood Root Valley, Bradys Pond Park, Father Macris Park, Franklin D. Roosevelt Boardwalk and Beach, Greenbelt Native Plant Center, High Rock Park, Last Chance Pond Park, Meredith Woods, Midland Field, Ocean Breeze Park, Old Place Creek Park, Pralls Island, Reed's Basket Willow Swamp Park, Saw Mill Creek Marsh, South Beach Wetlands, Staten Island Industrial Park, Von Briesen Park, Willowbrook Park, Freshkills Park, Great Kills Park, LaTourette Park and Golf Course, Richmond Parkway, Willowbrook Parkway
	51	Arthur Kill-Upper Bay, Raritan Bay-Lower Bay, Arthur Kill, Arthur Kill / Raritan Bay-Lower Bay	864	F L S C	Aesop Park, Arden Woods, Bayview Terrace Park, Bloomingdale Park, Blue Heron Park, Brookfield Park, Bunker Ponds Park, Conference House Park, Crescent Beach Park, Fairview Park, Huguenot Ponds Park, Hybrid Oak Woods Park, Isle Of Meadows, King Fisher Park, Kingdom Pond Park, Lemon Creek Park, Long Pond Park, Siedenburg Park, South Shore Country Club, Tottenville Pool, Wolfe's Pond Park, Freshkills Park, Great Kills Park, LaTourette Park and Golf Course, Meredith Woods, Richmond Parkway, Willowbrook Parkway

F Freshwater L Lake S Stream C Coastal

Salt marsh restoration at Soundview Park, The Bronx

APPENDIX B

NYC Parks with Wetlands

Park Name	City Council Districts
Aesop Park	51
Alice Austen Park	49
Alley Pond Park	19, 23
Allison Pond Park	49
Ambrosini Field	13
Arden Woods	51
Arlington Marsh Park	49
Baisley Pond Park	28
Bay Breeze Park	32
Bayview Terrace Park	51
Beach 17 Playground	31
Beach 9 Playground	31
Belt Parkway	28, 31, 32
Belt Parkway/Shore Parkway	32, 42, 43, 46, 47, 48
Bensonhurst Park	43
Blood Root Valley	50
Bloomingdale Park	51
Blue Heron Park	51
Bowne Park	19
Bradys Pond Park	50
Brant Point Wildlife Sanctuary	31
Bridge Park	16
Broad Channel American Park	32
Broad Channel Neighborhood Wetlands	32
Broad Channel Wetlands	32
Bronx Park	11, 15
Bronx River Parkway	11, 12, 15, 18
Brookfield Park	51
Brooklyn Botanic Garden	35
Brookville Park	31
Bunker Ponds Park	51
Captain Tilly Park	24
Central Park	6
Clearview Park Golf Course	19
Clove Lakes Park	49
College Point Fields	19
Concrete Plant Park	17
Coney Island Beach and Boardwalk	47, 48
Coney Island Creek Park	47
Conference House Park	51
Crescent Beach Park	51
Crocheron Park	19
Cross Island Parkway	19, 23, 27
Crotona Park	17
Cunningham Park	23
Douglaston Park Golf Course	23
Dubos Point Wildlife Sanctuary	31
Dyker Beach Park	43
Eibs Pond Park	49
Fairview Park	51
Father Macris Park	50
Ferry Point Park	13
Flushing Meadows Corona Park	19, 20, 21, 24
Forest Grove	49
Forest Park	29, 30, 37
Fort Totten Park	19
Four Sparrow Marsh	46
Francis Lewis Park	19
Franklin D. Roosevelt Boardwalk and Beach	50

Park Name	City Council Districts
Fresh Creek Nature Preserve	42, 46
Freshkills Park	50, 51
Gemini Fields	32
Goodhue Park	49
Grand Central Parkway	23, 24, 29
Grand Central Parkway Extension	19, 21, 22, 24, 29
Graniteville Swamp Park	49
Great Kills Park	50,51
Greenbelt Native Plant Center	50
Harding Park Beautification Project	18
Heritage Park	49
High Rock Park	50
Highland Park	30
Holocaust Memorial Park	48
Hook Creek Park	31
Huguenot Ponds Park	51
Hutchinson River Parkway	12, 13
Hybrid Oak Woods Park	51
Idlewild Park	31
Inwood Hill Park	10
Isle Of Meadows	51
Jamaica Bay Park	31
Jerome Park	11
Kaiser Park	47
King Fisher Park	51
Kingdom Pond Park	51
Kissena Corridor Park	20
Kissena Park	20
Last Chance Pond Park	50
LaTourette Park and Golf Course	50, 51
Laurelton Parkway	27, 31
Lemon Creek Park	51
Little Bay Park	19
Locust Point Marina	13
Long Pond Park	51
Manhattan Beach Park	48
Marine Park	46, 48
Mariners Marsh Park	49
McGuire Fields	46
Mentone Playground	31
Meredith Woods	50, 51
Midland Field	50
Ocean Breeze Park	50
Old Place Creek Park	50
Paerdegat Basin Park	46
Palmer Inlet	13
Pelham Bay Park	12, 13
Powell's Cove Park	19
Pralls Island	50
Prospect Park	39
Pugsley Creek Park	18
Reed's Basket Willow Swamp Park	50
Richmond Parkway	50, 51
Richmond Terrace Park	49
River Garden	15
Rockaway Beach	32
Rockaway Beach and Boardwalk	31
Rockaway Beach Boardwalk	32
Rockaway Community Park	31

Park Name	City Council Districts
Roy Wilkins Recreation Center	27
Saw Mill Creek Marsh	50
Seagirt Ave Wetlands	31
Seton Falls Park	12
Sherman Creek	10
Shooters Island	49
Siedenburg Park	51
Silver Lake Park	49
Snug Harbor Cultural Center	49
Soundview Park	18
South Beach Wetlands	50
South Brother Island	17
South Shore Country Club	51
Spring Creek Park	32, 42
Spring Creek Park Addition	32
Springfield Park	31
St. Albans Park	27
Starlight Park	17
Staten Island Industrial Park	50
Tottenville Pool	51
Udall's Park Preserve	19
Van Cortlandt Park	11
Vernam Barbadoes Peninsula	31
Von Briesen Park	50
West Farms Rapids	15
Willowbrook Park	50
Willowbrook Parkway	49, 50, 51
Wolfe's Pond Park	51

Sunset at Calvert Vaux Park,
Coney Island Creek, Brooklyn

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Glossary

Adaptive Management
An iterative process of identifying problems, setting objectives, taking action, conducting monitoring, and adjusting management actions to be more effective based on analysis of the information collected.

Bioswale
A depression designed to receive stormwater runoff from a hard surface like a parking lot or street incorporating vegetation, (such as grasses, herbs, and shrubs) soil, and organic matter (such as mulch) to capture, detain, filter, and infiltrate water.

Buffer or Adjacent Area
Areas that surround focal habitats. All habitats are affected by land use outside their boundaries. Because water flows across different lands before entering wetland habitats, regulations often protect the buffer or adjacent areas surrounding protected wetland habitats.

Combined Sewer Overflow
Older sections of the New York City sewer system, across about 60% of the city, deliver stormwater and sewage combined in a single pipe to wastewater treatment plants. During heavy rains, this system can be overloaded by stormwater, and as a result, a mixture of stormwater and sewage is directly released into the City's waterways in events called combined sewer overflows. These events degrade water quality and negatively impact aquatic habitat.

Daylighting
Fully or partially exposing the flow of a buried river, stream, or storm water drainage; typically involves reconstructing waterways that have been buried in culverts, pipes, and other infrastructure.

Degraded
Reduced in quality, for example loss of ecosystem structure, composition, or function, as a result of chronic human impact.

Dredging
Digging or excavation of sediment within a channel or wetland (removal, stockpiling, or reuse of sediment typically follow).

Estuary
A coastal brackish water ecosystem where saltwater from the ocean meets freshwater from rivers and streams. Salt marshes and connected freshwater streams are component parts of estuaries.

Freshwater Pond
A small body of standing water formed naturally, or constructed, with less than 30 percent vegetation cover.

Freshwater Wetlands
An area exhibiting standing water or saturated soil permanently or seasonally, encompassing a wide range of habitats and vegetation types, including open water, herbaceous plants, shrubs, and trees.

Filling
The destruction of wetlands (including freshwater wetlands, salt marshes, streams, and ponds) by dumping large scale debris (often originating from construction) to raise the elevation and create solid land.

Hardened Shoreline
Where natural habitats at water's edge have been replaced by engineered structures, such as bulkheads, to prevent erosion and/or to provide flood protection.

Headwater Stream
Headwater streams are the smallest streams and wetlands in a stream network at the highest end of a watershed. They often don't appear on maps, are dry much of the year, and may not have a pronounced channel shape. Most are fed by rainwater, but some are fed by groundwater or springs.

Impervious Area
A solid, impenetrable surface (such as asphalt or concrete) that inhibits the natural infiltration of stormwater into the ground.

Invasive Species
A nonnative species whose introduction causes environmental harm.

Lake
Bodies of water, larger than ponds (typically over 20 acres), that are natural or constructed, such as reservoirs or impoundments along a dammed river. They vary in depth and support emergent vegetation predominantly along their shoreline.

LiDAR
LiDAR (Light Detection and Ranging) is a surveying technology that measures distance by illuminating a target with a laser light.

Marsh Migration
The potential for salt marsh habitat to change location (both inland and to higher elevation) over time in response to large-scale processes such as sea-level rise and sediment build-up.

Mitigation Bank
A wetland that has been restored, enhanced, or re-established for the purpose of offsetting unavoidable negative impacts on aquatic ecosystems as permitted by state and federal regulations.

Municipal Separate Storm Sewer System (MS4)
In separate sewer areas (separate stormwater and sewer infrastructure systems) within New York City, as stormwater flows over impervious surfaces and transports pollutants like oils, chemicals, sediments, and pathogens, it is conveyed directly into surrounding waterways via streets, curbs, ditches, catch basins, gutters, and storm drains. MS4 discharge impacts on New York City's stream and freshwater wetland systems include poor water quality and sedimentation.

National Wetlands Inventory (NWI)
The NWI, established by the U.S. Fish and Wildlife Service, has been producing wetland maps and geospatial wetland data since 1974. The NWI focuses on: 1) map or digital database preparation and delivery to the public, and 2) projecting and reporting on national wetland trends using a probability-based sampling design.

Navigable Waters of the United States
Those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. These waters, and their connecting wetlands, are regulated by the federal government.

Outfalls
The discharge point or outlet of a stream or other flowing water into a body of water. This includes pipes, swales, ditches, etc., in accordance with the MS4 mapping protocol.

Remotely Sensed Data
Data obtained about objects or areas from a distance, typically from aircrafts or satellites.

Riparian
Located on or along the stream bank.

Salt Marsh
A type of vegetated tidal wetland flooded and drained by salt water brought in by the tides.

Sea-Level Rise
With a warming climate, glaciers and other large ice bodies are melting, and seawater is expanding in volume, which is causing ocean surface levels to rise. Global mean sea-levels have risen about 8-9 inches since 1880. By 2050, sea-levels in NYC are projected to rise by 11–21 inches, with upper projections as high as 30 inches.

Stormwater
A product of rain and snow melt, which is transported over impervious surfaces such as rooftops, streets, and sidewalks. Stormwater impacts on New York City stream and freshwater wetland systems include sedimentation, poor water quality, and erosion.

Tidal Wetlands
A variety of habitats and their adjacent areas that occur where the land meets the sea—including mudflats, salt marshes, and tidally influenced wetlands where streams or rivers drain into an estuary or bay. New York State law protects the area adjacent to these habitats, which is why many recreational beaches are categorized as tidal wetlands.

Urban Heat Island
An urban heat island is a metropolitan area that is significantly warmer than the surrounding landscape because concrete and other anthropogenic materials trap heat more than natural habitats. Urban heat island can lead to decreased air quality and increased heat-related health risks.

Watershed
A watershed is the entire surrounding land area from which water may flow into a watercourse.