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ACKNOWLEDGEMENTS

This plan was prepared by Brian DeGasperis and Betsy Blair of the Hudson River National Estuarine Research Reserve with support of staff from the New York State Department of Environmental Conservation and Ed McGowan of the New York State Office of Parks, Recreation, and Historic Preservation. We appreciate the input provided by local leaders, county officials, environmental organizations, researchers, educators, and marsh managers during the planning process, and we gratefully acknowledge all the members of the public whose unwavering interest in Piermont Marsh and active participation in scoping and fact-finding meetings significantly improved the content of this plan.

Suggested citation:

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EXECUTIVE SUMMARY

The Piermont Marsh Reserve is a unique and special place. It hugs the base of Tallman Mountain along the west shore of the Tappan Zee, one of the widest sections of the tidal Hudson River, and extends over 1.5 miles below Piermont Pier. The site’s 1,030 acres include the estuary’s largest brackish tidal marsh, a broad swath of adjacent shallows, and small areas of upland in the Village of Piermont. Given its proximity, the marsh provides a range of vital services to the Village, including protection of nearby homes and businesses from waves and storm debris. The marsh and shallow-water habitats are regionally rare, ecologically significant, and were historically home to a host of specially-adapted plants and animals. To the dismay of natural resource managers and long-time residents, Piermont Marsh has changed dramatically in recent decades and the diversity of habitats, plants, and animals it once supported is nearly gone. However, the seeds for restoration still remain and action is required to ensure that the diversity of life and services that make the marsh an extraordinary and special place are protected.

Marsh managers and community residents have a strong shared interest in protecting and managing the marsh so that it exists well into the future. Managing for marsh longevity will require a thoughtful, careful, and gradual management approach, with actions focused on building marsh resilience and the capacity to deal with unexpected change. If steps are taken now, key opportunities exist to ensure that the marsh remains resilient and able to provide the beneficial services needed to sustain and support the well-being of people in a rapidly changing world.

This plan will guide management of the Piermont Marsh Reserve for the next decade, including marsh management, habitat restoration, resource stewardship, public access, education programs, and research. It provides a foundation for increased educational programming, greater community participation in stewardship, and direction for collaboration among research partners. Although the plan’s horizon is ten years, it establishes a monitoring and adaptive management approach to support marsh resilience and conservation over the long term. Importantly, the plan provides for the protection of both natural and human communities, especially the vital services the marsh provides as a natural wave and debris barrier.

The Piermont Marsh Reserve Management Plan was developed with extensive input from the leaders and residents of the adjoining communities, county officials, environmental organizations, researchers, educators, and marsh managers. It was developed by staff from the New York State Department of Environmental Conservation (DEC) and the New York State Office of Parks, Recreation, and Historic Preservation/Palisades Interstate Park Commission (OPRHP/PIPC), the agencies with jurisdiction over the tidal wetlands and uplands that comprise the Piermont Marsh Reserve.
Planning Process and Goals

In April 2013, DEC issued a permit to the New York State Thruway Authority (NYSTA) for the construction of a new bridge over the Tappan Zee. The permit included a requirement for several habitat restoration projects to be completed as mitigation for unavoidable losses of habitat associated with bridge construction. Given its ecological significance and proximity to the bridge, Piermont Marsh was selected as the location for one of these projects. The project that was initially proposed focused on restoring native plant communities across the entire marsh by eradicating a non-native strain of *Phragmites australis*, a tall reed that has spread through the marsh over the last several decades. Village leaders and residents expressed a wide range of views, both for and against the project. Beginning in summer 2013, DEC and OPRHP staff met with ten different committees and organizations to listen to ideas and concerns about the initial marsh restoration project. Chief among the concerns were the loss of tall marsh vegetation as a storm buffer for the Village of Piermont, and the potential for health and ecological impacts of herbicides on nearby residents and the marsh. Staff listened closely to the public’s concerns, studied the issues carefully, and have responded with a dramatically different approach – one that is good for the environment, safe for the community, and responsive to public concerns.

The plan identifies management actions for achieving the following goals:

1. Maintain or enhance the Piermont Marsh Reserve’s ability to provide storm protection for neighboring landowners.
2. Sustain the presence of native marsh communities and the biological diversity they support.
3. Promote the structural and functional resiliency of the Piermont Marsh Reserve to storms, sea-level rise, and other disturbances.
4. Increase scientific knowledge, public understanding, and public use and enjoyment of the Piermont Marsh Reserve.

Key Elements of the Plan

Large Marsh Vegetation Buffers for Local Communities

Most of the existing tidal marsh community is dominated by *Phragmites australis*, also known as common reed, a tall non-native perennial grass with stout underground stems that enable it to spread and form dense colonies. The plan provides for retention of 85% (over 200 acres) of this existing marsh community as a vegetation buffer to dissipate wave energy and filter storm debris. This area extends about a half-mile south of the Village of Piermont and a comparable distance north of the hamlet of Palisades. This marsh buffer is retained as a conservative, precautionary measure, in the absence of empirical data about the nature of Piermont Marsh’s buffering capacity and tradeoffs of various kinds of marsh vegetation. A NOAA-funded collaborative research project is currently underway to specifically evaluate the marsh’s role in buffering adjacent communities.
Native Community Restoration

Historical Context

Until recent decades, Piermont Marsh was mainly a high salt marsh community dominated by saltmeadow cordgrass, also known as salt hay. Along the tidal creeks and at lower elevations, the marsh also supported a low salt marsh community comprised of saltmarsh cordgrass. These two community types sustained a host of fish, crabs, and other wildlife adapted to live in conditions that vary from wet to dry, and salt to fresh. Salt hay was also a vital resource for many residents, who harvested it from their family plots in the marsh. Today, this native community is all but gone from Piermont Marsh, and only found in small areas where Phragmites is less dense.

Restoration Strategy

This plan includes small-scale actions to sustain and restore native marsh communities and the fish and wildlife they support. A 10-acre site at the center of the marsh, more than one-half mile from neighboring residential areas, will be treated to reduce the abundance of Phragmites and facilitate the return of native plants. If this project is successful in restoring native communities and meeting other performance benchmarks, then two adjoining 15-acre units will be treated (successively) over the next ten years to restore native ecological communities. The total potential restoration is 40 acres, which represents 15% of the entire marsh. This is a very substantial reduction from the original 200 acres identified as a habitat mitigation project in the 2013 DEC permit for replacement of the Tappan Zee Bridge.

Restoration Methodology

Phragmites will be controlled with a combination of three techniques: 1) a limited ground-based application of a registered herbicide (an aquatic glyphosate formulation) and non-ionic surfactant (an additive that helps the herbicide coat and penetrate the leaf surface); 2) mowing prior to treatment and again the following winter, with cuttings left in place to serve as mulch until treated areas naturally revegetate within 1-3 years; and 3) solarization (covering with thick plastic) of the restoration area boundary that is not bordered by water to keep untreated plants from spreading into the treated area. The herbicide, applied at a dilute concentration, is absorbed and carried into underground plant parts, and disrupts a specific pathway for amino acid synthesis that is unique to plants and not present in animals.

This combination of methods was selected after considerable analysis of: 1) risks to human health, fish, or other aquatic animals; 2) effects on plant communities; and 3) impacts on water quality and erosion. A variety of alternative control methods were considered, and a summary of the alternatives analysis is included as Appendix A. While these alternative control methods have merit in some contexts, they are not practical or feasible as solitary treatments for managing Phragmites in these
environmental conditions and at this scale. When applied according to label instructions and applicable legal requirements using ground-based equipment, aquatic formulations of glyphosate are an approved and highly effective method (True, et al., 2010) for controlling Phragmites and the primary tool used by land managers in North America (Hazelton, et al., 2014). DEC and OPRHP/PIPC have experience using herbicides to successfully control Phragmites at various sites along the Hudson River, including Iona Island in Bear Mountain State Park.

**Herbicide Information**

During the scoping process for this plan, many people expressed public health concerns about the use of herbicide at Piermont Marsh at a large scale and near the Village of Piermont. Some people cited concerns about specific brands of herbicide that are terrestrial formulations of glyphosate (e.g., Roundup Pro®), which will not be used in Piermont Marsh since they are not registered for use in aquatic settings. Unlike the aquatic formulations, the terrestrial formulations often contain other chemical additives to increase their efficacy. These terrestrial formulations are used extensively in agriculture and residential and commercial landscaping.

Glyphosate is a non-selective, systemic herbicide that controls weeds by inhibiting a specific pathway for amino acid synthesis that is unique to plants and not present in animals. Since 1985, the U.S. Environmental Protection Agency (EPA) has conducted several in-depth evaluations of glyphosate to determine its potential risk to human and environmental health. Based on these evaluations, EPA determined that glyphosate exhibits low toxicity across species, durations, life stages, and routes of exposure. EPA is currently conducting a scheduled reevaluation to ensure that glyphosate continues to meet the statutory standard of no unreasonable adverse effect. In a press release dated December 18, 2017, the EPA announced that “…glyphosate is not likely to be carcinogenic to humans. The Agency’s assessment found no other meaningful risks to human health when the product is used according to the pesticide label. The Agency’s scientific findings are consistent with the conclusions of science reviews by a number of other countries as well as the 2017 National Institute of Health’s Agricultural Health Survey” (https://www.epa.gov/pesticides/epa-releases-draft-risk-assessments_glyphosate).

In addition to following all label requirements, appropriate measures will be taken to minimize the potential for any human exposure to glyphosate in four ways: 1) limiting the duration of use to one to three days per year; 2) applying it only under favorable weather conditions (e.g., calm with prevailing winds blowing away from residential areas); 3) using an appropriate spray height, angle, and droplet size; and 4) applying it at distances of more than one half mile from the Village of Piermont and hamlet of Palisades. Furthermore, DEC and OPRHP will establish an herbicide monitoring and data sharing program to document and evaluate any movement of herbicide beyond the designated treatment areas. The program will be developed in close consultation with local representatives, marsh managers, and pesticide regulators. The monitoring will evaluate herbicide levels prior to, during, and after treatment using best available
techniques. Information will be posted on a publicly accessible website as soon as analyses are completed.

Bird Nest Boxes and Platforms

For many bird species, the availability of nesting sites is a limiting factor. Where natural nesting sites are in short supply, artificial nest boxes and platforms can enhance wildlife habitat and increase bird densities and diversity. To that end, an osprey nesting platform and nest boxes for purple martins (*Progne subis*) and tree swallows (*Tachycineta bicolor*) will be erected at various locations within the Reserve. Nest boxes will be mapped and monitored to ensure their use by target species.

Piermont Marsh Resiliency Monitoring

The Hudson River National Estuarine Research Reserve (HRNERR) will implement monitoring protocols that will qualify Piermont Marsh as a national NERRS “Sentinel Site” for analyzing the impact of sea-level rise on tidal marsh habitat. Staff will install surface elevation tables (SETs) and use feldspar horizon markers to track changes in the elevation of the marsh surface over time. SET data combined with tidal datums and inundation patterns will show whether sediment accretion in Piermont Marsh is keeping pace with increasing rates of sea-level rise. Additional vegetation data will help us interpret whether climate change stressors are causing shifts in the plant communities. These protocols will be used in both managed and unmanaged sections of the marsh to test whether habitat restoration effects the marsh’s resilience to climate change. The sentinel site information will inform the current habitat restoration project and guide any future adaptive management to foster the marsh’s long-term persistence.

Public Access

DEC and OPRHP access experts will evaluate the site’s accessibility and compliance with the federal and state legislation (e.g., Americans with Disabilities Act) and assess opportunities to enhance access for everyone, including people with disabilities.

DEC and OPRHP recognize that opportunities for the public to experience the marsh interior are currently limited. We will explore a potential route for a public marsh boardwalk in consultation with the Village and interested residents. In addition, DEC and OPRHP will explore the costs and benefits of installing researcher access corridors in intensively studied areas of the marsh to reduce and minimize damage to the marsh surface. Any future construction will need to be consistent with tidal wetlands protection regulations, stewardship of the marsh, accessibility needs, and the agencies’ ability to provide maintenance.
Education and Interpretation

In 2016, HRNERR expanded education activities at Piermont Marsh and in the adjacent community. HRNERR staff will continue to consult with local organizations and individuals to explore education programs that will meet local needs and be sustainable. HRNERR, working with partners, will organize periodic presentations about current research occurring within the Reserve. DEC and OPRHP will update interpretive information about the marsh and explore ways to make this available online, on site, and through other avenues, including local partnerships.

Opportunities for Citizen Engagement in Stewardship

Citizen science programs, such as monitoring a new eel ladder at the Ferdon Pond dam, coastal clean-ups, and wildlife monitoring, will be fostered and expanded as resources permit.

Building our Knowledge for Future Management

DEC and OPRHP will advance research about the Piermont Marsh Reserve in several ways, including: 1) carrying out a ten-year research agenda; 2) fostering and tracking other scientific research; and 3) promoting collaborations and funding for research that addresses priority management information needs.

In response to strong community interest, HRNERR worked with a group of partners to develop a three-year collaborative research program to evaluate alternative marsh management scenarios and the coastal protection benefits the marsh provides. This work was funded by the NOAA NERRS Science Collaborative, and initiated in 2017. The team will develop predictive models of climate, coastal, and ecological processes. These will be used to evaluate how existing and hypothetical marsh management might affect the kinds and degree of storm protection afforded by the marsh for the Village of Piermont. Choices about marsh management scenarios and community resiliency planning products will be made in consultation with the Piermont Waterfront Resilience Commission, and information about the project will be shared with the community.
INTRODUCTION

PURPOSE AND SCOPE OF PLAN

This plan sets forth the long-term vision and goals for management of the Piermont Marsh Reserve (the Reserve), a large, ecologically significant tidal wetland complex and natural area on the west shore of the Hudson River’s Tappan Zee (Figure 1). The plan identifies objectives and preferred strategies for promoting climate resilience, restoring wetlands and native habitats, conducting research and monitoring, facilitating public access, offering education programs, and providing interpretative and scientific information over the next decade.

The plan also will guide the management direction, staff time, fiscal priorities, and resource protection activities of the responsible public agencies. It provides a foundation for increased educational programming about the marsh, greater community participation in stewardship of the marsh, and direction for collaboration among research partners. Although the plan’s horizon is ten years, it establishes a monitoring and adaptive management approach to support marsh resilience and conservation over the long term.

MANAGEMENT CONTEXT

Land Ownership

All the Reserve is in New York State ownership except for a small private inholding at the south end of the Reserve. State-owned lands are under the jurisdiction of three public agencies, as depicted in Figure 2. The portion of Piermont Marsh south of the Sparkill Creek and most of the shallows east of the marsh are within the boundaries of Tallman Mountain State Park, which is managed by the Palisades Interstate Park Commission (PIPC) in cooperation with the New York State Office of Parks, Recreation, and Historic Preservation (OPRHP). North of the Sparkill Creek, the remainder of the marsh, uplands east of Rittenberg Field, and a portion of the adjacent shallows extending to the end of Piermont Pier are managed by the New York State Department of Environmental Conservation (DEC). The remaining shallows are under the jurisdiction of the New York State Office of General Services (OGS).

Legal Restrictions on Land Use

The DEC land at Piermont Marsh was acquired using funds from the Environmental Quality Bond Act of 1972 for wetlands preservation. Chapter 659, Title 4, Section 265 (Restrictions on Alienation of Wetlands) states:
Figure 1. Piermont Marsh Reserve location map
Figure 2. Land ownership at Piermont Marsh Reserve
Any wetlands acquired or restored in part or in whole with state monies pursuant to this title shall not be sold, leased or otherwise disposed of or used for any purposes inconsistent with the character or value of such wetlands.

No structure shall be placed thereon except water level regulation works necessary to preserve, restore or maintain the biological productivity thereof.

PIPC lands shall not be sold for any purposes without the approval of both the New York and New Jersey legislatures. The Palisades Interstate Park Commission may grant easements, licenses, permits and other rights over any lands held by it in either state when, in the opinion of the Commission, they will not interfere with the use and enjoyment of the park by the public.

In addition, management activities at Piermont Marsh must be consistent with New York State laws and regulations.

Agency Missions

The mission of the OPRHP is to provide safe and enjoyable recreational and interpretive opportunities for all New York State residents and visitors and to be responsible stewards of our valuable natural, historic and cultural resources. As part of this mission, § 3.09(15) of the Parks, Recreation and Historic Preservation Law directs OPRHP to: “Enhance the natural resources by providing habitat for various wildlife species including endangered and threatened species of fauna through practices such as ecological restoration, wetland conservation, and the planting of trees, shrubs and herbaceous plants indigenous to the area which act as food and protective cover for fauna.”

DEC’s mission is to conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being. The mission of DEC’s Division of Marine Resources is to manage and maintain the state's living marine, estuarine and anadromous (species that migrate from salt water to spawn in fresh water) resources, and to protect and enhance the habitat upon which these resources depend to assure that diverse and self-sustaining populations of these resources are available for future generations.

This plan advances and is consistent with the agency missions described above.

Special Designations

Hudson River National Estuarine Research Reserve

In 1982, the National Oceanic and Atmospheric Agency (NOAA) designated the Hudson River National Estuarine Sanctuary, now known as the Hudson River National Estuarine Research Reserve (HRNERR). HRNERR includes four large and ecologically important
tidal wetlands on the Hudson River estuary (Figure 3). Piermont Marsh and the adjacent
shallows form the southernmost HRNERR site. DEC is the lead state agency for
HRNERR, in collaboration with other state agencies with jurisdiction over the lands
within the four HRNERR component sites and in partnership with NOAA. HRNERR is
operated under a NOAA-approved management plan (HRNERR, 2009). This Piermont
Marsh Reserve Management Plan is consistent with the 2009 HRNERR Management
Plan.

HRNERR is part of the National Estuarine Research Reserve System (Reserve
System), a network of protected areas representative of the various biogeographic
regions and estuarine types in the United States. Reserves are established for long-
term research, education and interpretation to promote informed management of the
nation’s estuaries and coastal habitats (15 C.F.R. Part 921.1(a)). The Reserve System
currently consists of 29 reserves in 24 states and territories, protecting over one-million
acres of estuarine lands and waters (Figure 4). The Reserve System is a partnership
program between the National Oceanic and Atmospheric Administration (NOAA) and
the coastal states. NOAA provides funding, national guidance and technical assistance.
The state partners (DEC and OPRHP) manage HRNERR sites on a routine basis
working collaboratively with local and regional partners.

Reserves respond to societal and ecological needs by providing a platform for research
and learning, applying research to management, and practicing coastal stewardship.
Each reserve in the national system serves as a place-based living laboratory and
classroom where program development, research techniques, and management
approaches can be piloted and applied to issues of local, regional, and national
significance. This Piermont Marsh Reserve Management Plan is consistent with
NOAA’s National Ocean Service priorities, which include conserving special coastal
places, supporting community climate resilience, and making observations and
monitoring change to inform stewardship and management. Activities at each reserve
are designed to fulfill the Reserve System’s goals as defined in the regulations (15
C.F.R. Part 921(b)).

**Piermont Marsh Significant Coastal Fish and Wildlife Habitat**

Piermont Marsh was designated a Significant Coastal Fish and Wildlife Habitat
(SCFWH) in 1987 by the New York State Department of State (DOS) in recognition of
its ecosystem rarity, the presence of vulnerable wildlife species, its regional significance
for human use, and an unusual concentration of fish and wildlife species in the area. It
was recognized to be irreplaceable. This designation brings an extra level of review to
management activities, which must be consistent with the maintenance and recovery of
habitat for native fish and wildlife species and the impact assessment considerations in
the SCFWH narrative (DOS, 2012).
Figure 3. Location of Hudson River National Estuarine Research Reserve component sites and the Norrie Point headquarters.
Local and Regional Plans


The Piermont Waterfront Resilience Task Force (Task Force) was convened by Mayor Chris Sanders in November 2013 to develop a shared vision for the Piermont waterfront and concrete steps to move Piermont toward its vision for greater resilience. The Task Force identified climate change challenges and risks, engaged in community visioning about the future of Piermont, learned about potential adaptation options, and developed solutions, all the time seeking to align immediate recovery actions with a longer-term perspective of how Piermont will adapt to rising seas and higher floods (Village of Piermont, 2014). The six-person Piermont Waterfront Resilience Commission was established in 2015 and charged with implementing the findings and recommendations of the Task Force.

The Task Force report included two recommendations for Piermont Marsh and one for Piermont Pier. This plan includes actions that will advance the following three recommendations:

- Evaluate ways to enhance the flood-buffering characteristics of Piermont Marsh and to protect the existing marsh area from degradation.
- Research the need for, and feasibility of, assisted marsh adaptation (e.g., through assisted accretion, engineering the outer edge for reduced erosion, etc.).
- Evaluate the benefits of the Pier’s current (and potential) uses and hydrologic impacts on Piermont Marsh (i.e., modifications to water flow in the Hudson, which likely support the marsh’s persistence). Compare these benefits to the cost of

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Figure 4. National Estuarine Research Reserve System map

- Local and Regional Plans
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- Evaluate ways to enhance the flood-buffering characteristics of Piermont Marsh and to protect the existing marsh area from degradation.
- Research the need for, and feasibility of, assisted marsh adaptation (e.g., through assisted accretion, engineering the outer edge for reduced erosion, etc.).
- Evaluate the benefits of the Pier’s current (and potential) uses and hydrologic impacts on Piermont Marsh (i.e., modifications to water flow in the Hudson, which likely support the marsh’s persistence). Compare these benefits to the cost of
maintaining the Pier’s elevation over the long run to make informed decisions about future public investments toward this asset.

The Task Force Report also included the following recommendation for the commercial core that relates to the marsh over the long term:

- Consider possibilities for long-term redevelopment of the commercial core, which can include allowing/facilitating marsh expansion in a north-south pattern through its center (between Piermont Avenue and Roundhouse Road), and with esplanades along business fronts on both sides, and bridges (walking and driving) to cross the marsh.

**Village of Piermont Local Waterfront Revitalization Program**

The most recent Village of Piermont Local Waterfront Revitalization Program (LWRP) was approved in 1992 and an update is in preparation to address community resilience. The northern part of the Piermont Marsh Reserve, primarily north of the Sparkill Creek, is within the Village’s boundary and identified as Area V in the 1992 LWRP, a conservation area. The LWRP includes the following fish and wildlife policies that apply to this area:

- Policy 7: Significant coastal fish and wildlife areas, as identified on the Coastal Area Map, shall be protected, preserved and, where practical, restored to maintain their viability as habitats.
- Policy 7A: Protect the Piermont Marsh south of the pier and the Sparkill Creek by severely restricting it to passive recreational uses.

**Piermont Critical Environmental Area**

In 1985, the village board designated three critical environmental areas (CEAs). CEAs are designated by a local or state agency under subdivision 6 NYCRR 617.14(g) to recognize a specific geographical area. One of the Piermont CEAs includes the portion of the marsh north of Sparkill Creek and a portion of the Sparkill Creek corridor. This area was recognized for being an exceptional or unique natural setting.

Under the State Environmental Quality Review Act (SEQRA), CEA designation means that potential impacts on the recognized special characteristics of a CEA warrant specific consideration in determining the significance of any Type I or unlisted actions that may affect the CEA. More information about CEAs can be accessed at: http://www.dec.ny.gov/permits/45500.html.

This management plan includes a recommendation for conserving the portion of the Piermont Marsh/Sparkill CEA within the Piermont Marsh Reserve as a storm buffer for the Village of Piermont, and for research to study how best to manage and protect Piermont Marsh so that it persists despite sea-level rise.
**Rockland County Comprehensive Plan**

The Rockland County Comprehensive Plan was adopted in 2011. The first recommendation in the Natural Resources chapter is to protect the Hudson River and other significant surface water resources. The plan recognizes the Hudson River as one of Rockland’s most valuable environmental resources, significantly affecting land use, commerce, ecosystems, and scenic vistas. A proposed measure for protecting the Hudson River and other significant water resources is to work with DEC’s Hudson River Estuary Program and neighboring counties to adopt the goals outlined in the program's 2010-2014 Action Agenda (see below) and to work to develop a river stewardship ethic.

**Hudson River Estuary Action Agenda**

DEC’s Hudson River Estuary Program helps people enjoy, protect, and revitalize the Hudson River and its valley. Created in 1987 through the Hudson River Estuary Management Act, the program focuses on the tidal Hudson and adjacent watershed, from the Troy Lock and Dam to the Verrazano Narrows in New York City. The program is steered by the Hudson River Estuary Management Advisory Committee, which includes representatives of the commercial fishing industry, recreational anglers, utility companies, local government, educators, researchers, conservationists and other river users. The *Hudson River Estuary Action Agenda 2015-2020* (HREP, 2016) is a conservation and restoration blueprint that guides the work of the Estuary Program and its partners. The *Action Agenda* defines the challenges and identifies practical solutions that can be carried out by civic leaders, policy makers, and citizens working together.

The *Piermont Marsh Reserve Management Plan* supports the realization of four of the five benefit areas identified in the *Hudson River Estuary Action Agenda*, including: 1) Resilient Communities; 2) Vital Estuary Ecosystem; 3) Estuary Fish, Wildlife, and Habitats; and 4) Education, River Access, Recreation, and Inspiration (HREP 2016).

**Hudson River Estuary Habitat Restoration Plan**

The *Hudson River Estuary Habitat Restoration Plan* (Miller, 2013) provides the foundation for restoring tidal wetlands, natural shorelines, and shallows, as well as facilitating fish passage up the Hudson River’s tributaries. The plan identified intertidal wetlands as a priority habitat for restoration, vital to the health and resiliency of the estuary. The *Piermont Marsh Reserve Management Plan* was developed with consideration of the principles, approaches, and priorities of the *Hudson River Estuary Habitat Restoration Plan*.

**Social and Community Context**

**Nearby Communities**

Piermont is one of four incorporated villages within the Town of Orangetown. The village directly abuts the northern extent of the Piermont Marsh, and its boundary includes
about 65 acres of Reserve lands, including marsh, uplands, and underwater shallows south of Paradise Avenue and Ferry Road, and north of the Sparkill Creek. Palisades is an unincorporated hamlet located on the west shore of the Hudson River, just below the south end of Piermont Marsh.

Piermont Marsh, formerly known as the Orangetown Salt Meadow, has been important to community life and the local economy of both communities. An 1877 survey map of the marsh shows 174 separate allotments for harvesting salt hay, presumably to feed livestock and possibly to provide roofing. Salt hay, also known as saltmeadow cordgrass (*Spartina patens*), is mostly gone from the marsh except in a few locations.

Although nearly all of Piermont Marsh lies outside the Village of Piermont boundary, many residents identify closely with the marsh and consider it a vital component of Piermont’s special sense of place. Village residents and visitors pass the northern part of the marsh on walks out onto Piermont Pier. The marsh is also a paddling destination that supports a canoe and kayak rental business. Many local restaurants, shops, and other businesses also benefit from tourism fostered by the marsh.

**Vulnerability to Storms and Changing Climate**

Piermont’s location at the confluence of the Sparkill Creek and the Hudson River is both a great asset and a significant challenge, as it experiences periodic waterfront flooding due to storms, high tides, and sea level rise. In 2011, storms Irene and Lee caused significant flooding resulting from stormwater flows in the Sparkill Creek and storm surge in the Hudson River. In fall of 2012, Post-Tropical Cyclone Sandy’s historic coastal storm surge resulted in severe damage to homes, marinas, boats, and other businesses (Village of Piermont, 2014). Through the community’s experience of these storms and the collective planning for risk reduction and greater resilience, the Village of Piermont has a solid foundation of knowledge about sea level rise and flooding adaptation approaches, and is moving forward to reduce risk and improve resilience.

Piermont leaders and residents are keenly aware that the marsh helps protect the village, especially buffering low-lying areas adjacent to the marsh. During Post-Tropical Cyclone Sandy, marsh vegetation acted as a wave buffer and filter for water-borne debris, which accumulated in the marsh instead of impacting residences and village infrastructure. There is debate about the role of the marsh in reducing unusually high water levels that arise from a combination of high tides, surge, and runoff (Jacob, pers. comm., 2016 and Sheng, pers. comm., 2016). The coastal protection benefits provided by the marsh will be investigated in detail through research described later in the plan.
NATURAL RESOURCES

INTRODUCTION

Piermont Marsh is the largest brackish tidal marsh in the Hudson River estuary, a rarity in this major ecological region. Piermont Marsh Reserve includes the 278-acre marsh that extends 1.5 miles north-south along the west shore of the Hudson River, as well as the adjacent shallows, for a total area of about 1,000 acres. The marsh is south of the Village of Piermont and north of the hamlet of Palisades, in the Town of Orangetown in southeastern Rockland County. Piermont Marsh is among the oldest marshes on the Hudson River (Wong and Peteet, 1999).

This section of the management plan briefly describes the geology, topography, and soils of Piermont Marsh. The property’s ecological resources are discussed in more detail and are based on an Ecological Profile of the Hudson River National Estuarine Research Reserve (Yozzo, et al., 2005) and surveys and research conducted over the last several decades. Emphasis is on the sensitive natural resources and the threats facing them. The information in this chapter provides the basis for many of the management recommendations discussed in the “Management Approach” chapter.

PHYSICAL SETTING

Geology

Piermont Marsh is bordered on the north by Piermont Pier and to the west by the 150-foot cliffs and talus slopes of the Palisades Ridge. This ridge was formed when molten basalt rock pushed upward through softer sedimentary rocks along fault lines, between 200 and 190 million years ago. The softer rocks gradually wore away, leaving the more resistant Palisades standing as dramatic, vertically jointed basaltic rock (Sirkin and Bokuniewicz, 2006).

Topography

Montalto, et al. (2006) documented the marsh’s physical characteristics from 1998-2000. Ground-based topographic surveys using a real-time kinematic global positioning system (RTK GPS) indicated that Piermont Marsh was flat, with the north end at about the same elevation as the south end. The study noted frequent localized depressions where muskrats had been feeding or burrowing between hummocks of tidal marsh plants and in unvegetated shallow salt pannes or shallow ponds. The banks of tidal creeks were steep and nearly vertical near the marsh surface, as is typical of tidal creeks in Phragmites-dominated marshes.
Soils

The retreat of the last glaciers about 22,000 years ago was followed by rising sea levels and the creation of estuarine conditions within the Hudson River valley. Evidence of salt marshes in the estuary dates from about 11,000 years ago (Sirkin and Bokuniewicz, 2006). Radiocarbon dating suggests that Piermont Marsh is approximately 6,800 years old (Newman, et al., 1987). The substrate of the marsh soil is an Ipswich mucky peat, and its profile can be described as alternating layers of peats and clays varying in color and texture (Wong and Peteet, 1999) to a depth of at least 43 feet (D. Peteet, pers. comm., May 15, 2017). Estimates of the rate of deposition of marsh sediments vary widely, from 0.06 to 0.60 inches/year (Wong and Peteet, 1999; Yozzo, et al., 2005; Kiviat, et al. 2006).

WATER RESOURCES

Hydrology

The Hudson River estuary is tidal, from the Troy Lock and Dam south to New York City. Hudson River tides are semi-diurnal, with two highs and two lows within a 25-hour period. The mean tidal range varies from 3.2 feet at West Point to about 5 feet at either end of the estuary. The average tidal range at Piermont Marsh is 3.2 feet.

Although tides rise and fall in the marsh’s tidal creeks (Sparkill, Kroomis Kill, and Crumkill), most of Piermont Marsh is only irregularly flooded during spring tides (those that occur around the time of full or new moons) up to a dozen times monthly, and during occasional flooding and storm surge events (Montalto, et al., 2006).

The salinity of the Hudson River at Piermont is generally brackish (less than half the salinity of ocean water), although it ranges from fresh to about 12 parts per thousand (ppt) of salt. The Sparkill Creek discharges into the north end of the marsh, draining 11.1 square miles of developed watershed.

Water Quality

HRNERR has been collecting monthly water samples at two locations in Piermont since 1991. The first sampling site is located at the Ferdon Pond dam, above the head of tide, to analyze the watershed input into the Sparkill Creek before it flows through Piermont Marsh. The second sample is collected at the mouth of Sparkill Creek on an outgoing tide to assess whether the marsh has an impact on creek
water quality. Standard water quality parameters and nutrient concentrations are analyzed, and weather data are recorded. These data are publicly available through HRNERR. While basic water quality conditions in the marsh are generally representative of estuaries in the Northeast, monitoring of nutrients has identified some areas of concern and potential sources of organic enrichment. Nitrate concentrations in Piermont Marsh and Sparkill Creek are higher than in other HRNERR marshes but typical of a marsh system in a developed watershed. However, water quality remains largely unchanged between the two sampling locations along the creek. This suggests that the marsh does not impact water quality in the creek, perhaps because the creek rarely crests its banks.

Since 1998, Rockland County Soil and Water Conservation District and DEC have been monitoring water quality at six locations along the Sparkill Creek using bottom-dwelling aquatic insects. These insects vary in their sensitivity to water quality, so the presence, absence, and abundance of certain species can be used to determine an overall water quality score. This score is called a Biological Assessment Profile (BAP), which classifies waterbodies as non-, slightly, moderately, or severely impacted. For more details on BAP, visit: http://www.dec.ny.gov/docs/water_pdf/sbusop12.pdf. Monitoring data indicate that the water quality in the lower reaches of the Sparkill Creek is slightly to moderately impacted.

Since 2006, Riverkeeper has been monitoring enterococci levels in water samples collected at various sites along the Hudson River, including Piermont Pier and the Orangetown Sewage Treatment Plant outfall. Enterococci are bacterial indicators of fecal contamination from humans and animals and used to assess the health risk of recreational waters. In partnership with the Sparkill Creek Watershed Alliance, Riverkeeper began monitoring enterococci levels in water samples collected from the banks of the Sparkill Creek in 2011. Monitoring results indicate chronic and severe fecal contamination in the Sparkill Creek upstream of Piermont Marsh. Contamination in the Hudson River downstream of Piermont Marsh is less frequent but still severe. Potential sources of contamination include failing septic systems, leaky sewers, improper sewage treatment, pump station malfunctions during rain events, and runoff. Specific sources of fecal contamination in the Sparkill Creek watershed and the relative contributions of the creek versus the river are currently unknown.

**ECOLOGICAL COMMUNITIES**

Eleven distinct ecological communities have been identified at the Piermont Marsh Reserve, including brackish tidal marsh, saltwater tidal creek, brackish intertidal mudflat, and floodplain forest (Table 1, Figure 5). Together, these communities form a large and diverse assemblage of wetland and aquatic habitats that are uncommon within the Hudson River estuary. The following community classifications are based on the New York Natural Heritage Program’s *Ecological Communities of New York State, Second Edition* (Edinger, et al., 2014). The New York Natural Heritage Program (NYNHP) ranks ecological communities based on their rarity and vulnerability within New York State (S-rank). S1 community types are considered the most imperiled, while S5 communities
are regarded as demonstrably secure. Some communities are given range ranks (e.g., S3/S4), indicating uncertainty about their status.

Table 1. Ecological community types occurring at the Piermont Marsh Reserve

<table>
<thead>
<tr>
<th>Community Type</th>
<th>Acreage</th>
<th>Percent</th>
<th>S-rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal River</td>
<td>742.09</td>
<td>72.00</td>
<td>S3</td>
</tr>
<tr>
<td>Saltwater Tidal Creek</td>
<td>15.75</td>
<td>1.53</td>
<td>S3</td>
</tr>
<tr>
<td>Salt Panne</td>
<td>3.09</td>
<td>0.30</td>
<td>S3</td>
</tr>
<tr>
<td>Brackish Tidal Marsh</td>
<td>19.1</td>
<td>1.85</td>
<td>S3/S4</td>
</tr>
<tr>
<td>Estuarine Common Reed Marsh</td>
<td>232.02</td>
<td>22.51</td>
<td>Unranked Cultural</td>
</tr>
<tr>
<td>Low Salt Marsh</td>
<td>1.62</td>
<td>0.16</td>
<td>S3/S4</td>
</tr>
<tr>
<td>Brackish Intertidal Mudflat</td>
<td>7.56</td>
<td>0.73</td>
<td>S1/S2</td>
</tr>
<tr>
<td>Estuarine Riprap/Artificial Shore</td>
<td>1.55</td>
<td>0.15</td>
<td>Unranked Cultural</td>
</tr>
<tr>
<td>Red Maple-Sweetgum Swamp</td>
<td>0.41</td>
<td>0.04</td>
<td>S1/S2</td>
</tr>
<tr>
<td>Floodplain Forest</td>
<td>7.42</td>
<td>0.72</td>
<td>S2/S3</td>
</tr>
<tr>
<td>Mowed Lawn</td>
<td>0.10</td>
<td>0.01</td>
<td>Unranked Cultural</td>
</tr>
</tbody>
</table>

Notably absent from the following list of ecological communities is high salt marsh. Prior to the expansion of Phragmites, Piermont Marsh supported an extensive high salt marsh community (S3/S4), which was historically harvested for salt hay. This community occurred as a mosaic of patches in a zone extending from mean high tide up to the limit of spring tides. The dominant plant species in this community were saltmeadow cordgrass (Spartina patens) and saltgrass (Distichlis spicata). Although no sizeable patches of this community type remain at the Reserve, saltmeadow cordgrass and saltgrass persist in some areas where Phragmites is less dense and light reaches the marsh surface. High salt marsh is rare in the estuary and a conservation target at the Reserve.

Tidal River (S3)

Portions of the Hudson River with continuously flooded substrates devoid of emergent vegetation are classified as tidal river. Within a tidal river community, there are typically two zones: 1) the deepwater zone, which includes areas where substrates are usually over 2m (6 ft.) deep at low tide; and 2) the shallow zone, which includes submerged areas less than 2m (6 ft.) deep at low tide that lack rooted aquatic vegetation. Most of the tidal river community within the Reserve boundary is within the shallow zone. These shallow waters provide critical habitat for waterfowl, invertebrates, and numerous year-round resident fish, as well as seasonal migrants that enter the river as adults to spawn and return to the ocean afterward.

Saltwater Tidal Creek (S3)

Several named tidal creeks meander through the marsh, including the Crumkill Creek, the Kroomis Kill, and the lower reaches of the Sparkill Creek. Water levels fluctuate with the tides, and two community depth zones are typically encountered: 1) the subtidal,
Figure 5. Ecological communities at Piermont Marsh Reserve.
permanently flooded portion of the creek; and 2) the intertidal portion, including banks and mid-channel bars or terraces exposed at low tide. Although the vertical banks of most creeks are regularly eroded and slump into the creek bottom, the position of the creek beds in the marsh has remained relatively stable, at least since the early 20th century. Smaller unnamed creeks and intertidal rivulets occur on the surface of the marsh and fish use them to access the marsh plain.

Salt Panne (S3)

Salt pannes are shallow depressions on the marsh surface, which are irregularly flooded during spring and flood tides. These depressions are not directly connected to tidal creeks and therefore do not readily drain as the tides recede. In the absence of additional freshwater inputs, the standing water in a panne can evaporate, thereby raising the concentration of salts in the soil water well above that of sea water. Most of the pannes in Piermont Marsh lack vegetation, although saltmarsh fleabane (*Pluchea purpurascens*) and dwarf spike rush (*Eleocharis parvula*) can occasionally be found inside them. Most pannes at Piermont Marsh are confined to a portion of the interior marsh between the Crumkill Creek and the Kroomis Kill. However, recent surveys suggest that several new pannes may also be forming south of the Crumkill Creek. Based on aerial photographs taken of the marsh since 1926, the number and average size of pannes/shallow pools on the marsh plain has increased. The location of some of them also appears to shift over time (B. DeGasperis, pers. comm., February 24, 2016).

Brackish Tidal Marsh (S3/S4)

Portions of the marsh interior support a brackish tidal marsh community. This community occurs in isolated patches within a larger matrix of estuarine common reed marsh. Characteristic species include chairmaker’s bulrush (*Schoenoplectus americanus*), three-square bulrush (*Schoenoplectus pungens*), saltmarsh bulrush (*Bolboschoenus robustus*), narrow-leaved cattail (*Typha angustifolia*), rosemallow (*Hibiscus moscheutos*), saltmarsh fleabane, fragrant flatsedge (*Cyperus odoratus*), seaside goldenrod (*Solidago sempervirens*), and saltmarsh aster (*Symphyotrichum subulatum*), a state-listed threatened species. This community type has declined dramatically since the 1960s and has been replaced by an estuarine common reed marsh community. Brackish tidal marshes provide excellent wildlife habitat, with abundant food sources for migratory and wintering waterfowl.
Estuarine Common Reed Marsh (Unranked Cultural)

A non-native strain of common reed (*Phragmites australis*) is the dominant vegetation on approximately 85% of the marsh surface. *Phragmites* is a tall, coarse perennial grass with stout rhizomes (horizontal underground stems that can sprout new roots and shoots) that forms dense, high-biomass colonies. *Phragmites* is hyper-dominant in many areas of the marsh, although remnant native plants characteristic of brackish tidal marsh (e.g., chairmaker’s bulrush and narrow-leaved cattail) and high salt marsh (e.g., saltmeadow cordgrass and saltgrass) communities can occasionally be intermixed. The abundance of *Phragmites* makes it impossible to classify the majority of the marsh as a natural estuarine community. Although an estuarine common reed marsh can develop at the expense of rare and vulnerable natural communities, it is not devoid of ecological value. At Piermont Marsh Reserve, this community provides several valuable ecosystem services, including soil stabilization, nutrient retention, carbon sequestration, and storm protection for neighboring developed areas. This community also provides foraging, breeding, roosting, and/or migratory stopover habitat for certain species of songbirds and waterbirds (Findlay, et al., 2014).

Low Salt Marsh (S3/S4)

This community mostly occurs along the eastern edge of the marsh, in areas regularly flooded by semidiurnal tides. Narrow bands of this community type can also be found along some of the tidal creeks that meander through the marsh. The vegetation of a low salt marsh is almost entirely composed of smooth cordgrass (*Spartina alterniflora*), a coarse grass that can grow up to 10 feet tall. Other characteristic plant species include dwarf spikerush, and eastern grasswort (*Lilaeopsis chinensis*), a state-listed threatened species. These tiny plants, typically less than 4 inches tall, can also be found growing between cordgrass stems along the Hudson River shoreline. Low salt marshes grade into brackish intertidal mudflats and subtidal communities seaward and brackish tidal marshes and estuarine common reed marshes landward.

Brackish Intertidal Mudflats (S1/S2)

Sparsely vegetated, unvegetated, and algal variants of brackish intertidal mudflats occur on shallow, sheltered, and nearly level areas along the Hudson River shoreline and margins of the Sparkill and Crumkill creeks. These communities are exposed at low tide
and are typically comprised of loosely consolidated deposits of silt and mud. While seemingly barren and devoid of life, mudflats are home to a variety of invertebrates and are prime feeding grounds for shorebirds, including least (Calidris minutilla) and semi-palmated sandpipers (C. pusilla), and lesser yellowlegs (Tringa flavipes).

**Estuarine Riprap/Artificial Shore (Unranked Cultural)**

Piermont Pier was created in 1838 as the terminus of the Erie Railroad by depositing rock and fill in the marsh and shallows. Consequently, the shoreline along the pier and the north side of the Sparkill Creek are generally composed of coarser stones and gravel. An intertidal sill composed of broken rocks extends through the shallows south of Ferry Road near the east end of Piermont Landing towards the mouth of the Sparkill Creek. This historic rock sill may have been placed to support a dock, prevent erosion and/or reduce wave and current energies in the area. Vegetative cover and species diversity along these artificial shores are typically low compared to natural estuarine shores. However, they provide valuable foraging and resting habitat for shorebirds and basking areas for turtles, including diamondback terrapin.

**Red Maple-Sweetgum Swamp (S1/S2)**

A small forested wetland dominated by sweetgum (Liquidambar styraciflua) occurs at the southern end of the marsh. This community is typically found on somewhat poorly drained seasonally wet flats, usually on acidic gleyed to mottled clay loam or sandy loam. Red maple-sweetgum swamps often occur as a mosaic with upland forest communities. The swamp at Piermont Marsh is particularly unusual in that it abuts a brackish marsh and is tidally influenced. More data are needed to describe this community type and its variants.

**Floodplain Forest (S2/S3)**

The largest wooded area within the Reserve occurs on the east side of Rittenberg Field along Ferry Road. It was formerly brackish tidal marsh before being used as a municipal waste landfill in the mid-1900s. The landfill has since revegetated and supports an open canopy of eastern cottonwood (Populus deltoides) and other tree species adept at colonizing disturbed soils and high-light environments. Given the shallow substrate, many of the canopy trees have been uprooted during wind storms and remain on the ground. The understory is a dense tangle of non-native and ruderal (growing in waste places or on disturbed land) species, including Japanese knotweed (Polygonum cuspidatum), Asiatic bittersweet (Celastrus orbiculatus), poison ivy (Toxicodendron radicans), and grape (Vitus sp.). In addition to providing limited habitat value for wildlife, the presence of inorganic refuse, including discarded automobiles, large appliances, and mechanical parts, creates a potential hazard for public access and recreation.

Smaller floodplain forest communities occur along the banks of the Sparkill Creek and near the southern tip of the marsh. At the southern end of the marsh, the floodplain forest is a small island surrounded by estuarine common reed marsh. These hardwood
forests are characterized by their flood regime. Lower areas are flooded every spring, and higher areas are flooded irregularly. Floodplain forests are insect-rich habitats that attract warblers, thrushes and other songbirds. In particular, yellow-throated and warbling vireos, which like to nest in the canopies of riverside trees, are frequently observed in floodplain forest communities. Raptors such as bald eagles and red-shouldered hawks also use riverbank trees as perch sites.

Mowed Lawn

There is a small area of lawn at the DEC pocket park between Paradise Avenue and the Sparkill Creek. The groundcover is dominated by clipped grasses and forbs and maintained by mowing to provide creek access and marsh visibility.

FISH AND WILDLIFE

Fish

Several studies have estimated the abundance of resident fish species at Piermont Marsh using intertidal lift nets. Mummichogs (*Fundulus heteroclitus*) comprise the majority of the fish community found on the marsh surface. The abundance of larval and juvenile mummichogs is generally lower in the dense *Phragmites* stands than in communities dominated by native vegetation (Hanson, et al., 2002; Osgood, et al., 2006). Other species found on the marsh surface include Atlantic silverside (*Menidia menidia*), white perch (*Morone americana*), and spotfin killifish (*Fundulus luciae*).

The first record for spotfin killifish in the Hudson River drainage was reported at Piermont Marsh (Yozzo and Ottman, 2003). This species is known to inhabit high intertidal marshes along the Atlantic coast, from southeastern Massachusetts to Georgia (Jorgenson, 1969; Hartel, et al., 2002). Spotfin killifish may not necessarily be rare, but their ability to remain concealed and preference for less frequently flooded salt and brackish marshes may have precluded their collection in previous studies.

The Sparkill and Crumkill creeks and shallow offshore waters provide limited spawning and/or nursery habitats for a variety of coastal migratory and resident freshwater fishes, including American eel (*Anguilla rostrata*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), white perch, striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), banded killifish (*Fundulus diaphanous*), Atlantic silverside, and mummichog.

Mammals

Only a few studies have focused on the ecology of mammal populations at Piermont Marsh. Several mammal species, such as muskrat, are conspicuous residents of the marsh. Muskrats are known for their burrowing, feeding, and lodge-building activity. They are the primary vertebrate consumer of intertidal marsh vegetation. It is unknown
to what extent muskrat grazing has affected and/or continues to affect plant species composition or richness at Piermont Marsh. However, it is known that muskrat activity increases soil nitrification rates through increased aeration (Connors, et al., 2000). Additionally, muskrat lodge construction contributes to the structural complexity of the intertidal marsh surface, providing nesting and feeding habitat for marsh birds and other vertebrates at the Reserve.

While their impact on the marsh may not be as conspicuous, white-tailed deer (*Odocoileus virginianus*) also forage and seek shelter in its dense vegetation. As deer traverse the marsh, they establish trails that facilitate the movements of smaller wildlife species. Other mammal species, such as the meadow vole (*Microtus pennsylvanicus*), shrews, moles, and bats are likely present but rarely noted due to their ability to avoid detection.

Birds

Much of what is known about the birds of the Piermont Marsh Reserve is based on data provided by the Rockland Audubon Society and the *Birds of Rockland County, NY and the Hudson Highlands, 1844-1976* (Deed, 2010). Deed's compilation of county bird records includes numerous species accounts from the Reserve. Historical breeding activity was noted for various species, including the pied-billed grebe (*Podilymbus podiceps*), black-crowned night heron (*Nycticorax nycticorax*), least bittern (*Ixobrychus exilis*), clapper rail (*Rallus crepitans*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), common moorhen (*Gallinula chloropus*), marsh wren (*Cistothorus palustris*), saltmarsh sparrow (*Ammodramus caudacutus*), seaside sparrow (*A. maritimus*), alder flycatcher (*Empidonax alnorum*), and willow flycatcher (*E. trailli*). Over the last ten years, ongoing breeding activity has been confirmed for several species, including the least bittern (Steve Sisti, pers. comm., 2013), marsh wren, and Canada goose (*Branta canadensis*).

At the Piermont Marsh Reserve, swallows (Hirundinidae), blackbirds (Icteridae), and other songbirds likely roost in the estuarine common reed marsh community. Although songbird roosting has not been confirmed at the Reserve, the phenomenon has been observed in other *Phragmites*-dominated habitats in the estuary (Kiviat and Talmage, 2006). Roosts of non-breeding songbirds may involve hundreds or thousands of individuals (Findlay, et al., 2014).
Pannes, mudflats, shorelines, and shallow-water habitats are frequented by various migratory waterfowl, wading, and shorebird species, including canvasback (*Aythya valisineria*), common goldeneye (*Bucephala clangula*), green heron (*Butorides striatus*), lesser yellowlegs, least sandpiper, and semi-palmated sandpiper.

Piermont Marsh has been designated part of the Atlantic Flyway for seasonally migrating birds and is used by many threatened and endangered raptor species such as osprey (*Pandion haliaetus*), northern harrier (*Circus cyaneus*), bald eagle (*Haliaeetus leucocephalus*), and peregrine falcon (*Falco peregrinus*).

**Amphibians and Reptiles**

Few studies of reptile and amphibian populations have been conducted at Piermont Marsh. Common snapping turtle (*Chelydra serpentina*), northern water snake (*Nerodia sipedon*), and diamondback terrapin (*Malaclemys terrapin*) are known to live within the Reserve and can often be observed basking along Piermont Pier. Diamondback terrapins were hunted to near extinction at the turn of the last century and are beginning to show signs of population recovery in the Hudson River and other northeastern estuaries. At Piermont Marsh, terrapins are subject to drowning in crab traps, and their eggs and young may be preyed upon by raccoons. A preliminary population survey conducted during summer 1997 identified eight terrapins (six males, two females) at Piermont Marsh. Although diamondback terrapins were using the marsh system, it was unclear whether they were nesting in the Reserve. The study suggested that dense stands of *Phragmites* might reduce the availability of suitable nesting areas at Piermont Marsh (Simoes and Chambers, 1998).

**Invertebrates**

At Piermont Marsh, the summer zooplankton assemblage is dominated by copepod larvae. Adult copepods (*Harpacticoida*) and barnacle larvae are also abundant. Spatial and temporal variations in zooplankton distribution in the marsh are determined by variables such as tributary flow, tidal mixing and resuspension, and storm events (Nemazie and Dexter, 1988).

Benthic invertebrate communities associated with the intertidal *Phragmites* stands at Piermont Marsh are dominated by annelids (*Tubificidae* and *Enchytraidae*), insect larvae (*Diptera*) and mollusks (*Sphaeriidae* and *Hydrobiidae*). Taxa richness is greater
in higher elevation *Phragmites* stands than in lower elevation stands (Osgood, et al., 2006).

Other commonly occurring estuarine invertebrates at the Piermont Marsh Reserve include daggerblade grass shrimp (*Palaemonetes pugio*), Atlantic marsh fiddler crab (*Uca pugnax*), and blue crab (*Callinectes sapidus*).

Little is known about the terrestrial invertebrate communities at the Reserve. Brackish tidal marsh and salt panne communities typically support a diverse array of insects and spiders, including ground crickets, mosquitoes, bees, wasps, syrphid flies, and butterflies. Needham’s skimmer (*Libellula needhami*), a locally uncommon dragonfly, was recently documented at Piermont Marsh. The larvae of this coastal species are aquatic, whereas adults are terrestrial and found in habitats surrounding ponds, lakes, tidal river areas, and brackish wetlands in New York State.

**SIGNIFICANT ECOLOGICAL FEATURES**

**Priority Ecological Communities**

Piermont Marsh is one of less than a dozen brackish marshes statewide. Few of the other documented marshes are protected on public land or private conservation land (NYNHP, 2015). The marsh supports an assemblage of ecological communities restricted to a small portion of the estuary where water salinities range from 0.5 to 18 ppt, and the water is less than six feet deep at high tide. All the ecological communities found at Piermont Marsh, with the exception of the Estuarine Common Reed Marsh, Estuarine Riprap/Artificial Shore, and Mowed Lawn communities, are uncommon in the state. These uncommon native communities, which provide critical habitat for the larval and juvenile stages of many fish and invertebrate species and are used for spawning by adults of these species, are locally rare and declining throughout the estuary. Given their rarity and vulnerability, they are priorities for conservation and management. The fact that these individual communities are part of a larger protected wetland complex adds to their significance.

**Rare Species**

Given their intermediate salinities, brackish marshes support a unique and diverse mixture of saltmarsh and freshwater tidal marsh plant species dominated by grasses,
sedges, and rushes. Many of the species associated with brackish marshes are uncommon in the state. From a conservation perspective, the plants and animals that are restricted to these areas are a high priority due to their vulnerability to extinction.

Two rare plant species and one rare animal species are known to occur at Piermont Marsh (Table 2). These species are protected under New York State Environmental Conservation Law and classified as endangered, threatened, or rare (for plants), or endangered, threatened, or special concern (for animals) based on their level of rarity. In addition, several other rare plant and animal species historically occurred at Piermont Marsh, but have not been documented in recent years.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Taxonomic Group</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltmarsh Aster</td>
<td>Symphyotrichum subulatum</td>
<td>Plant</td>
<td>Threatened</td>
</tr>
<tr>
<td>Eastern Grasswort</td>
<td>Lilaeopsis chinensis</td>
<td>Plant</td>
<td>Threatened</td>
</tr>
<tr>
<td>Least Bittern</td>
<td>Ixobrychus exilis</td>
<td>Bird</td>
<td>Threatened</td>
</tr>
</tbody>
</table>

**Ecosystem Services**

In addition to providing habitat for rare plants and animals, Piermont Marsh performs many critical ecosystem services, including production and transport of nutrients and organic matter, removal of nutrients and contaminants, reduction of wave energy during storms, storage of flood water, and trapping of sediment.

**Primary Production**

Marshes are the primary source of much of the organic matter and nutrients forming the basis of the coastal and estuarine food webs. As marsh vegetation decays, a steady supply of detritus is released into surrounding waters, promoting the secondary production of finfish, shellfish, crustaceans, and birds.

Mudflats are also important contributors to primary production and breakdown of organic materials. Algal communities on mudflats are primary producers and provide a food source for snails and other benthic organisms. Bacterial communities contribute to the breakdown of organic materials.

**Attenuation of Wave Energy and Reduction of Storm Surge**

Tall, robust marsh plants such as *Phragmites*, saltmarsh cordgrass, and cattail reduce the energy of waves moving shoreward (Gedan, et al., 2011; Duarte, et al., 2013). At the seaward edge of salt marshes, a wave energy reduction of 26% per square meter of vegetation has been reported (Fonseca and Cahalan, 1992). Wave energy reduction decreases with distance into the marsh. The ability of marsh vegetation to reduce wave energy in this manner helps to protect adjacent infrastructure and prevent shoreline erosion (Gedan et al., 2011). Based on limited field observations and quantitative studies, tidal marshes are thought to play a role in buffering storm surge. In a study of
three-dimensional simulations of the reduction of storm surge by vegetation canopies, the effectiveness of vegetation in dissipating storm surge and inundation was found to depend on the intensity and forward speed of the hurricane, as well as the density, height, and width of the vegetation canopy (Sheng, et al., 2012).

Enhancement of Sedimentation/Accretion

Reduction of wave and current energies in tidal marshes causes them to trap sediment. As water moving across the marsh surface slows down, it loses its capacity to carry sediment particles (Nixon, 1982; Gedan, et al., 2011). Sediment then settles on the marsh surface. The large initial reduction in flow velocity at the river edge of tidal marshes concentrates sediment accumulation at this location, contributing to long-term maintenance and development of the marsh (Teal, 1986). Marsh grasses also reduce the velocity of terrestrial runoff. Water leaving the marsh, therefore, carries less particulate material and is less turbid (Desbonnet, et al., 1994).

Storage of Flood Water

Reduction of flow velocities by salt marsh grasses can contribute to flood control. Decreased flow velocities enable water to be transferred into soils and underground watercourses (Desbonnet, et al., 1994), potentially decreasing the impact of flood waters on adjacent upland. Piermont Marsh’s ability to store floodwater and reduce still water levels is thought to be minimal given its small size compared to the area of the nearby Hudson River and the stormwater contributions of the Sparkill Creek (Jacob, pers. comm, 2016).

Nutrient Retention

As water flows across the surface of Piermont Marsh, the dense vegetation removes nutrients, especially nitrogen. In particular, the Phragmites stands at the Reserve have a superior capacity for nutrient retention relative to native intertidal wetland vegetation (Meyerson, et al., 2000; Findlay, et al., 2003) and contribute to overall water quality in the Hudson River estuary.

SIGNIFICANT ECOLOGICAL THREATS

Changing Climate

The greatest threat to Piermont Marsh is the acceleration in the rate of sea-level rise, which may outpace the marsh’s ability to build up sediment and persist long term. If a marsh cannot keep pace with sea level rise, it becomes increasingly flooded and may ultimately drown and become open water. Along the Hudson River estuary, sea level rose about one foot in the 20th century. However, by 2100, sea level is projected to rise between 15 and 75 inches in New York City and the lower Hudson Region (Horton, et al., 2014; NYSDEC, 2015, Table 3). These projections take into account all known
components of sea-level rise and are based on advances in physical understanding, climate modeling and computing. They also incorporate observational data from recent storms, including Tropical Storm Irene and Post-Tropical Cyclone Sandy.

**Table 3. Sea Level Rise Projections for New York City/Lower Hudson Region**

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Low Projection</th>
<th>Low-Medium Projection</th>
<th>Medium Projection</th>
<th>High-Medium Projection</th>
<th>High Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020s</td>
<td>2 inches</td>
<td>4 inches</td>
<td>6 inches</td>
<td>8 inches</td>
<td>10 inches</td>
</tr>
<tr>
<td>2050s</td>
<td>8 inches</td>
<td>11 inches</td>
<td>16 inches</td>
<td>21 inches</td>
<td>30 inches</td>
</tr>
<tr>
<td>2080s</td>
<td>13 inches</td>
<td>18 inches</td>
<td>29 inches</td>
<td>39 inches</td>
<td>58 inches</td>
</tr>
<tr>
<td>2100</td>
<td>15 inches</td>
<td>22 inches</td>
<td>36 inches</td>
<td>50 inches</td>
<td>75 inches</td>
</tr>
</tbody>
</table>

Piermont Marsh has kept up with sea-level rise by building up or accreting sediment at the marsh surface. With sea level rising faster than before, there is uncertainty about how much more sediment will be available for the marsh to build up and, hence, how resilient it will be. There is a projected increase in frequency of “heavy rainfall events” (Rosenzweig, et al., 2011) which may result in higher than normal upland erosion, high turbidity, and increased deposition of sediment into marshes and shallows. This occurred during Tropical Storms Irene and Lee in 2012 (Ralston, et al., 2013) when 2.7 million tons of sediment—about five times the annual average—washed into the upper estuary from the watershed. In this instance, most of that sediment remained in the upper estuary in the months after the storm, at least temporarily trapped in the freshwater tidal part of the estuary. In the future, these storms may increase potential sediment inputs to Hudson River tidal marshes, to an extent depending in part on marsh elevation (which determines how long a marsh is flooded by tides bearing sediments) and marsh location relative to sediment inputs.

Regional analyses, such as the Sea Level Affecting Marsh Migration (SLAMM) models, have been run to assess potential impacts of sea-level rise on Hudson River tidal marshes. This modeling is based on information about marsh vegetation and height, rates of marsh vertical buildup, and other factors, some of which have been measured, while others are estimated. These initial analyses suggest that between now and 2085, Piermont Marsh may convert from irregularly flooded (high) marsh to regularly flooded marsh, and potentially to tidal flats and open water under higher sea-level rise scenarios (Tabak, et al., 2016; NYSERDA, 2014). There is evidence that more salt pannes are developing in the marsh, though the reasons for this are not well understood and may be the result of one or more factors.

Adding to this complexity, the ClimAID Report (Rosenzweig, et al., 2011) also projects increased heat, with more frequent and longer heat waves (three or more days at or above 90 °F). Total annual precipitation is expected to increase slightly, but delivered less frequently in heavier rainfall. The report states that even with this slight increase in rainfall, hotter temperatures will drive more evaporation, and drought is likely to increase, especially during warmer months. This in turn, may lead to greater salinity intrusion into the estuary and more saline waters at Piermont. Some species, including *Phragmites*, have a limited tolerance for saline water.
Given the vulnerability of Piermont Marsh and other Hudson River intertidal marshes to sea-level rise and other climate changes, there is a need to closely monitor marsh health and integrity, and to take steps to enhance the structure, function, and resiliency of the marsh for the benefit of fish, wildlife, and public well-being.

Non-Native Invasive Species

Many of the rare species and native plant communities at Piermont Marsh have declined over the past several decades, largely due to the spread of a Eurasian strain of *Phragmites australis*. Since the 1960s, *Phragmites* coverage at Piermont Marsh has increased by nearly 60 percent, in a pattern consistent with the invasive Eurasian strain (Winogrond and Kiviat, 1997). This increase has been accompanied by a corresponding loss of native species. Once established, *Phragmites* shades existing vegetation and hinders the germination and growth of other species (Niedowski, 2000). As a result, complex communities of native plants at Piermont Marsh have been replaced by hyper-dominated stands of *Phragmites*.

As *Phragmites* has replaced native plant communities in the Reserve, it has altered the composition and physical structure of the marsh for fish and wildlife species. By altering the physical environment in the marsh, the expansion of *Phragmites* can result in the decline of wildlife habitat, including that needed to support migratory bird assemblages and native, resident animal species (Raichel, et al., 2003; Shriver, et al., 2004; Guntenspergen and Nordby, 2006; Wells, et al., 2008). Although the positive and negative impacts of *Phragmites* can vary by taxa, species, and life stage (Kiviat, 2010), it has been shown to be detrimental to many of the conservation priorities at the Reserve. For example, *Phragmites* is used as foraging and roosting habitat for various bird species (Kiviat, 2005). However, the breeding activity of marsh-dependent bird species found at the Reserve, such as marsh wren and least bittern, is often lower in *Phragmites* than in other plant communities (Kiviat and Talmage, 2006; Wells, et al., 2008; Kiviat, 2010).

*Phragmites* proliferation can carry negative social and economic consequences, too. Thick patches of *Phragmites* reduce access for boating, fishing, and bird watching in nearby river areas, and they create potentially serious fire hazards to structures due to the amount of standing dry biomass during the dormant season (Niering and Warren, 1980).

Other non-native invasive species have been documented both within (e.g., purple loosestrife) and around the periphery of the marsh (e.g., Asiatic bittersweet, Japanese knotweed). Although populations of these species have the potential to expand and impact native ecological communities, staff have determined that they do not pose an immediate threat to critical resources within the Reserve.
Visitor Impacts

The north end of Piermont Marsh, especially the area south of the Kroomis Kill that has several shallow ponds or pannes, has been the focus of concentrated study by scientists and students who access it by canoe and informal foot paths. These paths have widened over time and multiplied as the marsh surface has broken down and visitors sought firmer ground. Areas around the pannes have become trampled, with a loss of vegetation cover. Research equipment and markers have been left in place long after projects have been completed. Marsh managers are exploring options to improve researcher access, and are more actively managing research activities in the marsh to protect marsh surface integrity, maintain vegetation, and reduce human impacts on habitat.

Water Quality

Since 2010, the lower Sparkill Creek has been on the Section 303(d) List of Impaired Waters (NYSDEC, 2016). Aquatic life and recreational uses are impaired by pathogens, organic inputs, nutrient enrichment, and toxicity attributed to sewage discharges and urban runoff.

While water quality, nutrient loading, and fecal contamination issues are a concern within the Sparkill Creek, they do not currently pose a significant threat to the marsh. The interior of the marsh is irregularly flooded, so the daily tide cycle only influences the marsh and tidal creek edge to about 60 feet from the closest water source, either Sparkill Creek, other tidal creeks, or the Hudson River. This water is only reaching the interior of the marsh 10-12 times a month (Montalto, et al., 2006). Most of the research linking nutrient enrichment to marsh loss has focused on tidal, low-marsh systems that are frequently flooded (Blum, 1993; Darby and Turner, 2008a; Darby and Turner 2008b; Turner, 2011; Anisfeld and Hill, 2012; and Deegan, et al., 2012). However, recent studies of nutrient enrichment on high-marsh systems with less frequent inundation, lower salinities, and perennial grass and sedge dominance like Piermont Marsh suggest that moderately elevated nutrient levels may not impede the growth of native grasses (Wejrowski, 2013) and, in some cases, may give plants the enhanced ability to tolerate sea-level rise (Langley, et al., 2013).

Erosion

Slump-block erosion has been observed along the Hudson River shoreline of Piermont Marsh. Fresh slump-block undercutting and calving is visible along much of the shoreline. This erosion can occur when the relatively unconsolidated sediments that underlie the vegetative rhizome layer of the marsh are dislocated by hydraulic...
turbulence, leaving the rhizome layer above it intact. Eventually, the rhizome layer becomes completely unsupported by the sediments, and blocks of vegetated marsh (still held together by the rhizome and root network) fall into the river. HRNERR staff have compared the morphology and location of the marsh edge over time and found the average rate of erosion between 1926 and 2013 to be approximately 0.5-1 ft/year (B. DeGasperis, pers. comm., July 24, 2015).

![Slump block caused by erosion along the Hudson River shoreline of Piermont Marsh (Photo by AKRF, Inc.)](image-url)
EXISTING CONDITIONS AND MANAGEMENT

PUBLIC ACCESS

Access to the interior of Piermont Marsh is inherently limited by soft soils, tides and intermittently flooded conditions, a network of tidal creeks, and dense vegetation. The tidal creeks and marsh edges are best viewed by canoe or kayak. However, residents and visitors can enjoy close views of Piermont Marsh and its adjacent shallows from several land locations in the Village of Piermont and Tallman Mountain State Park. These access points are described below.

Access to DEC lands at the Piermont Marsh Reserve is via Paradise Avenue and Ferry Road in the Village of Piermont. Parking is available in the Village’s parking area on Paradise Avenue, adjacent to the ball field. DEC lands adjoin the south side of Piermont Pier, which extends one mile into the river and provides the northern boundary of the Reserve, although it is not part of it. A DEC parking area at the east end of the pier on the south side of the road provides free parking for 12 vehicles. Parking outside this area is by local permit only. From Piermont Pier, visitors have exceptional views of the marsh, shallows, Hudson River, and Tappan Zee.

Access to PIPC-held uplands adjacent to Piermont Marsh is via a bike and foot trail in Tallman Mountain State Park along the marsh edge. Views of the marsh and the Tappan Zee can be enjoyed from a scenic overlook within the park from the north picnic area. Both Piermont Pier and the bike/foot trail are level, firm ground and generally accessible to people with disabilities. Parking is available near the swimming pool in the park.

The accessibility of state lands within and adjacent to the Piermont Marsh Reserve, including parking areas, interpretive signs, and trails, has not yet been evaluated with respect to compliance with the Americans with Disability Act.

INTERPRETIVE SIGNS

Several years ago, DEC installed a three-sided interpretive kiosk overlooking the marsh on PIPC lands at the east side of the pathway near the swimming pool. Low-profile wayside signs interpreting the marsh were also installed on DEC lands in a small park on Paradise Avenue, although these require frequent cleaning to remain visible. More recently and with the support of the village and a community member, DEC worked with an eagle scout who rebuilt and

Newly installed Fishes of the Hudson River interpretive sign on Ferry Road (Photo by Chris Bowser, DEC)
replaced a *Fishes of the Hudson River* interpretive sign on DEC lands near the dogleg on Ferry Road.

**CULTURAL AND HISTORICAL RESOURCES**

Little is known about historic sites and cultural artifacts within and adjacent to the marsh. Virtually all PIPC lands within the Reserve are tidal wetlands. DEC lands include a mix of tidal wetlands and upland fill associated with the original construction of the pier and railroad yard. Pilings that remained from an old ferry dock on the south side of the east end of the pier have gradually worn away from storms and ice. Docks that extended across the shallows to the channel south of the pier have similarly been erased with time.

**RECREATIONAL USES**

**Fishing**

The Piermont area offers excellent warm water recreational fishing opportunities that vary seasonally and from year to year, with blue crabs and both marine and estuarine fish present. People typically fish both the shallows adjacent to Piermont Pier at the north end of the Reserve, as well as the deeper waters at the end of pier. The area is notable for striped bass in spring and blue crabs in summer. In dry years, when river water is saltier due to limited freshwater inflow, marine species such as bluefish are occasionally present.

**Bird Watching**

The Piermont area also offers excellent bird-watching opportunities in and along the marsh and river. Piermont Pier is recognized by the Rockland Audubon Society as a local birding hotspot (http://www.rocklandaudubon.org/HOTSPOTS.htm). Rockland Audubon’s website lists a wide variety of resident and migratory songbirds, waterbirds, and birds of prey, as well as migrants, escapees, and other unusual birds by season.

**Paddling**

The shallows and tidal creeks of Piermont Marsh are best experienced by canoe or kayak, though visitors would do well to avoid low tides when waters can become too shallow to navigate, and soft mudflats are exposed. Canoes and kayaks are available
for rent from a canoe livery located along the Sparkill Creek on Paradise Avenue. Visitors with their own canoes may also park in the DEC lot near the end of Piermont Pier and hand launch from the shoreline.

Hunting and Trapping

Hunting at Piermont Marsh is currently limited to waterfowl in the shallow water areas under DEC and OGS jurisdiction at the northern and southern ends of the Reserve (see Figure 2). Hunting is not allowed in any portion of the Reserve owned by OPRHP. The presence of residential and commercial development adjacent to the north end of the marsh restricts, but not does prohibit, waterfowl hunting over water. Per state regulations, waterfowl hunting with a firearm or bow, over water, is allowed near dwellings or public structures as long as neither are within 500 feet (for a firearm) or 150 feet (for a bow) in the direction of discharge. DEC will facilitate waterfowl hunting access by allowing hunters to use the existing public hand launch for canoes, kayaks, and other appropriate watercraft.

Recreational trapping is not permitted within the Piermont Marsh Reserve.

VISITOR-USE REGULATIONS

Both DEC and OPRHP/PIPC lands are closed during hours of darkness. All regulations on public use of state-owned tidal wetlands apply. Permitted uses at and near the Piermont Marsh Reserve include: nature study, hiking, canoeing, boating, and picnicking at day-use facilities located in adjacent Tallman Mountain State Park, and mountain biking along the Tallman Mountain bike trail. Fishing is permitted, and a valid state fishing license is required to fish on tributaries to the Hudson River. Prohibited activities include: camping, swimming, trapping and operating all-terrain vehicles and motorized personal watercraft including, but not limited to, Jet Skis®, WaveRunners®, Sea-Doos®, wet bikes, and surf jets. As indicated above, hunting is limited to waterfowl and only allowed on the shallow water areas under DEC and OGS jurisdiction. Collection of plants, animals, artifacts or any other materials is strictly controlled and requires one or more state and/or HRNERR permits. A permit is required to conduct research in the marsh. The HRNERR research guidelines and OPRHP research permit application can be found in Appendices B and C, respectively.
EDUCATION ACTIVITIES

Public Education Programs

Piermont Marsh and areas adjacent to Piermont Pier are used for a variety of formal and informal education programs. These include middle and high school field programs on the pier hosted by partners at the Lamont-Doherty Earth Observatory, work in the marsh by the Lamont-Doherty Secondary School Field Research Program (see below), public fishing programs hosted by HRNERR educators and DEC’s I Fish NY Program, and public canoe trips offered by DEC.

Lamont-Doherty Secondary School Field Research Program

The Lamont-Doherty Secondary School Field Research Program is operated in consultation with the Reserve and PIPC using Piermont Marsh as the main research site. Founded in 2005 by Lamont-Doherty Earth Observatory scientists, this program brings high school teachers and their students together with Lamont-Doherty scientists for six weeks in the summer to do research projects on plants, fish, water quality, soils, and other topics. The program works with teachers and students from several New York City public high schools, including the Young Women’s Leadership Schools of East Harlem and Queens and the Urban Assembly New York Harbor School. Participants include a high percentage of typically under-represented groups in science, technology, engineering, and math programs, including women, underserved ethnic groups, and students from a diverse range of economic backgrounds. The program has been successful in attracting students and affirming their interest in science and technical careers.

STEWARDSHIP

Ferdon Pond Dam Eel Ladder

HRNERR staff designed and installed a suspended eel ladder for assisting juvenile eels in their passage up the Sparkill Creek from the Hudson River to the watershed. This unique trap-and-pass “eel-evator” was created for use on the Ferdon Pond dam, the first barrier upstream of tidewater. It is small and lightweight and was designed to be safely lifted and lowered from a sturdy walkway at the top of the dam. It will be deployed each spring and removed for the winter, in cooperation with the Village of
Piermont, the Rockland County Division of Environmental Resources, and several volunteer residents.

Pilot Phragmites Control

Beginning in 2014, the Lamont-Doherty Secondary School Field Research Program undertook a series of pilot Phragmites control projects. Students used black geotextile to cover small areas of previously flattened Phragmites in the northeast part of the marsh to deprive the plants of sunlight, and in time kill the rhizomes (underground horizontal stems) and roots. It presented an opportunity to study the impacts of this technique on the seed bank, recovery patterns, and sediment surface, among other effects. Marsh managers will work with program leaders to determine how best to advance this project, including duration of the experimental approach, monitoring strategies, and next steps.

RESEARCH AND MONITORING

The National Estuarine Research Reserve System (NERRS) mission specifies that reserves are protected and managed to afford opportunities for long-term research, particularly work that addresses coastal management issues identified as significant. HRNERR seeks to promote federal, state, public, and private use of its sites to conduct estuarine research. The following sections briefly describe recent management-oriented research and monitoring at Piermont Marsh.

Vegetation Mapping

DEC co-produced vegetation maps for all four HRNERR sites in 1991, 1997, and 2005. These were delineated from aerial photographs interpreted for 20 categories of tidal wetland vegetation and field checked. Multiple inventories were conducted so that vegetation change over time could be analyzed. In addition, Piermont Marsh was included as part of a 2007 tidal wetlands inventory (interpreted for 13 vegetation categories) produced for the entire Hudson River estuary. Most recently, vegetation was inventoried at Piermont Marsh in 2014 and 2015 by the New York State Thruway Authority’s consultant AKRF, Inc. Two of these ArcGIS maps (Hudson River NERR Vegetation, 2005 and Hudson River Estuary Tidal Wetlands, 2007) are available to the public via the NYS GIS Clearinghouse (http://gis.ny.gov/). Other ArcGIS maps and project reports are available through HRNERR.
Water Quality Monitoring

As part of the NERRS System-Wide Monitoring Program (SWMP), HRNERR staff have collected a time series of water quality parameters (temperature, salinity, total suspended solids, dissolved oxygen, pH) and nutrient concentrations (ammonia, nitrate, phosphate, sulfate, chloride and chlorophyll a) within Piermont Marsh and Sparkill Creek since 1991. The use of standardized instrumentation and protocols for data collection at reserve sites across the country establishes the NERRS as a coordinated network of coastal observation sites for detecting and understanding environmental change.

Surge, Wave, and Tide Hydrodynamics (SWaTH) Network

Following Post-Tropical Cyclone Sandy in 2012, the United States Geological Survey (USGS) began construction of an overland Surge, Wave, and Tide Hydrodynamics (SWaTH) Network along the northeastern Atlantic Coast, from North Carolina to Maine. This network of collaborating partners features the integration of long-term tide gage networks, with real-time rapid-deployment gages and mobile storm-tide sensors. The USGS installed receiving brackets in 2016 north and south of Piermont Pier, co-located with a real-time gage at end of the pier and deployed in a transect of three sensors perpendicular to the shoreline through the marsh. Brackets were surveyed to permit rapid deployment and recovery of instruments and data dissemination in the hours and days immediately after an event. USGS will deploy sensors only during severe nor’easters or tropical cyclones. Sensors installed surrounding the pier will provide information on tidal and wave characteristics, timing and extent of inundation, and interactions with local landforms. In addition, the sensor transect through the marsh will provide information on how vegetation dissipates wave-setup and inform management for community and marsh resiliency.

Sediment-bound Contaminant Resiliency and Response (SCoRR) Network

The USGS Sediment-bound Contaminant Resiliency and Response (SCoRR) Project has been implemented from Maine to Virginia to accomplish the following objectives: 1) develop a strategy to assess sea-level rise and storm-derived changes in contaminant threats to humans and ecosystems; 2) demonstrate the strategy by conducting a pilot implementation in the northeastern U.S.; and 3) deliver interpretive products that map, measure, and evaluate vulnerability from contaminant threats. In response to the potential landfall of Hurricane Joaquin, the SCoRR team collected a baseline sediment core sample from Piermont Marsh adjacent to the swimming pool at Tallman Mountain State Park on October 15, 2015. Samples are being analyzed by four different USGS laboratories, and data will be publicly released through the USGS SCoRR mapper. The SCoRR team plans to collect a comparison sample after the impact of a significant storm surge.
Other Scientific Activity at Piermont Marsh

Many scientists from a wide variety of institutions have used Piermont Marsh as a research site to explore many topics. A bibliography of scientific reports and published work is available from the HRNERR research coordinator. Several scientists have been based at the nearby Lamont-Doherty Earth Observatory and Columbia University. Many graduate and undergraduate student projects related to Piermont Marsh have been fostered and partially supported by HRNERR, including one NERRS Graduate Research Program project and 21 Polgar Fellowship Program projects. The Tibor T. Polgar Fellowship is a student research program by the Hudson River Foundation in cooperation with HRNERR to provide a summertime grant and research funds for eight graduate and undergraduate students to conduct research on the Hudson River. The objectives of the program are to gather important information on all aspects of the Hudson River, with a concentration on the four marshes of HRNERR, including Piermont Marsh. Application information and a complete set of Polgar Fellowship reports can be found at www.hudsonriver.org/?x=polgar.

Scientific Research Permits

DEC and OPRHP instituted a research permit requirement and process for planning work in Piermont Marsh. All researchers are required to obtain a research permit from OPRHP before undertaking work at the Piermont Marsh Reserve. Applications to obtain a research permit are reviewed by OPRHP/PIPC biologists and the HRNERR research coordinator to prioritize space assignments, minimize conflicts among research projects, manage environmental impacts, and ensure compliance of projects with all regulations and standards. The HRNERR research guidelines and OPRHP research permit application can be found in Appendices B and C, respectively.
MANAGEMENT APPROACH

PLANNING PROCESS

DEC and OPRHP staff have collectively developed this plan over the course of two years, following extensive engagement with leaders of the Village of Piermont and Rockland County, residents, and people representing a broad range of environmental, research, and educational interests on the topics of marsh management and the marsh’s role in protecting the Village.

Scoping

Following the April 2013 announcement that Piermont Marsh was to be the site of a habitat restoration project focused on enhancing the marsh community, as part of the mitigation for construction of a new Tappan Zee Bridge, village leaders and residents expressed keen interest in the project.

Beginning in summer 2013, DEC and OPRHP staff met with ten different committees and organizations to listen to ideas and concerns about this project. One significant concern was the potential impact of marsh management on storm risk and community resiliency, especially in the wake of Post-Tropical Cyclone Sandy’s $20 million of damage to the Village. A second prominent concern centered on the potential human health and ecosystem impacts of herbicide use in proximity to the Village. Other issues were identified as well. Some wished to retain *Phragmites* for its aesthetic value, while others desired a return to historic village views of the marsh that are now blocked by *Phragmites*. Many were concerned that underlying water quality had been a driving factor in the shift from native to non-native vegetation, and that agency budget constraints will preclude long-term maintenance of any restored areas.

Subsequently, four fact-finding meetings were held in 2014-2015 on technical topics to address community questions and inform management planning. Each forum featured invited experts on the meeting topic. Topics included Piermont Marsh habitats and biological diversity (September 30, 2014), water quality and the marsh (November 13, 2014), the marsh’s role in providing storm protection for the Village (January 7, 2015), and marsh vegetation management options (May 21, 2015). Meeting summaries and presentations are available at:

https://www.hrnerr.org/piermont-marsh/.
Goal Setting

The following four goals were established for Piermont Marsh. Development of these goals was heavily informed by extensive public comments, derived from agency missions and policies, and developed to be consistent with the HRNERR Revised Management Plan, the Piermont Marsh Significant Coastal Fish and Wildlife Habitat designation, and neighborhood-based recommendations for Piermont Marsh in the Piermont Waterfront Resilience Task Force’s Resilience Roadmap (2014).

Goal 1: Maintain or enhance the Piermont Marsh Reserve’s ability to provide storm protection for neighboring landowners.

Goal 2: Sustain the presence of native marsh communities and the biological diversity they support.

Goal 3: Promote the structural and functional resiliency of the Piermont Marsh Reserve to storms, sea-level rise, and other disturbances.

Goal 4: Increase scientific knowledge, public understanding, and public use and enjoyment of the marsh.

Plan Development

To achieve these goals, agency staff developed and considered several potential management scenarios through a detailed, multi-step process. Staff reviewed published literature about the marsh and consulted with past and current researchers. They collected new information about marsh habitats, trends, and conditions via field surveys and new vegetation mapping. They reviewed many case studies of habitat restoration and considered the results of sea-level rise and marsh inundation modeling (Tabak, et al., 2016). They also researched and assessed alternative vegetation management approaches.

The result is this draft plan, which is intended to be a conservative, balanced approach to marsh management for the next ten years, one that will yield highly relevant information about the role of Phragmites in buffering the southern portion of the Village from waves and storm-borne debris; inform us about how the marsh is keeping up with sea-level rise and how management can foster the long-term survival of the marsh; help restore rich natural communities that support fish and wildlife; and provide a foundation for understanding and appreciating the marsh.

MANAGEMENT OBJECTIVES

The following management objectives fall under the four goals identified by DEC and OPRHP in 2013. These were shaped not only by the significant ecological features, threats, and opportunities at the site, but also by stakeholder interests in the marsh.
Goal 1: Maintain or enhance the Piermont Marsh Reserve’s ability to provide storm protection for neighboring landowners.

  o **Objective 1.1:** Through 2026, retain at least 85% of the marsh surface (over 200 acres) as an unmanaged vegetative buffer to dissipate wave energy and filter storm debris on the south side of the Village and along the shoreline near Palisades.

  o **Objective 1.2:** By 2019, work with the Village and other partners to develop predictive models of climate, coastal, and ecological processes to evaluate alternative marsh management scenarios, especially their impacts on wave attenuation and debris removal.

Goal 2: Sustain the presence of native marsh communities and the biological diversity they support.

  o **Objective 2.1:** By 2026, restore native ecological communities on up to 40 acres of brackish tidal marsh.

  o **Objective 2.2:** Within the designated restoration area, increase the abundance of marsh specialist birds and marsh breeding birds by 25% over the next five years.

  o **Objective 2.3:** Over the next ten years, increase the abundance of larval and juvenile marsh surface fishes by 15% in the designated restoration area.

Goal 3: Promote the structural and functional resiliency of the Piermont Marsh Reserve to storms, sea-level rise, and other disturbances.

  o **Objective 3.1:** Over the next ten years, monitor sediment accretion rates in both actively managed and unmanaged areas in the marsh, and identify the range of marsh surface elevations needed in actively managed areas to keep pace with sea-level rise and support target plant communities.

  o **Objective 3.2:** Over the next ten years, minimize visitor impacts to the surface of the marsh.

Goal 4: Increase scientific knowledge, public understanding, and public use and enjoyment of the Piermont Marsh Reserve.

  o **Objective 4.1:** By 2018, evaluate the Piermont Marsh Reserve’s accessibility and compliance with the Americans with Disabilities Act and comparable state legislation, and by 2019 assess the need for and feasibility of developing increased public access for everyone, including people with disabilities.

  o **Objective 4.2:** Increase marsh education opportunities by offering public field programs (at least two per year), school programs (number to be determined),
and public presentations (one to two per year), and update and increase public access to information about the marsh.

- **Objective 4.3:** Create new opportunities for citizen engagement in stewardship of Piermont Marsh.

- **Objective 4.4:** Implement a research agenda to increase scientific knowledge about the marsh and generate information pertinent to marsh management.

**MANAGEMENT ACTIONS**

The following sections detail management actions that will enable Piermont Marsh Reserve managers and partners to realize the goals and objectives defined above. We have developed these actions based on the current state of knowledge about the Reserve and an exploration of alternative ways to meet the management objectives. As we implement them, we will monitor to learn about the impacts of these management actions, use the results to update and supplement our knowledge, and adjust management actions accordingly. Our focus will be on learning and adapting, through partnerships of managers, scientists, and other stakeholders who collaborate to create and maintain a sustainable Piermont Marsh.

**Goal 1: Maintain or enhance the Piermont Marsh Reserve’s ability to provide storm protection for neighboring landowners**

**Retain Vegetated Storm Buffers**

**Objective 1.1**

For the next ten years, a one-half-mile vegetated buffer will be retained south of the Village of Piermont to maintain Piermont Marsh’s storm-buffering capacity for neighboring landowners (Figure 6). This buffer will extend from the Village south to Crumkill Creek. A second large vegetated buffer will be maintained in the southern part of the marsh, from the Sneden’s Landing area of Palisades north approximately one-half mile. Together, these vegetated buffers, dominated by *Phragmites*, constitute 85% of the marsh and over 200 acres. Only limited vegetation management, associated with small-scale experimental research, will be permitted in these areas. Protection of these very large buffers is a highly conservative approach pending the results of the collaborative study described in the following section. This study will inform subsequent decisions about the size and composition of the buffers to be maintained long term.
Figure 6. Vegetated storm buffers to be retained at Piermont Marsh Reserve
Evaluate Piermont Marsh's Role in Storm Protection

Objective 1.2

In response to strong community interest, HRNERR worked with a group of partners to develop and fund a three-year collaborative research program to evaluate alternative marsh management scenarios and the coastal protection benefits the marsh provides. The team will develop predictive models of climate, coastal, and ecological processes. These will be used to evaluate how existing and hypothetical marsh management might affect the kinds and degree of storm protection afforded by the marsh for the Village of Piermont. Choices about marsh management scenarios and products will be made in consultation with the Piermont Waterfront Resilience Commission, and information about the project will be shared with the community, also in consultation with the Commission.

The project team includes researchers, marsh managers, and community representatives from the University of Florida, University of Miami, NASA Goddard Institute, United States Geological Survey, Hudson River National Estuarine Research Reserve, Palisades Interstate Park Commission, the Consensus Building Institute, and the Piermont Waterfront Resilience Commission. This project began in November 2016. The research was funded by the National Estuarine Research Reserve System Science Collaborative.

Goal 2: Sustain the presence of native marsh communities and the biological diversity they support

Restore Priority Ecological Communities in Center of Marsh

Objectives 2.1, 2.2, and 2.3

Native Marsh Restoration

A maximum of 40 acres, which represents approximately 15% of the entire marsh, will be restored in three success-dependent phases over the next ten years through a partnership among the New York State Thruway Authority (as partial mitigation for impacts on habitats associated with construction of the Governor Mario M. Cuomo Bridge), DEC, and OPRHP (Figure 7). A detailed implementation plan is being developed to guide the three phases of this project, which will begin with 10 acres in 2018 (Figure 8, Table 4). The restoration area is located in the middle of the marsh, more than one-half mile from both the Village of Piermont and Palisades. This site was selected because it supports existing native plant communities, it is as far as possible from neighboring landowners, and it is mostly surrounded by river or tidal creeks, which are natural barriers to Phragmites reinvasion.
Figure 7. Potential restoration area south of Crumkill Creek
Figure 8. Phased restoration of up to 40 acres south of Crumkill Creek
Table 4. Proposed schedule for restoring native marsh communities

<table>
<thead>
<tr>
<th>Task</th>
<th>Acreage</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>10</td>
<td>2018</td>
</tr>
<tr>
<td>Phase 2</td>
<td>15</td>
<td>2021*</td>
</tr>
<tr>
<td>Phase 3</td>
<td>15</td>
<td>2024*</td>
</tr>
<tr>
<td>Long-Term Maintenance</td>
<td>40</td>
<td>2025 onward</td>
</tr>
</tbody>
</table>

Movement to the next phase of restoration is contingent upon meeting performance benchmarks established for the previous phase. As such, the schedule for Phases 2 and 3 is subject to change based on the results of post-treatment monitoring.

Native ecological communities currently comprise approximately 12% (five acres) of the restoration area. As is the case marsh-wide, the expansion of *Phragmites* directly threatens the persistence of these existing native communities. Therefore, management actions in this area will focus on restoring and expanding existing priority ecological communities by reducing invasive *Phragmites* cover.

*Phragmites* control will be achieved using a combination of methods, including mowing, wetland-approved herbicide application, and solarization (covering with geotextile). These techniques have been successfully used to restore desired natural communities, rare plants, and marsh-nesting birds at the Iona Island Reserve, Constitution Marsh, Tivoli Bays, and other tidal marshes in the region. The Piermont Marsh Reserve project will benefit from lessons learned in the past two decades about the timing of treatments, feasibility and efficacy of methods, and restoration of native plants and animals.

When applied according to label instructions and applicable legal requirements using ground-based equipment, herbicide is an approved and highly effective method (True, et al., 2010) for controlling *Phragmites* and the primary tool used by land managers in North America (Hazelton, et al., 2014). While alternative control methods have merit in some contexts, they are not practical or feasible as solitary treatments for managing *Phragmites* in these environmental conditions and at this scale (Kiviat, 2010; Ontario Ministry of Natural Resources, 2011; Findlay, et al., 2014). See Appendix A for an evaluation of *Phragmites* management methods for Piermont Marsh.

During Phase 1, approximately ten acres of *Phragmites* will be controlled using a limited ground-based application of an aquatic formulation of glyphosate in combination with a non-ionic surfactant, which helps the herbicide coat and penetrate the leaf surface so it can be absorbed and transported to the plant roots and rhizomes. Glyphosate is a non-selective, systemic herbicide that controls weeds by inhibiting a specific pathway for amino acid synthesis that is unique to plants and not present in animals. Only certain formulations of glyphosate are registered for aquatic use (e.g., Rodeo®, AquaPro®, Aquamaster®) by the United States Environmental Protection Agency (EPA) and approved for use in New York State. The terrestrial formulations of glyphosate (e.g., Roundup Pro®, Landmaster®, Ranger Pro®) differ from those registered for aquatic use in that they often contain other ingredients that are added to increase their effectiveness. Improper use of terrestrial formulations in aquatic habitat is a violation of state and federal laws.
During the winter preceding the initial herbicide treatment, the Phase 1 site will be mowed to remove the dead standing *Phragmites* stems from the previous growing season. Mowing the site in advance of the herbicide application will improve the efficacy of the chemical treatment by clearly delineating the management area and increasing access to live *Phragmites* stems. Herbicide treatment will take place over 1-3 days in late August through September and only under optimal weather and tidal conditions to minimize non-target impacts. Where *Phragmites* is mixed with native vegetation, herbicide will be applied by a certified pesticide applicator, or someone working under their direct supervision, using a low-volume spot treatment method (e.g., backpack spraying, stem injection, etc.). In areas where *Phragmites* is dominant, herbicide will be applied by a certified pesticide applicator, or someone working under their direct supervision, using a sprayer on a small amphibious vehicle that is capable of driving across the marsh surface. The treatment area will be mowed during the winter following herbicide application to mulch the dead plant material and accelerate the establishment and growth of native plant species. In the years following the initial treatment, low-level maintenance spraying will likely be necessary to address any remaining *Phragmites* or incipient invasions. Geotextile will be installed along the southern boundary of the restoration area to create a barrier to limit *Phragmites* reinvasion from adjacent unmanaged areas. The remaining three sides of the restoration area are bordered by water, which will serve as a natural barrier to *Phragmites* reinvasion.

Restoring native plant communities in the central portion of the marsh while retaining extensive *Phragmites*-dominated buffers to the north and south, will promote a mosaic of habitats across the Reserve to meet multiple goals and objectives. *Phragmites* control will promote the reestablishment of native ecological communities, including brackish tidal marsh, high salt marsh, and low salt marsh. These native communities complement the habitat values and ecosystem services *Phragmites* provides by adding structural and functional complexity to the marsh and serving as important nursery habitat for marsh fish and as foraging, nesting, and migratory stop-over habitat for marsh birds.

**Herbicide Monitoring and Data Sharing Program**

The aquatic formulation of glyphosate has been reviewed and approved by both the EPA and New York State for use in wetlands, and the treatment area is a significant distance from both the Village of Piermont and Palisades. However, given the community concerns about potential herbicide exposure, DEC and OPRHP will establish an herbicide monitoring and data sharing program to evaluate and document herbicide use and evaluate whether herbicide moves beyond the treatment areas. The program will be developed in close consultation with local representatives, marsh managers, and pesticide regulators. The monitoring will evaluate herbicide levels prior to, during, and after treatment using best available techniques. Information will be posted on a publicly accessible website as soon as analyses are completed.

**Restoration Monitoring**
Extensive pre- and post-treatment monitoring will be conducted according to a detailed monitoring plan to assess native marsh recovery and resiliency, including changes in marsh elevation, biota, sediment accretion, and hydrology. Monitoring data will be used to evaluate progress toward restoration goals and detect and address any issues through an adaptive management process. Performance benchmarks (e.g., achieving ≥ 75% native plant cover) will be used to appropriately time the three phases of the project. Movement to the next phase of restoration will occur only after all established benchmarks for the previous phase have been met. If performance benchmarks are not reached, restoration will not proceed to the next phase, and corrective actions will be taken as needed.

Phases 2 and 3 will each add approximately 15 adjoining acres of restored marsh. Pending a comprehensive evaluation of Phase 1, the proposed methods for implementing and monitoring these subsequent phases are the same as described above.

**Install Bird Nest Boxes and Platforms**  
**Objective 2.2**

For many bird species, the availability of nesting sites is a limiting factor. Where natural nesting sites are in short supply, artificial nest boxes and platforms can provide birds with an alternative. While they cannot fully replace natural nesting sites, artificial nesting structures can enhance wildlife habitat and increase bird densities and diversity. To that end, an osprey nesting platform and nest boxes for purple martins (*Progne subis*) and tree swallows (*Tachycineta bicolor*) will be erected at various locations within the Reserve. Nest boxes will be mapped and monitored to ensure their use by target species. Monitoring is a critical part of a nest box program to avoid promoting the proliferation of non-native species and ensure that boxes are maintained in good condition.
Goal 3: Promote the structural and functional resiliency of the Piermont Marsh Reserve to storms, sea-level rise, and other disturbances.

Monitor Marsh Surface Elevation and Rates of Sediment Accretion

Objective 3.1

The HRNERR Research Program will implement monitoring protocols that will qualify Piermont Marsh as a NERRS Sentinel Site for analyzing the impact of sea-level rise on tidal marsh habitat. This national initiative includes the installation of surface elevation tables (SETs) and use of feldspar horizon markers to track changes in the elevation of the marsh surface over time. SET data combined with tidal datums and inundation patterns will show whether sediment accretion in Piermont Marsh is keeping pace with sea-level rise. Additional vegetation data will show whether climate-change stressors are causing shifts in the plant communities. These protocols will be implemented both within the Phragmites treatment area and in a reference area that will not be treated to test whether Phragmites treatment impacts the marsh’s resilience to climate change. The DEC and OPRHP/PIPC restoration team will identify the range of marsh surface elevations needed in actively managed areas to keep pace with sea-level rise.

Reduce Visitor Impacts to Marsh Study Areas

Objective 3.2

Piermont Marsh is an excellent venue for conducting marsh research and training young scientists. Several investigators have explored interesting and important topics in the marsh, primarily accessing the sites by canoe and a network of pathways. We previously noted that foot traffic in the marsh has resulted in damage to the marsh surface integrity, particularly in the northern half. To minimize further impacts and to foster marsh recovery, DEC and OPRHP/PIPC will explore options for installing elevated walkways primarily intended to get researchers to and from research sites in consultation with the research community actively using Piermont Marsh. One option is to install permanent walkways along the most intensively used routes and to supplement these with short extensions to less-visited sections of the marsh using footers and moveable decking. For any of these improvements we will seek to minimize impact; all will require a tidal wetlands permit prior to construction.
Goal 4: Increase scientific knowledge, public understanding, and public use and enjoyment of the Piermont Marsh Reserve.

Explore Opportunities to Enhance Public Access
Objective 4.1

DEC and OPRHP access experts will evaluate the site’s accessibility and compliance with the federal and state legislation (e.g., Americans with Disabilities Act) and assess opportunities to enhance access for everyone, including people with disabilities.

Several residents expressed interest in having a boardwalk to view portions of the marsh interior, and others recommended that a boardwalk be built on DEC lands north of Sparkill Creek. We took a close look at this idea and met with both the mayor and area educators to walk the site and explore the desirability and usability of such a trail/boardwalk. The proposed route would begin at Rittenberg Field and follow along the Sparkill Creek before looping north to rejoin Ferry Road near the dogleg. It would cross the old landfill, which has refuse and debris emerging at the surface, and tidal wetlands along the east side. Unless the trail is routed directly along the shoreline, *Phragmites* would significantly limit visibility. The route was evaluated based on whether it would substantially add to the waterfront access already present in the village, augment opportunities for education about the marsh, and/or likely be used by residents, visitors, or educators. Given Piermont’s remarkable waterfront access for pedestrians and several areas that currently serve as outdoor classrooms, we determined that this new trail/boardwalk route did not generate any significantly novel opportunities for access. We also considered installation and maintenance challenges, particularly routing over the landfill and repairing after storm damage, before ruling out this option.

DEC and OPRHP/PIPC recognize that opportunities to experience the marsh interior are currently limited. We will explore a potential route for a marsh boardwalk in another part of the marsh in consultation with the village and interested residents. Any future construction will need to be consistent with tidal wetlands regulations, stewardship of the marsh, accessibility needs, and the agencies’ ability to provide maintenance.

Increase Marsh Education Opportunities
Objective 4.2

Interpretive Information

DEC will update interpretive information about the marsh and explore ways to make this information available online, on site, and through other avenues, potentially local partnerships.
School and Public Programs

In 2016, HRNERR expanded existing and developed new education opportunities at Piermont Marsh and in the adjacent community. HRNERR staff will continue to consult with local organizations and individuals to explore education programs that will meet local needs and be sustainable over the long term. Programmatically, this will include a modest but consistent number of school and public offerings implemented directly by DEC education staff, as well as additional support for regular programming by local partners.

Public Forums on Science in the Marsh

HRNERR, working with partners, will organize periodic presentations about current research on marsh buffers and other topics, and on the marsh restoration project, showcasing interesting, important, and unusual findings. We anticipate these will take place once or twice a year, depending on local interest.

Create Opportunities for Citizen Engagement in Stewardship
Objective 4.3

Citizen Science

The Ferdon Pond dam eel ladder will be installed each spring and removed before winter, assuming it passes eels and retains needed community support. Community and student volunteers, under the supervision of DEC staff in partnership with the Rockland County Division of Environmental Resources, will count eels trapped in the eel ladder on their migration from the Sargasso Sea to freshwater habitats, and pass them upstream, where they will grow to adulthood.

Installation and Monitoring of Nest Boxes and Platforms

Volunteer partners from local communities and/or members of the Palisades Interstate Park League of Naturalists, will be sought to build and monitor nest boxes for selected birds in and adjacent to the marsh, in coordination with OPRHP and DEC. Monitoring data will be collected by volunteers and retained in a long-term database.
Coastal Cleanups

DEC will seek partners, such as Keep Rockland Beautiful, to host or co-host periodic marsh and shoreline cleanups to remove marine debris that may be hazardous to wildlife and/or a potential source of pollution.

Increase Scientific Knowledge about Piermont Marsh

Objective 4.4

In addition to the ongoing research and monitoring described in the “Existing Conditions and Management” chapter, DEC and OPRHP will advance research about the Piermont Marsh Reserve in several ways, including: 1) implementing priority research projects; 2) fostering and tracking other scientific research; and 3) promoting funding for and attention to other priority management information needs. A research permit system exists and will be used to track research projects, reduce visitor impacts, and provide a vehicle for sharing information among researchers and with the public.

The following research priorities and information needs were identified during the fact-finding and management planning processes by agency staff, community members, and a team of local scientists at the Lamont-Doherty Earth Observatory.

Research Priorities

In addition to the habitat restoration and sentinel site monitoring described above, the following projects will inform adaptive management actions in the Piermont Marsh Reserve.

Investigate options for minimizing marsh edge erosion and promoting lateral accretion

Tidal marshes can experience significant land loss through erosion and retreat of their perimeter edges. As waves intercept the marsh edge, they can dislodge sediment and remove pieces of marsh, leading to a lateral retreat of the edge and loss of marsh area. Sea-level rise is predicted to cause more rapid erosion of marsh boundaries due to increases in water depth and wave heights. The installation of sills, artificial reefs, protective breakwaters or other subtidal structures could potentially protect the marsh edge and promote lateral accretion. However, it is unknown how these nearshore structures would affect the movement of intertidal organisms and impact natural processes (e.g., sediment transport).
Investigate the feasibility and impacts of management approaches needed for the marsh to keep pace with accelerating sea-level rise

Sediment accretion rates at Piermont Marsh are currently keeping pace with sea-level rise. However, if rates of sea-level rise eventually exceed sediment accretion rates, additional management measures, such as thin-layer sediment addition, may help ensure long-term persistence of the marsh. Prominent examples of wetland restoration sites that have incorporated thin-layer sediment additions from dredge spoil include Gateway National Recreation Area (New York City), several National Wildlife Refuges in Rhode Island, San Francisco Bay, and numerous sites along the Mississippi River Delta region of Louisiana (Schrift, et al., 2008).

Investigate the impact of Piermont Pier on sediment accretion and wave energy in Piermont Marsh.

The Piermont Waterfront Resilience Task Force recommended an evaluation of the benefits of the pier’s current and potential uses and hydrologic impacts on Piermont Marsh, as part of an assessment of the costs and benefits of long-term maintenance of the pier. Since the pier likely plays an important role in the marsh’s persistence, this topic is included as a research priority.

Investigate elevating the large wrack piles deposited by Post-Tropical Cyclone Sandy to enhance the marsh’s ability to provide storm protection for the village.

The areas where large amounts of wrack were deposited during Post-Tropical Cyclone Sandy remain elevated above the rest of the marsh surface. These areas could potentially be augmented to support robust plant species (e.g., woody shrubs) and enhance the marsh’s ability to provide storm protection for neighboring landowners. However, the long-term stability of these wrack piles is unknown. These wrack piles are also currently supporting a diverse assemblage of native plants, including some rare and uncommon species.

Other Information Needs

The following research needs were identified during the management planning process to address critical knowledge gaps about the marsh and inform future management decisions. These needs will be addressed with the assistance of (or by) research partners and collaborators, as time and resources allow.

Plants and Wildlife

- **Investigate least bittern distribution, abundance, productivity, and habitat requirements.** The least bittern is the smallest member of the heron family in North America. Least bitterns occur in freshwater and brackish marshes with tall, dense emergent vegetation such as cattails, sedges, and rushes interspersed with woody shrubs and open water. Recent surveys of Piermont Marsh have documented at
least one breeding pair of least bitterns in 2009, 2010, and 2013. The U.S. Fish and Wildlife Service considers the least bittern to be a “Bird of Conservation Concern” (USFWS 2008), and it is a threatened species in New York State. In New York, declines in the Hudson River least bittern population have been documented over the last 20 years except at certain sites where management of invasive plants, such as *Phragmites* and purple loosestrife, has occurred (NYNHP, 2009). A national effort is underway to survey secretive marsh bird species, including least bittern, with a goal to estimate the population status and long-term trends.

- **Study the impacts of Canada geese on smooth cordgrass growth and productivity.** Recent surveys of the Piermont Marsh shoreline have documented significant grazing on smooth cordgrass. The herbivory appears to be correlated with an increase in Canada goose foraging and nesting activity in the area. Smooth cordgrass is a foundational species in the lower intertidal zone and helps stabilize and protect the marsh edge from erosion.

- **Develop genetic markers which can be used to identify New England bulrush (Bolboschoenus novae-angliae) from tissue samples.** This species historically occurred along the creeks and ditches throughout Piermont Marsh but has not been documented since 1984. New England bulrush is found in brackish marshes along tidal creeks and rivers. This species is probably of hybrid origin because its characteristics and habitat preferences are intermediate between the freshwater species river bulrush (*Bolboschoenus fluviatilis*) and the salt water species sturdy bulrush (*Bolboschoenus robustus*); *Flora of North America*, 2002; NYNHP, 2010). Without flowers or fruits, it is not currently possible to differentiate it from the other co-occurring species of *Bolboschoenus*. New England bulrush is endangered in New York State because of its extreme rarity (fewer than five remaining populations) and vulnerability to extirpation. The remaining populations of this species are particularly vulnerable to *Phragmites* invasion.

- **Investigate habitat requirements of New England bulrush.** See rationale above.

- **Study diamondback terrapin distribution, abundance, productivity, and habitat requirements.** The diamondback terrapin is locally uncommon and the only species of turtle in North America that spends its life in brackish water. They inhabit marshes that border quiet salt or brackish tidal waters and can also be found in mudflats, shallow bays, coves, and tidal estuaries. Adjacent sandy, dry upland areas are required for nesting. Anecdotal observations suggest that diamondback terrapin are using habitats on and around the pier. This species was nearly wiped out by
gourmet consumption around the turn of the 20\textsuperscript{th} century. The loss of salt marsh habitat and sandy nesting habitat continues to threaten this species.

- **Investigate feasibility and sustainability of creating nesting islands for diamondback terrapin.** See rationale above.

- **Conduct field surveys to characterize uncommon ecological communities.** Additional data is needed to characterize the flora and fauna of uncommon ecological communities at the Piermont Marsh Reserve. In particular, more information is needed on the biological composition and environmental features of the red maple–sweetgum swamp, floodplain forest, brackish intertidal marsh, and brackish tidal creek (as a variant of Saltwater Tidal Creek) communities.

- **Characterize benthic aquatic and infaunal invertebrate communities.** Little is known about the invertebrate communities within the tidal channels and marsh sediments at the Reserve. Benthic invertebrates are essential members of estuary food webs and play a critical role in nutrient cycling and sediment bioturbation. Within the Reserve, they are likely to be important as both prey to higher consumers, such as fish within the tidal channels, and as contributors to nutrient cycling and detrital processing within sediments.

**Ecosystem Services**

- **Develop ecosystem nutrient budgets for carbon, nitrogen, and phosphorus.** Marshes have a significant impact on the fluxes of nutrients between land and estuary. Marsh nutrient dynamics are influenced by a variety of factors including hydroperiod, salinity, microbial populations, invertebrate communities, and dominant vegetation. For example, *Phragmites*-dominated marshes effectively capture and sequester carbon and also tend to accumulate greater nitrogen in leaves and pore water than comparative marshes dominated by native species. Developing a detailed nutrient budget will allow us to better understand the ecosystem services currently provided by the marsh to the estuary and how these may change due to management actions.
ADMINISTRATION and BUDGET

ADMINISTRATIVE FRAMEWORK

Administration of the Piermont Marsh Reserve and execution of this management plan will be accomplished through a multi-agency collaboration. The Tallman Mountain State Park manager, the PIPC science director, the OPRHP natural resources steward for the Palisades region, and HRNERR manager, HRNERR research coordinator, and DEC habitat restoration biologist will function as a management team and coordinate as needed on all aspects of the management plan.

Table 5 provides a list of annual operation and management actions that will be implemented by staff of the identified agency. Table 6 provides a schedule for non-annual restoration, stewardship, and management activities by year, with cost and funding source identified.

TEN-YEAR SCHEDULE OF MANAGEMENT ACTIONS AND BUDGET

The following tables outline a schedule for the implementation of proposed management actions and their projected costs.

Table 5. Annual Operations Activities, 2017-2026

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost or Effort</th>
<th>Lead Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintain 12-car parking area on Piermont Pier.</td>
<td>2 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Conduct Reserve education programs.</td>
<td>6 staff days</td>
<td>HRNERR</td>
</tr>
<tr>
<td>Coordinate research permits.</td>
<td>4 staff days</td>
<td>HRNERR &amp; OPRHP/PIPC</td>
</tr>
<tr>
<td>Monitor Ferdon Pond dam eel ladder &amp; engage citizen scientists.</td>
<td>12 staff days</td>
<td>HRNERR</td>
</tr>
<tr>
<td>Monitor marsh elevation.</td>
<td>6 staff days</td>
<td>HRNERR</td>
</tr>
<tr>
<td>Maintain wayside exhibits at pocket park.</td>
<td>1 staff day</td>
<td>HRNERR</td>
</tr>
</tbody>
</table>

Table 6. Schedule of Management Actions, 2017-2026

<table>
<thead>
<tr>
<th>Schedule of Additional Management Actions</th>
<th>Estimated Cost and Staff Effort*</th>
<th>Lead Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
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<tr>
<td>Facilitate three-year collaborative study to evaluate marsh’s role in storm protection.</td>
<td>10 staff days</td>
<td>HRNERR project team</td>
</tr>
</tbody>
</table>
### 2018

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Time</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate three-year collaborative study to evaluate marsh’s role in storm protection.</td>
<td>10 staff days</td>
<td>HRNERR project team</td>
</tr>
<tr>
<td>Finalize restoration monitoring plan. Conduct pre-restoration monitoring in Phase 1 treatment and reference areas.</td>
<td>$50,000 20 staff days</td>
<td>DEC</td>
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<tr>
<td>Install permanent sediment elevation tables in restoration and reference areas. Install boardwalk platforms to access HRNERR Sentinel Site infrastructure.</td>
<td>$17,510 20 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Initiate Phase 1 10-acre habitat restoration. Mow untreated <em>Phragmites</em> at Phase 1 site during winter preceding the initial herbicide application. Also mow treated <em>Phragmites</em> at Phase 1 site during winter following herbicide application.</td>
<td>$20,000 8 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Construct and install nest boxes and osprey platform.</td>
<td>$750 6 staff days</td>
<td>OPRHP/PIPC</td>
</tr>
<tr>
<td>Conduct accessibility review of access and interpretive facilities and features.</td>
<td>6 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Identify priority routes for research access and assess alternate designs for elevated walkways. Seek permits and funding for walkway design.</td>
<td>5 staff days</td>
<td>DEC</td>
</tr>
</tbody>
</table>

### 2019

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Time</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate three-year collaborative study to evaluate marsh’s role in storm protection.</td>
<td>10 staff days</td>
<td>HRNERR project team</td>
</tr>
<tr>
<td>Monitor Phase 1 restoration and reference areas. Spot-treat remaining <em>Phragmites</em> at Phase 1 site.</td>
<td>$53,000 20 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Explore feasibility and impact of a publicly, accessible marsh boardwalk.</td>
<td>10 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Bid contract for installation of elevated walkways for research, if permit and funding are received.</td>
<td>10 staff days</td>
<td>DEC</td>
</tr>
</tbody>
</table>

### 2020

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Time</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Phase 1 restoration and reference areas. Spot-treat <em>Phragmites</em> at Phase 1 site as necessary. If performance benchmarks for Phase 1 are being met, conduct pre-restoration monitoring in Phase 2 treatment and reference areas.</td>
<td>$72,000 20 staff days</td>
<td>DEC</td>
</tr>
<tr>
<td>Install elevated research walkways.</td>
<td>$100,000 20 staff days</td>
<td>DEC</td>
</tr>
</tbody>
</table>

### 2021

<table>
<thead>
<tr>
<th>Description</th>
<th>Estimated Time</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Phase 1 restoration and reference areas. Spot-treat <em>Phragmites</em> at Phase 1 site as necessary. If performance benchmarks for Phase 1 are met, initiate Phase 2 15-acre habitat restoration. Mow untreated <em>Phragmites</em> at Phase 2 site during winter preceding the initial herbicide application. Also mow treated <em>Phragmites</em> at Phase 2 site during winter following herbicide application.</td>
<td>$72,000 22 staff days</td>
<td>DEC</td>
</tr>
</tbody>
</table>
treated *Phragmites* at Phase 2 site during winter following herbicide application.

### 2022
Monitor Phase 1 and 2 restoration and reference areas. Spot-treat *Phragmites* at Phase 1 and 2 sites as necessary.

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
<th>Cost</th>
<th>Staff Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td></td>
<td>$85,000</td>
<td>22 staff days</td>
</tr>
</tbody>
</table>

### 2023
Monitor Phase 1 and 2 restoration and reference areas. Spot-treat *Phragmites* at Phase 1 and 2 sites as necessary. If performance benchmarks for previous phases are being met, conduct pre-restoration monitoring in Phase 3 treatment and reference areas.

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
<th>Cost</th>
<th>Staff Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td></td>
<td>$110,000</td>
<td>25 staff days</td>
</tr>
</tbody>
</table>

### 2024
Monitor Phase 1 and 2 restoration and reference areas. Spot-treat *Phragmites* at Phase 1 and 2 sites as necessary. If performance benchmarks for Phases 1 and 2 are met, initiate Phase 3 15-acre habitat restoration. Mow untreated *Phragmites* at Phase 3 site during winter preceding the initial herbicide application. Also mow treated *Phragmites* at Phase 3 site during winter following herbicide application.

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
<th>Cost</th>
<th>Staff Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024</td>
<td></td>
<td>$95,000</td>
<td>25 staff days</td>
</tr>
</tbody>
</table>

### 2025
Monitor Phase 1, 2, and 3 restoration and reference areas. Spot-treat *Phragmites* at Phase 1, 2, and 3 sites as necessary.

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
<th>Cost</th>
<th>Staff Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td></td>
<td>$87,000</td>
<td>20 staff days</td>
</tr>
</tbody>
</table>

### 2026
Monitor Phase 1, 2, and 3 restoration and reference areas. Spot-treat *Phragmites* at Phase 1, 2, and 3 sites as necessary.

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
<th>Cost</th>
<th>Staff Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>2026</td>
<td></td>
<td>$87,000</td>
<td>20 staff days</td>
</tr>
</tbody>
</table>

*All estimates of cost and staff effort are preliminary and will be refined once the restoration monitoring plan is finalized.*
REFERENCES


Wejrowski, M. 2013. Response of a Spartina patens-dominated oligohaline marsh to nitrogen enrichment in coastal North Carolina, USA. Master's Thesis. Department of Biology, East Carolina University, Greenville, NC.


## APPENDIX A: Evaluation of *Phragmites* Management Methods for Piermont Marsh

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
<th>Considerations for Piermont Marsh</th>
<th>References</th>
</tr>
</thead>
</table>
| Burning | Prescribed fire is used to remove above-ground biomass during the growing season and/or dead plant material during the dormant season. | Effectively removes dead plant material and prevents the spreading of plant fragments and seeds to other areas. 
Increases light availability for native plant species and facilitates native plant recruitment. 
Can be applied to large areas. | Ineffective as a single control strategy because rhizomes are rarely impacted. Most effective when coupled with hydrologic restoration or herbicide application. 
Can stimulate *Phragmites* expansion. 
Non-selective and can negatively impact native plant and wildlife species. 
Implementation is limited by the season, and fuel and weather conditions. 
Safety risks associated with an escaped fire and smoke inhalation. | Fire containment and short-term air quality concerns near developed areas. 
Removal of dead plant material may deplete wave-attenuation functions. | 1, 3, 5, 6, 7 |
<p>| Mowing | Mechanical cutting is used to reduce above-ground biomass during the growing season and/or mulch dead plant material during the dormant season. | Effectively removes dead plant material. Increases light availability for native plant species and facilitates native plant recruitment. | Ineffective as a single control strategy because rhizomes are rarely impacted. Most effective when coupled with water-level manipulation or herbicide application. Must be repeated several times a year. Can stimulate <em>Phragmites</em> growth. Labor intensive. Frequent use of mowing equipment can cause compaction and leveling of the marsh surface. Equipment can spread plant fragments and/or seed to other areas. Must be continued in perpetuity unless below-ground biomass is addressed. | Frequency of treatment can limit recovery of native species and marsh functions, including wave and surge attenuation. | 1, 2, 3, 5, 6, 7 |
| <strong>Ditching/Dredging/Physical Barriers</strong> | Physical barriers are created to slow or prevent the expansion of <em>Phragmites</em> stands. Can be used to increase inundation while simultaneously removing rhizomes. | Can effectively contain <em>Phragmites</em> in discrete areas. Can increase habitat and structural diversity. | Large-scale dredging to remove rhizomes and lower marsh surface may threaten marsh resilience to sea-level rise and climate change. Wetland regulations usually prohibit excavation in tidal marshes. May inadvertently spread rhizome fragments. Can potentially destabilize the marsh surface. Does not facilitate native species recovery in currently invaded areas. Costly to remove excavated material from the site. | Altering the marsh surface could exacerbate interior ponding and increase erosion. May negatively impact wave and surge attenuation. | 3, 7 |
| <strong>Flooding (water-level manipulation)</strong> | Water levels in a marsh are raised to drown <em>Phragmites</em>. Surface water levels must be maintained at a minimum depth of six inches for a minimum of one year. Effectiveness of this method is increased if plants are cut prior to flooding. | Periodically increasing water levels can effectively prevent reinvasion. Potential benefits for waterbirds and fish. | Non-selective and can negatively impact native plant and wildlife species. Can negatively impact soils and marsh functions, including wave and surge attenuation. Wetland regulations usually prohibit construction of an impoundment in a tidal wetland. | Contingent upon impoundments that enable water-level manipulation; unlikely to be feasible in this setting. More effective in higher salinity waters. | 3, 5, 6, 7 |</p>
<table>
<thead>
<tr>
<th>Solarization (cover, black plastic)</th>
<th>Black plastic or geotextile is used to cover areas of cut or flattened <em>Phragmites</em>. Soils must reach minimum temperatures to effectively kill rhizomes.</th>
<th>Effective for treating recent, small-scale invasions. Does not require special equipment or machinery. Can be implemented by volunteers.</th>
<th>Labor intensive. Limited to small stands. Requires several years to successfully kill plants, during which time ecosystem services and marsh functions are compromised. Can kill the native seedbank and soil biota. Non-selective and can negatively impact native plant and wildlife species.</th>
<th>Only practical for very small-scale control projects. Local projects have incorporated use of herbicide to increase effectiveness.</th>
<th>3, 5, 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing (livestock)</td>
<td>Livestock are contained within treatment areas to graze on <em>Phragmites</em>, thereby reducing above-ground biomass.</td>
<td>Does not require the use of heavy machinery. Above-ground biomass is consumed, making the removal of plant material from the marsh unnecessary.</td>
<td>Ineffective as a single control strategy because rhizomes are rarely impacted. Livestock may preferentially feed on native marsh plants. Trampling by livestock can prevent native plant recovery and destabilize the marsh surface. Livestock can spread seeds and plant fragments to other areas. Must be continued in perpetuity unless below-ground biomass is addressed.</td>
<td>Not recommended for soft sediment marshes due to health concerns for animals and potential impacts to the marsh surface. Livestock management would be labor intensive in a tidal wetland environment. Not recommended for tidal wetlands where nutrients released by grazers can be directly transported to surface waters.</td>
<td>1, 3, 4, 7, 8</td>
</tr>
<tr>
<td><strong>Herbicide</strong></td>
<td>Wetland-formulated herbicide is applied to growing plants to kill above- and below-ground biomass.</td>
<td>Effective on both above- and below-ground portions of the plant. Requires limited use of heavy machinery. Application method can be tailored to avoid non-target species. Limited impacts to marsh surface. Practical for small and large-scale projects.</td>
<td>Human health and environmental concerns over toxicity of glyphosate and additives to improve herbicide effectiveness. Periodic follow-up treatments may be necessary. Non-selective and can negatively impact native plant species, depending on application method.</td>
<td>Successfully used to manage <em>Phragmites</em> in other Hudson River tidal marshes.</td>
<td>1, 2, 3, 5, 6, 7</td>
</tr>
<tr>
<td><strong>Biocontrol</strong></td>
<td>Intentional introduction of natural predators or grazers to reduce invasive species abundance.</td>
<td>Minimal cost and labor beyond initial release of biocontrol agent.</td>
<td>Potential for newly introduced species to negatively impact native flora and fauna.</td>
<td>Biocontrols for <em>Phragmites</em> are not approved in New York State.</td>
<td>1, 3, 5, 7, 9</td>
</tr>
</tbody>
</table>
References


APPENDIX B: Hudson River National Estuarine Research Reserve Research Guidelines

Updated November 30, 2017

These guidelines apply to all research activities involving utilization of the HRNERR component sites (Piermont Marsh, Iona Island, Tivoli Bays, Stockport Flats). Research Guidelines apply to class and group projects as well as to individual investigators.

- All researchers are required to obtain a research permit before working in a HRNERR component site (see table for site specific application information).

- Strict adherence to all permit conditions is required by the permitting agency.

- Please submit your application package THREE MONTHS before your anticipated start date to the Permit Contact and copy the HRNERR Research Coordinator (Sarah Fernald: 845-889-4745 x111; sarah.fernald@dec.ny.gov) and the appropriate Facility Manager (see table) in order to ensure that there will be no overlapping activities within each HRNERR component site.

<table>
<thead>
<tr>
<th>HRNERR Site</th>
<th>Permit Title</th>
<th>Permit Agency</th>
<th>Permit Contact</th>
<th>Facility Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piermont Marsh</td>
<td>Scientific Research Application and Permit</td>
<td>NYS Office of Parks Recreation and Historic Preservation</td>
<td>Jesse Jaycox (<a href="mailto:Jesse.Jaycox@parks.ny.gov">Jesse.Jaycox@parks.ny.gov</a>)</td>
<td>Clark Alexandre (<a href="mailto:Clark.Alexandre@parks.ny.gov">Clark.Alexandre@parks.ny.gov</a>)</td>
</tr>
<tr>
<td>Iona Island</td>
<td>Scientific Research Application and Permit</td>
<td>NYS Office of Parks Recreation and Historic Preservation</td>
<td>Ed McGowan (<a href="mailto:Edwin.McGowan@parks.ny.gov">Edwin.McGowan@parks.ny.gov</a>)</td>
<td>Elizabeth OLoughlin (<a href="mailto:Elizabeth.Oloughlin@parks.ny.gov">Elizabeth.Oloughlin@parks.ny.gov</a>)</td>
</tr>
<tr>
<td>Tivoli Bays</td>
<td>Temporary Revocable Permit</td>
<td>NYS Department of Environmental Conservation</td>
<td>Nathan Ermer (<a href="mailto:Nathan.Ermer@dec.ny.gov">Nathan.Ermer@dec.ny.gov</a>)</td>
<td>Nathan Ermer (<a href="mailto:Nathan.Ermer@dec.ny.gov">Nathan.Ermer@dec.ny.gov</a>)</td>
</tr>
</tbody>
</table>

- Additional permits from the NYSDEC or USFWS may be required for certain types of work. This may include, but is not limited to, work on listed species and the collection and possession of wildlife. Please submit documentation of all required state and federal permits to the Permit Contact and HRNERR Research Coordinator. All required permits must be in hand prior to initiating work.

- In the Research Methodologies section of the application, please describe what steps will be taken to minimize non-target impacts from site access/foot traffic to sensitive natural resources of the tidal marsh surface.
• For projects lasting more than one year, a new research application must be submitted annually to the appropriate agency. Please copy the HRNERR Research Coordinator and the appropriate Permit Contact and Facility Manager (see table) on your annual submissions.

• Researcher(s) or their representatives are to notify the HRNERR Research Coordinator and the appropriate Facility Manager (see table) of specific study dates at least one week prior to site access to ensure there will be no conflicting activities on those dates.

• All field equipment (traps, measuring devices, etc.) left in the field must be labeled with the Principal Investigator’s name, date of installation, and the research permit number.

• Superfluous plot markers and unused equipment must be removed from study sites annually.

• Annual progress reports must be provided to the Permit Contact, the HRNERR Research Coordinator and the appropriate Facility Manager (see table) by December 31st of each study year. Please also include a GIS shapefile of all study site locations.

• Research shall be used for scientific or interpretive purposes only, be dedicated to the public benefit, and not be used for commercial purposes.

• The use of HRNERR component sites or facilities should be acknowledged in any publication resulting from work done at HRNERR component sites.

• Failure to comply with any element of the Research Guidelines may be grounds for rejection of subsequent research applications and/or immediate termination of the project.
APPENDIX C: New York State Office of Parks, Recreation and Historic Preservation Scientific Research Application and Permit
SCIENTIFIC RESEARCH APPLICATION AND PERMIT

Instructions: Please type or print. Attach additional information as necessary. Indicate fields not applicable with N/A. Electronic signatures are acceptable. Send application to the appropriate contact.

### Section A - Applicant Information

1. **Principal Investigator** *(Last-Initial-Middle initial)*

2. **Mailing Address**

3. **Affiliation** *(Graduate students, include name & phone number of major professor)*

4. **Names of Field Assistants**

5. **Project Title**

### Section B – Project Information

6. **Park and Project Location** *(include site names with GPS coordinates when applicable and/or attach map)*

7. **Research Purpose and Methodologies** *(include objectives, design, methods, equipment & materials, and any collection or disposition of specimens as well as proof of other required permits, if any.)* Attach research proposal if necessary.

### Section C – Time Frame

8. **Time Frame** *(start and end dates, including project scoping and clean up)*

### Section D – Project Relationships

9. **Project’s Relationship to Other Research Projects** *(Note whether related projects are in or near State Parks)*

### Section E – Final Report

10. **Project Report** *(Provide a copy of the final research report when it becomes available. Submittal of interim reports is encouraged.)*

Anticipated date of Final Report:

Attached report(s) and provide comments as deemed necessary:
SCIENTIFIC RESEARCH PERMIT

Standard Conditions and Restrictions:

It is the intention of the NYS OPRHP to further scientific research within the areas administered by it, and to cooperate with authorized workers to the fullest extent compatible with its charge to protect all species of flora and fauna and all soil and geologic material in a natural state insofar as possible.

1. Except for the resources indicated in the permit, the taking or disturbing of resources (including cultural or archaeological materials) is specifically prohibited.
2. Research shall be used for scientific or interpretive purposes only, be dedicated to the public benefit, and not be used for commercial purposes.
3. All research should be done in an inconspicuous manner away from roads, trails and developed areas unless specified in the permit, and shall not cause significant damage to the environment. In some cases, researchers and state parks may agree to location that enhances environmental education opportunities while meeting research and park management goals. Because of the scarcity and/or importance of some resources, the OPRHP may designate other restrictions necessary for the preservation of the area.
4. All field equipment (traps, measuring devices, etc) left in the field must be labeled with the Principal Investigator’s name, date of installation, and the OPRHP permit number.
5. A permit from the NYS DEC and USFWS is required for certain types of work. This may include, but is not limited to, work on listed species and the collection and possession of wildlife. State and federal permits must be in hand prior to initiating work and be available for inspection on site.
6. Any research that leads to the discovery of new rare species or ecological communities requires the submission of a Natural Heritage Reporting Form to the New York Natural Heritage Program.
7. The permittee shall submit a summary of information gathered to the contact for the Region where the investigations took place within a year of the research end date (as identified on this permit). The OPRHP further requires that the researcher(s) provide copies of or otherwise make available to the OPRHP any material published as a result of this permit.
8. Researcher(s) or their representatives are to contact the appropriate Facility Manager before beginning, and to present a copy of this permit together with evidence of additional research licenses and permits, if required.
9. Researcher(s) will discuss with the Facility Manager the type and extent of work to be performed. The Facility Manager will describe any rules and regulations that may apply to the work.
10. If research is not conducted in accordance with this permit and/or to the satisfaction of the OPRHP, this permit will be immediately revoked.
11. The permittee shall promptly report any and all unusual incidents directly to the Facility Manager or Park Police. Unusual incidents include, but are not limited to, damage to Park property, accidents, personal injuries, and emergencies involving medical personnel.
12. Permittee shall defend, indemnify and hold harmless the People of the State of New York, the Executive Department, the New York State Office of Parks, Recreation and Historic Preservation and its commissioners, officers, agents and employees from and against damages for injury to or death of persons and for damage to or destruction of property of State Parks or others occurring during Permittee’s use of said Premises and caused by the acts, omissions, neglect or misconduct of Permittee or any of its employees, agents, contractors, licensees or guests in the conduct of Permittee’s operations under this permit. The Permittee assumes all risk of loss of the Permittee’s property or that of its agents, employees, contractors and guests. Permittee’s liability is not limited to the insurance coverage provided.

Special Conditions:

I have read the Conditions and Restrictions above and agree to those terms.

APPLICANT’S SIGNATURE   APPLICANT’S NAME (Print or type)   DATE

APPROVAL SIGNATURE   OPRHP PERMIT ADMINISTRATOR   DATE

APPLICANT MUST CARRY THIS PERMIT AT ALL TIMES WHILE IN PARK OR HISTORIC SITE.

PERMIT VALID FROM ________ TO ________

Entrance fees/admission to the park or site will be waived only in accordance to the research identified on this permit; specifically to those individuals identified on this permit and within the time period described on this permit.

Copies to: Permit Contact. (Distribute both approved and denied permits.) Version 01/08/2013
APPENDIX D: Summary of Public Comments on Draft Management Plan

(To be completed following the end of the public comment period)