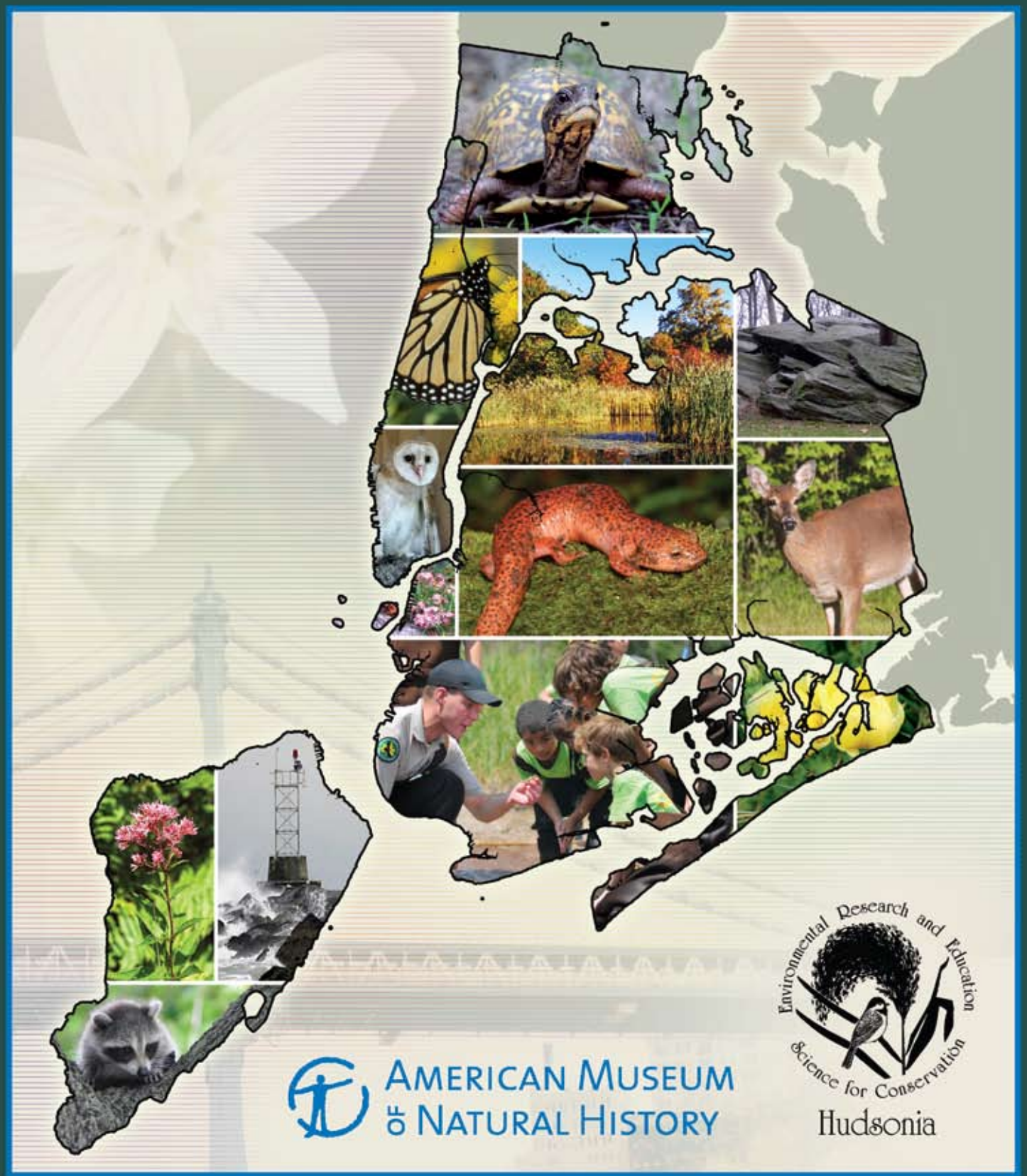
Biodiversity Assessment Handbook for New York City

Erik Kiviat • Elizabeth A. Johnson



American Museum of Natural History

Environmental Research and Education
Science for Conservation
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LIST OF CORRECTIONS AND AMENDMENTS

The Biodiversity Assessment Handbook for New York City will be corrected and updated from time to time as errors are identified and new information comes to light. This page will list the locations of changes to help readers keep abreast of new information in the Handbook.

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Introduction

Many people assume that biodiversity—nature—only exists in faraway places like tropical rainforests or the Adirondacks. But urban areas support much more than weedy plants like dandelions (*Taraxacum*) and adaptable animals like raccoons (*Procyon lotor*) and house sparrows (*Passer domesticus*).

In fact, a surprising array of uncommon and rare species is found in New York City. Did you know that the peregrine falcon (*Falco peregrinus*), an endangered bird in New York State, nests on high-rise buildings and bridges in the City? That New York City's beaches harbor rare beach-nesting birds like the piping plover (*Charadrius melodus*) and a federally protected plant, the seabeach amaranth (*Amaranthus pumilus*)? That its parks and greenways provide critical resting and feeding habitat for migrating songbirds en route to their northern nesting grounds each spring and returning to their overwintering sites in autumn? That one of only three locations for the New York State-endangered little bluet damselfly (*Enallagma laterale*) is found in Queens? That more than 230 species of bees pollinate crops in community gardens and plants in natural areas, pocket parks, and even window boxes and roof gardens? That beavers (*Castor canadensis*) are now living in the Bronx River, and river otters (*Lontra canadensis*) have recently been seen on Staten Island? Or that scientists recently discovered species entirely new to science in the City, including the dwarf centipede (*Nannarrup hoffmani*) in Central Park, the Gotham bee (*Lasioglossum gotham*) in Brooklyn Botanic Garden, and a new species of leopard frog in Staten Island—so new it hasn't even been officially named yet?

Stephen M. Young/NY Natural Heritage Program

Seabeach amaranth.

The truth is that New York City is an important ecological crossroads where the presence of a variety of salt- and freshwater habitats, major migratory corridors, and the convergence of three ecological regions prove critical to the survival of many species of fish, birds, and other animals. Biodiversity provides services that are key to the City's quality of life, from clean air, clean water, and flood control to natural beauty. Yet its diversity of plants, animals, and habitats is often underappreciated or ignored. As a consequence, during the past 400 years much of New York City has been built on and paved over, with only a small fraction of its original habitats remaining. For these reasons, Hudsonia and the Center for Biodiversity and Conservation at the American Museum of Natural History have teamed up to create this *Biodiversity Assessment Handbook for New York City.*

The purpose of the handbook is to:

- Synthesize and organize information about the City's biodiversity from disparate and fragmented sources and make this information accessible to planners, land managers, researchers, consultants, students, advocacy groups, and other interested professionals and citizens;
- Provide a citywide perspective on the importance of urban biodiversity and greenspace preservation;

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- Help practitioners and interested non-specialists identify, locate, and explore existing habitats and plan how to conserve, manage, and restore areas with the greatest conservation potential;
- Aid in determining targets, thresholds, techniques, and tools for managing these areas;
- Educate and engage New Yorkers about the value of remaining greenspaces and the need to conserve and manage them over the long-term; and
- Promote community involvement in the stewardship of biodiversity in New York City.

The handbook study area encompasses the five boroughs of New York City, including the wetlands and shallows of the Hudson River and the other estuaries bordering the City. Ecological boundaries clearly extend far beyond the City's legal boundaries, so it is anticipated that this handbook will be useful as a general ecological and conservation guide throughout the Hudson-Raritan Estuary. Legal and regulatory information, however, covers only the City itself.

In these pages you will find:

- A case for the importance of urban biodiversity;
- An overview of New York City's ecological setting;
- A summary of the key threats to biodiversity inside and outside the City's borders;
- Tools for identifying habitats and species of conservation importance;
- An examination of the biodiversity value of uniquely urban habitats such as dredged material, waste ground, bridges, buildings, and similar structures, gardens, and green roofs;
- A guide to performing a biodiversity assessment of a site;
- An analysis of the most appropriate management options; and
- Illustrated profiles of key species and habitats of conservation concern.

Fortunately, the wealth of biodiversity that was once widespread in the City can still be found in resilient pockets of aquatic and terrestrial greenspace (by "greenspace" we mean areas that are not paved or built on, including parks, nature reserves, undeveloped lands, gardens, and vacant lots). Although much has been lost, far-sighted New Yorkers have set aside many magnificent greenspaces and even created semi-natural places, like Central Park, Van Cortlandt Park, and the Hudson River Park's Estuarine Sanctuary, where nature can flourish. However, urban stresses are great, greenspaces are being developed rapidly, and biodiversity can disappear quickly. We hope that this handbook will help readers better recognize and appreciate the City's native biodiversity, understanding that its conservation and management will provide the foundation on which we can build a healthy, prosperous, and sustainable future.

Sara Cedar Miller/Central Park Conservancy

Aerial view of Central Park.

Urban Biodiversity

The classic definition of "biodiversity" is the variety of life at all its levels, from genes to ecosystems, and also the ecological and evolutionary processes that sustain life. For years, ecologists focused their efforts on managing areas apart from where most people live. Only recently have scientists begun to study the biodiversity of cities, the most human-dominated lands. Without the conservation of urban biodiversity, many habitats and species, and much variation within species would be lost (Noël and Lapointe 2010).

Conserving biodiversity is the key to long-term sustainability and the quality of life for all of us, even urbanites. Species and habitats in distant lands as well as those here in New York City all play an important role in maintaining the ecosystem services on which we depend, such as nutrient cycling and water filtration. Furthermore, cities are refuges for certain rare species that may even do better in urban areas than in the countryside. For example, peregrine falcons (*Falco peregrinus*), a state-protected species, have found a niche in the City, successfully using high-rise buildings, church steeples, and bridges for nesting (NYC Department of Environmental Protection 2012a), and American kestrels (*Falco sparverius*), small cavity-nesting raptors that are declining statewide, are holding their own in the City. Open disturbed habitats in cities often support rare plants, such as the eastern gammagrass (*Tripsacum dactyloides*) in Pelham Bay Park.

Mike Feller

Peregrine falcon.

The world is rapidly becoming more urbanized. It is projected that by 2050 close to 70 percent of the world's population will be living in urban areas—compared to 60 years ago when the reverse was true and 70 percent were living in rural areas (U.N. 2011). In recognition of this fact, researchers and others gathered in 2008 to explore the best ways to implement the recommendations from the 2002 Convention on Biological Diversity in towns and cities. The Erfurt Declaration, which was developed at this conference to promote the values of urban biodiversity, states in part:

- Urban ecosystems have their own distinctive characteristics;
- Urban areas are centers of evolution and adaptation;
- Urban areas are complex hotspots… for regional biodiversity;
- Urban biodiversity can contribute significantly to the quality of life in an increasingly urban global society;
- Urban biodiversity is the only biodiversity that many people directly experience.

The Declaration further states: "Experiencing urban biodiversity will be the key to halting the loss of global biodiversity, because people are more likely to take action for biodiversity if they have direct contact with nature" (International Conference of the Competence Network Urban Ecology CONTUREC 2008). The ability to experience urban biodiversity will depend

on sound research, conservation, and management of the plants, animals, fungi, microbes, and their habitats in cities.

The Value of Biodiversity

Elizabeth Johnson

Bumble bee on zinnia.

Diverse terrestrial and aquatic landscapes with a wide range of animals and plants provide natural benefits that are essential to daily life. Often, we have underestimated or even ignored their value when making decisions that affect the land and water, but they are the key to the environmental and economic health of cities as well as suburban and rural areas. And an increasing body of evidence indicates they are also essential to human health.

One effort to calculate the global value of landscapes with rich biodiversity estimated that every year they provide $33 trillion worth of natural services—nearly twice the global gross national product of $18 trillion (Constanza et al. 1997). This estimate, which was based on 1997 dollars, would be much higher today. Among the many benefits that biodiversity provides are:

• Food, medicine, wood, and other products

Many medicines are derived from plants, including aspirin, which comes from the willow tree (*Salix*). Even New York City waters are habitat for fish important for both the commercial and sport fishing industries, such as striped bass (*Morone saxatilis*).

• Cooler communities

Trees and other plants provide cooling shade and help stabilize the global climate by removing carbon dioxide, the major greenhouse gas, from the atmosphere. Vegetation also cools the environment by transpiration (moving water from soils and surface waters through plants to the air).

• Cleaner air and water

Plants, through photosynthesis, provide us with the oxygen we breathe. The cooling effects of shade and transpiration, mentioned above, also reduce the production of ground-level ozone, a major urban pollutant that aggravates asthma and other respiratory illnesses. In coastal systems, Eastern oysters (*Crassostrea virginica*) and ribbed mussels (*Geukensia demissa*) cleanse the water by filtering out suspended sediments and excessive nutrients.

• Pollination

Fully one-third of our food, including apples, tomatoes, and squash, depends on the services of a pollinator—a bee or other animal. As European honey bees (*Apis mellifera*) have been declining due to the affliction known as Colony Collapse Disorder, the value of a diverse community of native bees and other pollinators has become increasingly apparent, whether on rural farms or city rooftops.

• Stormwater control and natural water storage

In healthy landscapes, stormwater is absorbed by plants and the soil, in the process removing pollutants and replenishing underground water supplies. In urban areas, where much of the natural landscape has been replaced by concrete and asphalt, contaminated stormwater runoff ends up in local waterways, accounting for 70 percent of water pollution (Loizeaux-Bennett 1999). New York City's combined sewer system compounds the problem, sending both stormwater runoff and untreated municipal sewage into waterways during heavy rainfalls.

• Erosion control

As we witnessed in October 2012 with Hurricane Sandy, the degradation and destruction of coastal ecosystems such as salt marshes and sand dunes, which serve as natural buffers, can lead to increased damage to coastal communities by storm surges (the rise of sea level associated with storms). Often, beaches are rebuilt to save homes and other structures, at an enormous economic cost to the public.

• Waste decomposition and soil fertility

Healthy soil transforms wastes into the nutrients necessary for sustaining life. Small organisms in the soil break down dead plants and animals, and in the process nutrients such as nitrogen and phosphorus are recycled to enrich the soil, enabling growth to continue.

• Human health and well-being

Our connection to nature sustains us physically and mentally. Research shows that encounters with everyday nature restore concentration, calm anxiety, and reduce aggression in adults and children (Louv 2008). Biodiversity can also reduce the risk of disease transmission to humans (Keesing et al. 2010). A more diverse small mammal community—one that includes different species of mice, eastern chipmunks (*Tamias striatus*), gray squirrels (*Sciurus carolinensis*) as well as predators such as red foxes (*Vulpes vulpes*), for example—reduces the spread of tick-borne Lyme disease to humans in rural areas (Ostfeld et al. 2002).

• A natural insurance policy

Ecologists believe that biodiversity makes landscapes more resilient, acting as a kind of insurance policy to cushion them from shocks, such as climate change or new insect pests and diseases. A biologically impoverished world would be unable to support us as effectively, or for as long, as one rich in organisms, biological communities, and ecosystems.

• A source of inspiration and ideas

Scientists and engineers often turn to nature for ideas. The invention of Velcro, for example, was inspired by observation of plants like burdock (*Arctium*), whose seeds are dispersed by tiny hooks that grab onto animal fur (or clothing) (Gebeshuber and Drack 2008).

Perhaps most important, as environmental ethicists point out, biodiversity—species and ecosystems—have intrinsic value, which comes simply from the fact that they exist, not from some benefit they provide to humans or other species.

Carl Heilman II/ Wild Visions, Inc.

View from Inwood Hill Park.

How Does Biodiversity Benefit New York City?

New York City residents and visitors benefit from biodiversity in many ways. In 1992, for example, to avoid building a costly drinking water treatment plant, the City began acquiring thousands of acres of land in the New York City water supply watersheds and working with local communities to promote environmentally sensitive development and land management. According to City calculations, its planned investment of approximately $1.5 billion over the course of ten years saved it $4 billion to $6 billion in construction costs and an estimated $300 million per year in operational costs for the new water filtration plant that was no longer necessary (Chichilnisky and Heal 1998, Wilson 2002). The treatment plant would have doubled or tripled water bills; by contrast, the watershed protection plan increased the average New Yorker's water bill by only $7 per year.

Helen Forgione

Ashokan Reservoir, part of the New York City water system.

According to a 2007 study by the Center for Urban Forest Research, New York City trees intercept almost 890 million gallons of rainwater each year, preventing it from entering storm sewers and saving the City an estimated $35 million annually in stormwater management costs. The cooling effect of all those trees also reduces energy consumption by a whopping $6.9 million (Peper et al. 2007).

Landscapes with a rich variety of habitats and organisms not only save the City money but make it more beautiful and livable. Imagine Manhattan without Central Park. Greenspaces provide an important connection with nature and opportunities for daily recreation for City residents and workers, and are ecotourism destinations for millions of nature-lovers and birders each year—all at "no charge."

Adriana Palmer

Birdwatchers at Jamaica Bay.

In fact, greenspaces actually generate dollars. According to the U.S. Fish and Wildlife Service's 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation report, in New York State there are an estimated 3.8 million bird and other wildlife watchers who annually contribute an estimated $1.6 billion to the state economy, including $250 million in state sales tax revenue, and support thousands of jobs across the state, including New York City.

New York City's greenspaces also enhance property values. Studies show that homes situated near parks, public gardens, rail trails, etc. sell for significantly more money than those with no nearby greenspace (Crompton 2004).

In recognition of the importance of biodiversity, both species and habitats, New York City recently developed a Green Infrastructure Plan. The plan, developed by the Department of Environmental Protection, is a

blueprint for stormwater management that complements the City's PlaNYC sustainability initiatives. The goal is to manage runoff from 10 percent of the impervious surfaces in combined sewer watersheds through detention and infiltration over the next 20 years. The New York City Department of Parks and Recreation has been building "greenstreets" for stormwater capture (streets with vegetated median strips or other features that reduce stormwater runoff) for nearly five years. The Parks Department will be working with the New York City Department of Environmental Protection to promote a comprehensive approach to green infrastructure, which will transform neighborhoods from "gray" to "green" through greenstreets, bioswales (typically small landscape elements in which vegetation and soil absorb and treat stormwater runoff), green roofs, stream daylighting (uncovering previously buried streams and restoring natural flow), and natural areas restoration.

The aim of the Green Infrastructure Plan is to change the paradigm of planning in New York City from a site-specific to a landscape approach — strategically designed, engineered, and managed networks of natural and developed lands working in concert to conserve existing landscapes, retain stormwater, and enhance environmental benefits such as natural water filtration and carbon sequestration (the removal and storage of atmospheric carbon in carbon "sinks" such as forest vegetation and soils). While green infrastructure projects are not designed as biodiversity conservation per se, they do in fact protect biodiversity by creating and maintaining greenspace. And conserving biodiversity in turn maintains the City's pool of species that potentially can be used for ecological engineering, such as different kinds of marsh plants for bioswale plantings, or varieties of trees and shrubs that survive with a minimum of care in parks or restored habitats.

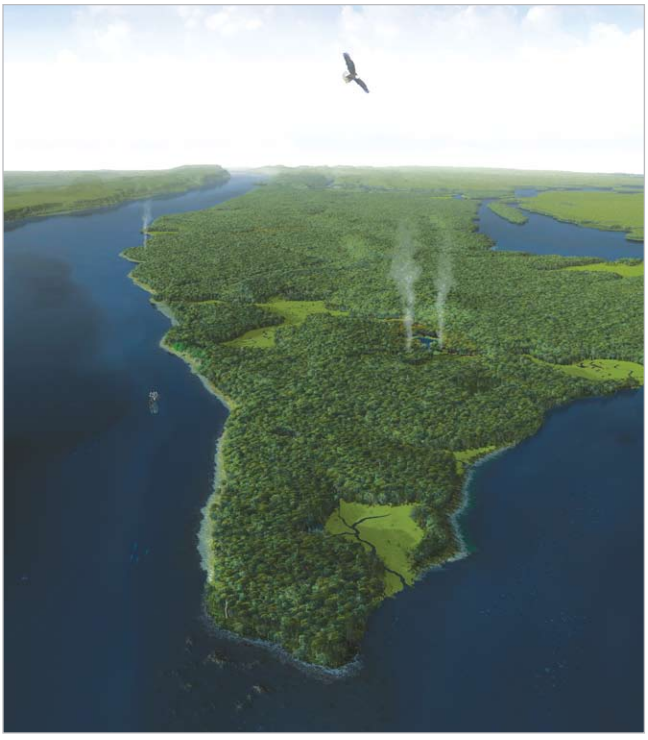
NYC Department of Parks and Recreation

Water infiltration swale at Oaktree Place (Bronx) captures stormwater runoff.

New York City's Ecological Setting

New York City is world-renowned for its diverse arts and cultures, but less known is the fact that the City also has a rich ecological diversity. New York City encompasses approximately 303 square miles of land and 166 square miles of water, featuring highly varied environments (U.S. Census Bureau 2010). There is gneiss, schist, quartzite, and serpentinite bedrock. Surface features range from rock ledges to sandy flats; tiny freshwater pools to vast tidal estuaries; and densely packed skyscrapers to extensive undeveloped lands. This variation has shaped and continues to influence the numerous soils, habitats, and plant and animal species that constitute the City's biodiversity.

The final, Wisconsinan Ice Age glacier extended as far south as what is now the middle of New York City. Just after its retreat 15,000 years ago, Bronx and Manhattan north of 59th Street were barren rock. Immediately south of the glacial terminus, a Coastal Plain province was formed from glacial outwash (materials such as sand and gravel carried from the melting glacier by streams), including the rest of Manhattan and the southern portions of Brooklyn, Queens, and Staten Island. During the intervening millennia, New York City became vegetated with a lush and diverse flora that sustained a diversity of invertebrates, birds, amphibians, reptiles, and mammals, including, eventually, the first people, the Lenni Lenape. For more information on the City's prehistory, see the Wildlife Conservation Society's Welikia Project.



Markley Boyer / The Mannahatta Project / Wildlife Conservation Society

Manhattan Island as it may have looked in 1609.

The City sits at the nexus of three physiographic provinces (large areas that have distinctive soils, vegetation, and animal life): the New England province extending southward to New York City and Staten Island, the Piedmont province reaching northward to the Hudson River at the Palisades, and the Coastal Plain province. In another ecological nexus, the Hudson River meets the Atlantic Ocean in New York City. The mixing of fresh and saline waters in this estuary makes for diverse and productive underwater and intertidal environments, although human activities have profoundly altered them. For example, approximately 300,000 acres (121,410 hectares) of estuarine wetlands (including saltmarshes and mudflats) and underwater lands have been filled in over the years (U.S. Fish and Wildlife Service 1997). Even though many sections of the harbor have always been naturally deep, heavy use by ever-larger ships has encouraged a long history of channel dredging, and the major shipping channels are currently undergoing additional deepening to 50 feet. The impacts of this ongoing activity have not been well studied. Sand mining for construction purposes has also altered the harbor's bottom contours, leaving behind gigantic holes or "borrow pits," the ecological impact of which is a subject of ongoing debate.

The meeting of important geological and geographical features in New York City has contributed to a third ecological nexus: the convergence of several migratory corridors critical for the continued existence of many species of fish, birds, and insects. The harbor is located at a bend in the coastline of the Atlantic Ocean referred to as the Apex of the Bight, where the east-west oriented coastline of the New England and Long Island coasts meets the north-south oriented shorelines of the Mid-Atlantic coast. This nearly right-angle turn in the coastline funnels many migratory species right through New York City, and leads to some spectacular sightings. As just one example, Glassberg (1999) related the following: "On one September day I observed about 6,000 Monarchs, 4,000 Red Admirals, 4,000 Question Marks, and 2,000 Mourning Cloaks flying south through a 10-foot wide path adjacent to a beach in New York City."

In addition, New York City lies along the Atlantic Flyway, a major bird migration route, making the City's parks, shorelines, forests, and greenspaces essential stopover places where these birds rest and feed. In 2008 New York City became the ninth city in the country to sign the Urban Conservation Treaty for Migratory Birds (Abramson and DeLuca 2008). As a result, the U.S. Fish and Wildlife Service, New York City Audubon and Audubon New York, and City of New York Parks and Recreation are working together "to improve New York City's bird habitat by increasing stewardship, providing restoration of key areas, and ensuring proper monitoring in all New York City natural areas, including the City's Important Bird Areas, Forever Wild sites, and other critical habitats."

In its definitive study *Significant Habitats and Habitat Complexes of the New York Bight Watershed* (1997), the U.S. Fish and Wildlife Service concluded that the human imprint over much of the area increased this geographic concentration, further concentrating species into the remaining natural terrestrial and aquatic areas—and that therefore the continued preservation and maintenance of these areas within New York City is critical to the survival of migratory species.

Don Riepe/American Littoral Society

Migrating shorebirds (ruddy turnstones).

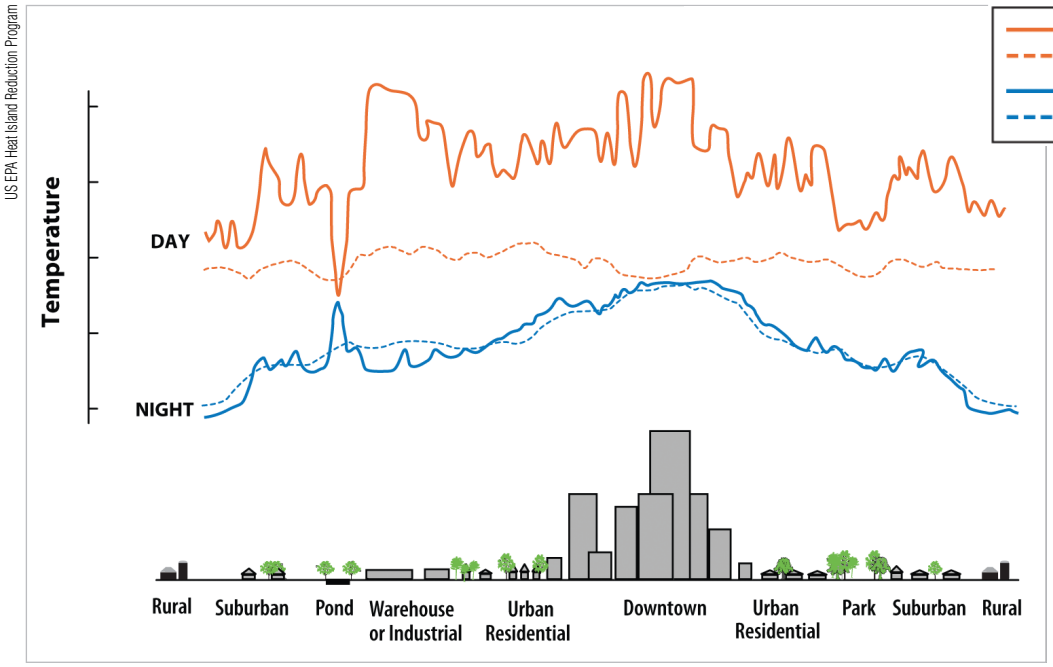
Climate

No location in New York City is more than about four miles from a major estuary, and no more than 20 miles from the Atlantic Ocean. Thus New York City has a maritime (coastal) climate characterized by milder temperatures, a longer growing season, stronger winds, and more fog than inland cities at the same latitude. Notwithstanding the coastal location, winters can be cold and summers hot. The average daily high and low in January are 38 degrees F (3 degrees C) and 26 degrees F (-3 degrees C); average daily high and low in July 84 degrees F (29 degrees C) and 69 degrees F (21 degrees C). Average annual precipitation is just under 50 inches (127 cm), and average annual snowfall 22 inches (56 cm). The average growing season (period without killing frost) is about 190 days.

This is a fairly mild climate for the northeastern U.S. and allows a wide variety of organisms to thrive. Given variation in slope aspect (for example, cooler north-facing slopes compared to warmer south-facing slopes), distance from the ocean, shade of trees or buildings, and other factors that create "microclimates," there is even greater variation in particular habitats.

Another effect of the City's location near the ocean and the frequent onshore winds is that sea salts are carried inland and deposited on the soil or surface waters. These may be crucial to the mineral nutrition of certain organisms while inhibiting others, especially very close to the ocean such as on the Rockaway Peninsula. Some species occur only near the ocean, probably because they require an abundance of certain minerals. Among these is Atlantic white cedar (*Chamaecyparis thyoides*), which was a dominant tree in many nontidal wetlands in the New Jersey Meadowlands until a century ago, and probably occurred in New York City. Another strictly coastal species is seabeach amaranth (*Amaranthus pumilus*; see species profile).

An urban heat island (area where pavement and buildings absorb and retain more solar heat than surrounding non-urban landscape), New York City is significantly warmer than surrounding rural areas, and this may facilitate the establishment and survival of species like the Italian wall lizard (*Podarcis muralis*) (Burke and Ner 2005), a nonnative species, as well as many native species with southern affinities (i.e., species that have most of their geographic ranges south of New York City).



Surface and atmospheric temperatures vary over different land use areas. Surface temperatures vary more than air temperatures during the day, but they are both fairly similar at night. The dip and spike in surface temperatures over the pond show how water maintains a fairly constant temperature day and night, due to its high heat capacity.

*** Note: The temperatures displayed above do not represent absolute temperature values or any one particular measured heat island. Temperatures will fluctuate based on factors such as seasons, weather conditions, sun intensity, and ground cover.**

Another factor complicating the distribution and survival of species is climate change. Average temperature for the metropolitan East Coast region increased 2 degrees F (1 degree C) during the 20th Century, and is predicted to increase another 2 to 7 degrees F (1 to 4 degrees C) by the 2050s (Rosenzweig and Solecki 2001). Thus in recent decades there likely has been a gradual loss of species adapted to cooler climates, and the arrival or increase of species adapted to warmer climates (see the Threats to New York City Biodiversity chapter for a more detailed discussion).

Surface Waters

New York City lies in an estuarine delta, a region where major rivers empty into the sea and deposit sediments that build shoals, wetlands, beaches, and other features. The City is surrounded by brackish (somewhat salty) or saline tidal waters, except where Queens adjoins the rest of Long Island and Bronx adjoins Westchester County. (See Figure 1.)

These estuarine waters and their tributaries include Long Island Sound between Queens and the Bronx; Jamaica Bay and the Atlantic Ocean south of Queens and Brooklyn; Lower New York Bay, New York Harbor, Arthur Kill, Kill van Kull, and Raritan Bay surrounding Staten Island; and the Hudson River on the west side of Manhattan. In addition, the Harlem River separates Manhattan and the Bronx, and the East River separates Brooklyn and Queens from Manhattan. There are also several large estuarine inlets, including the Hutchinson River, which drains into Long Island Sound; the mouth of the Bronx River, and Newtown Creek between Queens and Brooklyn, which both drain into the East River; and the Gowanus Canal in Brooklyn, which drains into New York Harbor. Many of these inlets and shores have been modified by filling, dredging, construction of seawalls, and other human activities over the past few hundred years.

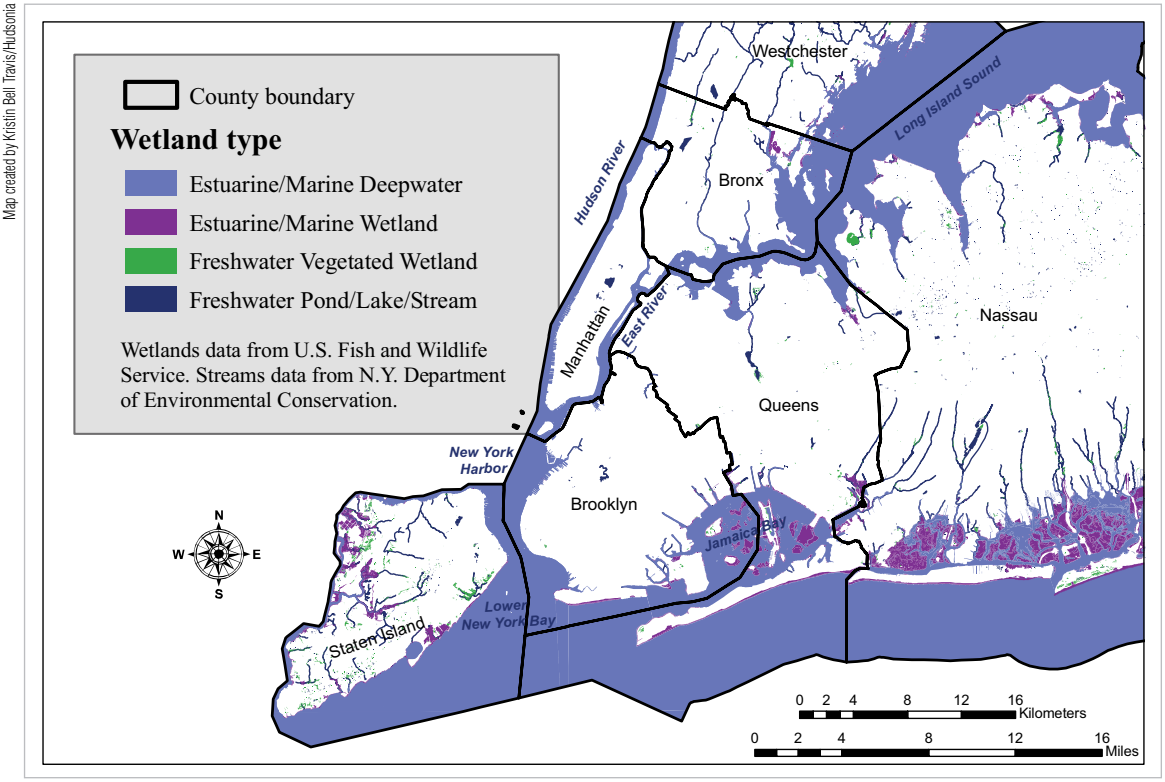


Figure 1— Wetlands of New York City.

These estuaries are affected by twice-daily tides (two tidal cycles in 25 hours), a mean tide range of about 6 vertical feet (about 2 meters), and strong reversing tidal currents that can reach 7 knots (about 8 miles per hour or 13 km per hour). Salinity varies seasonally and with distance from the ocean. Salinity is lower in winter and early spring when snowmelt and spring floods inland drive large amounts of fresh water into the estuaries; the Hudson River at the George Washington Bridge can even be fresh at that time. In summer, especially during droughts and closer to the ocean, salinity is higher. Maximum salinities approach 30 parts per thousand (ppt) at times in lower New York Bay. (Note: Average salinity in the open Atlantic Ocean is 35 ppt.)

Because estuaries tend to funnel pollutants from nearby landmasses, including the City and other areas, it is not surprising that water quality is poor in these waterways. Levels of the principal plant nutrients (especially nitrogen and phosphorus), sulfate, and petroleum hydrocarbons are high, and the dissolved oxygen required by most aquatic life is often low. The pollutants, in addition to local differences in salinity and water quality, affect the fish, invertebrates, and other organisms of the estuaries and their shorelines, preventing some of the more sensitive species from thriving.

Although many of the nontidal streams have been filled or culverted, there are seminatural streams in Manhattan, the Bronx, Queens, and Staten Island with relatively intact headwaters (E. Pehek, personal communication, 29 January 2012). There are also numerous enclosed or semi-enclosed lakes and ponds, some brackish and others fresh. Some of these were estuaries that were closed off, such as Meadow Lake and Willow Lake in Queens. Others were partly or entirely created by excavation or damming, including most or all of the lakes and ponds in Central Park. The City's large variety of small ponds, both permanent and intermittent, includes rain pools covering no more than a few square feet, as well as groundwater seeps and springs (see the habitat profiles for more information).

In addition, New York City has many wetlands ranging from tidal marshes that are flooded twice per day to wet meadows with soils that are seasonally saturated but infrequently flooded. Wetlands, ponds, and other wet habitats are extremely important for biodiversity in the City.

Mike Feller

Seaton Falls Park wetland in winter.

Human influences on wetlands have been complex and pervasive. Except for a few long-standing natural seeps in Highbridge and Inwood Hill Parks, there are no remaining natural freshwater wetlands in Manhattan or Brooklyn, and less than a handful large enough to be regulated by the state remain in Queens and the Bronx. However, there are many smaller isolated wetlands, including vernal pools (see habitat profiles: Intermittent Woodland Pools, and Springs and Seeps). Although small, these are important habitats; nevertheless, wetlands or pools without a surface water connection to a stream may not be federally regulated under Section 404 of the Clean Water Act, and a wetland under 12.4 acres (5 hectares) is not automatically regulated by New York State. The Bronx River is the only extensive freshwater riverine ecosystem remaining in the five boroughs. About 3,400 acres of wetlands remain on Staten Island, occupying 9 percent of the borough (Tiner 2000).

Salt marshes that were not filled and developed were often ditched and drained in an attempt to control mosquitoes. Old photos and maps show picturesque meandering tidal creeks extending through most of the marshes. Virtually all were straightened and deepened or filled; only three remain in an almost natural shape, all on Staten Island. The net loss of coastal wetlands in New York City has been great—fewer than 15 percent remain unaltered (Mayor's Office of Long-term Planning and Sustainability 2012).

This handbook focuses on the smaller bodies of water, along with wetlands and uplands that can be conserved and managed on a scale that is feasible for city planners and land managers.

Geology, Geography, and Soils

Figure 2 shows the bedrock underlying New York City. The bedrock influences the surficial (surface) geology and overlying soil layers and the texture, pH, fertility, and hydrological characteristics of the soil, which in turn help determine which plants and animals are best adapted to an area.

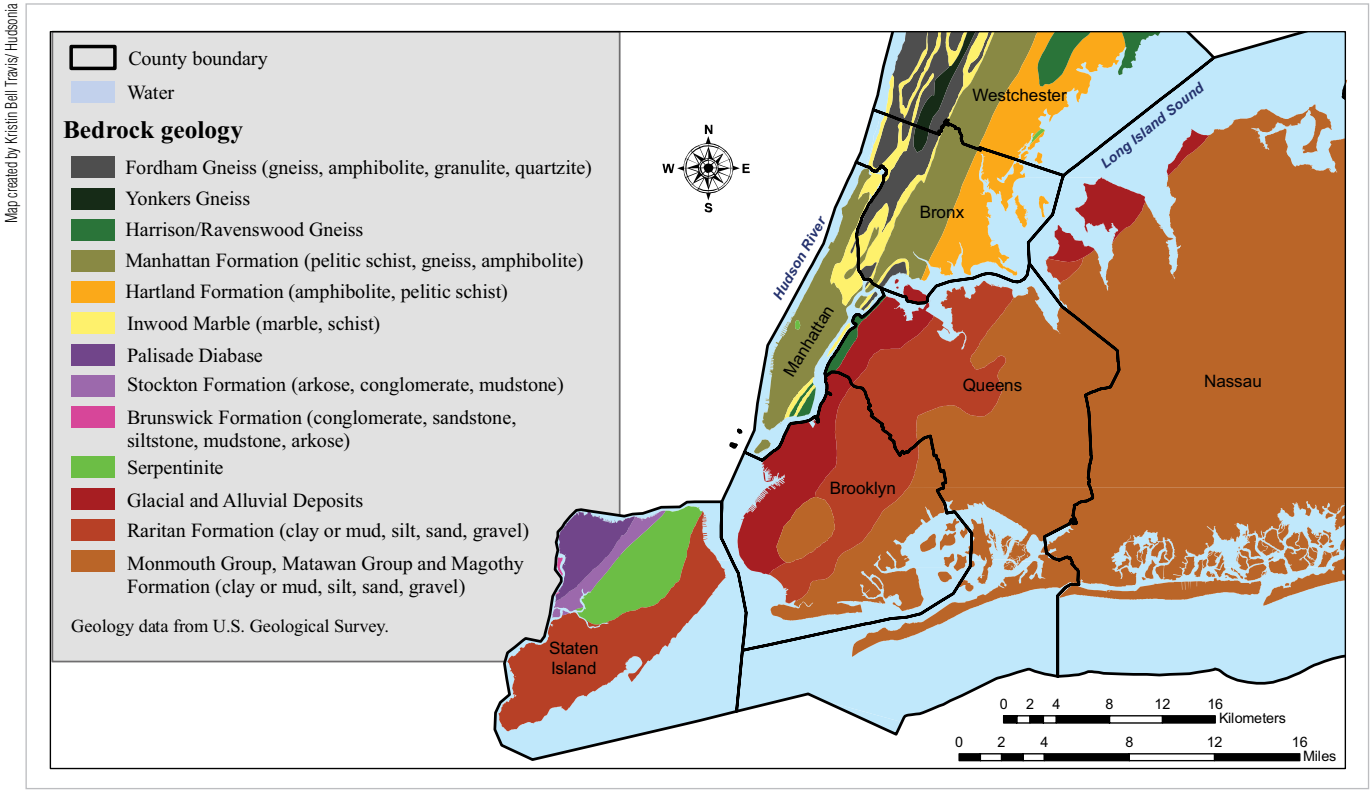


Figure 2—Bedrock Geology Map.

Sidney Horenstein

Manhattan Schist.

Bedrock in the Bronx and northern Manhattan is composed of gneiss, schist, and quartzite, with smaller areas of marble. These are mainly hard rocks resistant to erosion and overlain by shallow soils. Gneiss and schist often form ledges and tend to produce acidic soils. Typical of these soils are ridge top forest plants such as white oak (*Quercus alba*) and black oak (*Q. velutina*), with an understory of mapleleaf viburnum (*Viburnum acerifolium*) and low bush blueberry (*Vaccinium angustifolium*). The intervening valleys typically support tulip tree (*Liriodendron tulipifera*), red oak (*Q. rubra*), arrowwood (*Viburnum dentatum*), and spicebush (*Lindera benzoin*).

The southeastern half of Staten Island, all of Brooklyn, and all of Queens except a narrow strip along the East River are composed of glacial tills, which contain mixtures of different particle sizes, from tiny clay particles to boulders. Sandy and gravelly materials were deposited as glacial outwash by streams flowing off the melting glaciers. Among the habitats found on gravelly glacial outwash are the deep kettle wetlands that are most favorable for amphibians such as mole salamanders (see Intermittent Woodland Pools).

Sidney Horenstein

Fordham Gneiss.

Because the New York Palisades cut across Staten island as they slope gently westward away from the Hudson River, the Island is geologically unique among the five boroughs. The bedrock of the Palisades is diabase, a hard rock that intruded in molten form between layers of softer sandstone and shale. Staten Island also contains areas of serpentinite, a dark, typically greenish metamorphic rock. Consisting largely of serpentine, a mineral toxic to many plants, it supports an unusual natural community, adding to local biodiversity (see habitat profile). Large sections of Staten Island contain clay deposits, which on flat or depressed surfaces tend to accumulate water, often leading to the formation of "perched" wetlands.

Notable natural sand deposits are found in western Staten Island. Artificial deposits of sand from the disposal of dredged material ("dredge spoil") were used to create islands in the Arthur Kill, a "tidal straight" or narrow, poorly flushed body of water that separates New Jersey from Staten Island. These islands were once important colonial waterbird rookeries, and the habitats are being restored (S. Elbin, personal communication, 29 January 2012). Because they drain freely and erode readily, sands produce habitats that may be very dry at the soil surface in summer. While the natural sand deposits, especially those in and around Claypit Ponds State Park Preserve, are acidic and infertile, dredge spoil sands are apparently more neutral in pH and somewhat more fertile, containing modest amounts of organic matter and calcareous mollusk shell from the dredged estuarine sediments. The natural Staten Island sands support vegetation more typical of the Mid-Atlantic region, such as pitch pine (*Pinus rigida*), Virginia pine (*P. virginiana*), and shortleaf pine (*P. echinata*) along with blackjack oak (*Quercus marilandica*), chestnut

oak (*Q. prinus*), willow oak (*Q. phellos*), and various hybrid oaks.

Queens and Brooklyn, which comprise the western-most portion of Long Island, are separated from Manhattan by the East River (actually a tidal strait like the Arthur Kill). Their southern portions share a typical Atlantic Ocean barrier island (the Rockaways) and back-bay ecosystem (Jamaica Bay) similar in many respects to the south shore of Long Island farther east. The Rockaways barrier beach system protects Jamaica Bay and creates a safe haven for many forms of wildlife, including diamondback terrapins (*Malaclemys terrapin*) and various bird species. In fact, the best shorebird and tern habitat in all of New York City is at Breezy Point, at the western tip of the barrier beach, supporting least tern (*Sterna albifrons*), common tern (*S. hirundo*), roseate tern (*S. dougallii*), black skimmer (*Rhynchops niger*), and piping plover (*Charadrius melodus*).

Barbara Saunders

Black skimmer at Breezy Point.

Jamaica Bay has virtually no remaining natural freshwater sources; almost all fresh water now comes from sewage treatment plants and storm sewer outfalls. Yet remnants of Jamaica Bay's once extensive salt marshes remain, mostly at the edges of the bay and on islands in the middle, and serve as important refuges for clapper rail (*Rallus longirostris*), nesting laughing gull (*Larus atricilla*), saltmarsh sparrow (*Ammodramus caudacutus*), many species of shorebirds, waterfowl such as ruddy duck (*Oxyura jamaicensis*), diamondback terrapin, and other species (Tanacredi 1995). Jamaica Bay's islands are under assault by a combination of forces and are eroding rapidly. If the current rate of loss continues, the marshes may become completely overwashed within the next 10 to 20 years (NYC Department of Environmental Protection 2012b).

Queens and the Bronx are separated from each other by the East River and western Long Island Sound. They both have an irregular coastline with significant bays and several rocky islands. Like the islands around Staten Island, these islands have become important breeding areas for waterbirds.

If left alone long enough by humans, large portions of New York City would be forested. The lowland areas with deep soils and intermediate moisture were probably farmed continuously after European settlement until they were developed for residential, commercial, or industrial use. As a result, the biological communities once found in these habitats, including old growth forests with large trees, are all but gone, and we know little of their ecology. Remnants of lowland old growth forest with deep leaf litter and uncompacted soils in the Bronx, Queens, and Staten Island are all that remain of this natural community that may once have covered large areas.

Mike Feller

Forests in Van Cortlandt Park.

Urban Habitats

The first Europeans visiting what is now New York City wrote vivid accounts of the richness and incredible productivity they found here, but their arrival profoundly changed the local ecology. Europeans introduced not only themselves, but also many other organisms, including birds, plants, mussels, microbes, and even worms—sometimes intentionally and other times quite by accident. Four hundred years later, some of these introductions have displaced, or threaten to displace, many native species. Other changes to the local ecology are far more visible, such as the extent to which the built environment far outstrips the natural areas of the City.

Most of New York City sits at or just slightly above sea level. Many of the highest points are artificial; Staten Island's former Fresh Kills landfill, for example, reaches 225 feet (69 meters). The highest point, however, is natural: Todt Hill, also on Staten Island, is 440 feet (134 meters).

Much of the land surface in the City is covered by structures such as buildings, roads, bridges, fences, and piers. Structures replace natural habitats but also provide "built" habitats that support many organisms. Some species that evolved in association with cliffs are able to use tall buildings or bridges as habitat substitutes. In New York City these cliff-adapted organisms include the peregrine falcon (*Falco peregrinus*) and rock pigeon (*Columba livia*), which nest on buildings and bridges, and some ferns, which can grow on concrete or mortared walls (see the Cliff Ferns species profile).

Unbuilt, "undisturbed" areas in the City are mostly underlain by unconsolidated (loose), naturally deposited materials, including glacial till, glacial outwash, alluvium, beach, and tidal marsh deposits. Although naturally formed, soils in these areas are still affected by urban conditions such as increased temperature, atmospheric deposition of pollutants, and nonnative species. More pronounced soil disturbance can include loss of horizonation (layers

Richard Shaw

A sandy soil of the Deerfield series formed in glacial outwash at Corporate Park Woods, Staten Island. Note the different layers and at 40 inches depth the water table.

Richard Shaw

La Guardia soil, Neu Recycling Center, Hunts Point, the Bronx, rich in coarse rock fragments and artifacts. "Chunky" soils like this are found in urban areas worldwide.

that form naturally in soils) through mixing or cut and fill (excavation of material in a higher area that is used to fill or raise the surface of an adjacent area), and loss of topsoil. At the extreme end are "anthropogenic" soils formed by human-transported materials or fill, including excavated soil and dredge spoil as well as materials such as coal ash, construction debris, and domestic and industrial wastes. Anthropogenic soils often have chemical and physical properties that are unfavorable for native animals and plants (amphibians, moles, and sedges, for example) and are highly susceptible to invasion by nonnative plant species able to tolerate such altered conditions.

Soil profiles

The extent and type of soil disturbance in urban areas differ, and as a result the physical and chemical properties of urban soils differ as well. An understanding of these properties is important for restoration and revegetation efforts and stormwater management. The USDA Natural Resources Conservation Service has conducted a Reconnaissance Soil Survey for New York City at a scale of one inch to the mile (1:62,500) that serves as an introduction to urban soils and a general guide to soil patterns across the City. A more detailed 1:12,000 scale citywide soil survey should be available on the Web Soil Survey before the end of 2013. It will provide information on the physical and chemical properties of all of the City's soils as well as the extent of impermeable surfaces, soils formed from human-transported materials, and soils formed from naturally deposited materials (R. Shaw, personal communication, 31 January 2013).

See Table 1 for more information on the characteristics of the urban environment and their effects on biodiversity in New York City.

Table 1. Characteristics of the urban environment and their implications for biodiversity. Suburban environments are intermediate between urban and rural environments in many respects, but may be difficult to define.

Category	Difference from rural	Implications for habitats	Implications for species
Microclimate (the climate in a small or restricted area, with the greatest effect on organisms)	Warmer, drier, windier; greater and more frequent runoff	Greater evapotranspiration (water loss from plants and surface waters); unstable and flashy water and moisture levels	Believed more favorable for "southern" species or dryness-tolerant species
Soils	Much cut and fill; garbage layers common; poorly developed structure; low in organic matter; high in nitrogen and calcium; compacted, eroded, and contaminated	Droughtier, more wind erosion; compaction may support perched surface water; chemically different (construction debris may make soils more alkaline); higher levels of contaminants (from fossil fuel combustion and other sources)	Less favorable for burrowing species, species requiring abundant stable soil moisture, acidicolous (acid-associated) species, and species affected by toxicity

Category	Difference from rural	Implications for habitats	Implications for species
Surface waters	Streams commonly culverted or channelized and subject to more rapid flow fluctuations; ponds often have altered shores; elevated levels of plant nutrients such as phosphorus, nitrogen, sulfur; often salinized from de-icing salts; higher levels of other pollutants; water temperatures may be higher in summer; more refuse	Lower habitat quality where banks or channel bottom are artificial, nutrient levels higher; salt may exclude strictly freshwater species	Usually dominated by generalist species tolerant of high temperatures and other stresses; cool-water fishes and invertebrates usually absent; in more extreme urban conditions, no fish or only the hardiest species such as American eel (*Anguilla rostrata*) and mummichog (*Fundulus heteroclitus*)
Vegetation	Cover sparse; low biomass; high proportion of nonnative plants; shallow or no leaf litter	Less vertical habitat structure; less O-layer (litter layer) structure	Fewer vegetation microhabitats supporting fewer species; less favorable for litter species and species that depend on particular urban-sensitive native plants
Habitats	Diverse natural and artificial habitats; high degree of fragmentation; smaller patches, subject to greater physical disturbance		Especially favorable for species that do not require large blocks of habitat and those that are able to move from one habitat patch to another
Fauna	Subset of regional fauna able to tolerate or exploit urban conditions; some species may be abundant		Lower levels of predation, competition, parasitism, or disease favor certain species; more food and other resources for certain species

Threats to New York City Biodiversity

Nature in New York City faces the same threats as biodiversity everywhere: habitat loss, degradation, or fragmentation; invasive and overabundant species; pollution; unsustainable use of resources; and climate change. However, the City's highly altered landscapes intensify many of these stresses.

Habitat Loss, Degradation, and Fragmentation

The sheer loss of greenspace of all kinds, only partially mitigated by the re-greening of gardens and roofs, is the main threat to biodiversity in urban areas. Many of the alterations to New York City's original habitats happened long ago. Land use and settlement by the Lenni Lenape, followed by Henry Hudson's arrival in the region and the subsequent colonization by Europeans and human population growth have transformed the area's original forests and wetlands.

Today, much of the City is covered with buildings and pavement—close to 80 percent of Manhattan is covered by impervious surfaces, for example (Sanderson and Brown 2007). Roads and buildings are often obstacles to movement and migration for birds and other animals. Shorelines have been hardened with groins and bulkheads, altering wave action and preventing natural dune creation and replenishment. Almost all of the City's wetlands have been filled in over the years.

Don Riepe/American Littoral Society

Shoreline hardening projects like this jetty at Breezy Point alter normal beach forming processes.

Fortunately, more than 52,000 acres of greenspace in the City has been set aside, including 29,000 acres owned and managed by City of New York Parks and Recreation, plus state and federal holdings, public gardens, etc. (PlaNYC 2011). Yet biodiversity faces challenges even in these areas. Overuse by park visitors at sensitive sites can degrade habitat for some species. For example, if soils are densely compacted from heavy foot traffic, seeds of certain plants cannot germinate and become established, and insects and other animals are unable to burrow into the soil for nesting or winter protection. The activity of people and pets can make it difficult for birds or other animals that require undisturbed habitats to thrive or even survive—by preventing them from nesting successfully, for instance. Important ecological processes such as flooding or periodic natural fires are often suppressed, altering the conditions that some native plants and animals require. Additional impacts to parks and other greenspaces and waters include the effects of erosion and siltation from stormwater runoff on streams, wetlands, beaches, and mudflats.

Moreover, because many greenspaces are small, they may not provide all the resources that wildlife needs. Surrounding development isolates most parks and other greenspaces in the City, separating the populations of plants and animals that live in one area from populations elsewhere with which they need to interact for long term viability. Even in highly urbanized New York City, development pressure is an ongoing threat to greenspaces.

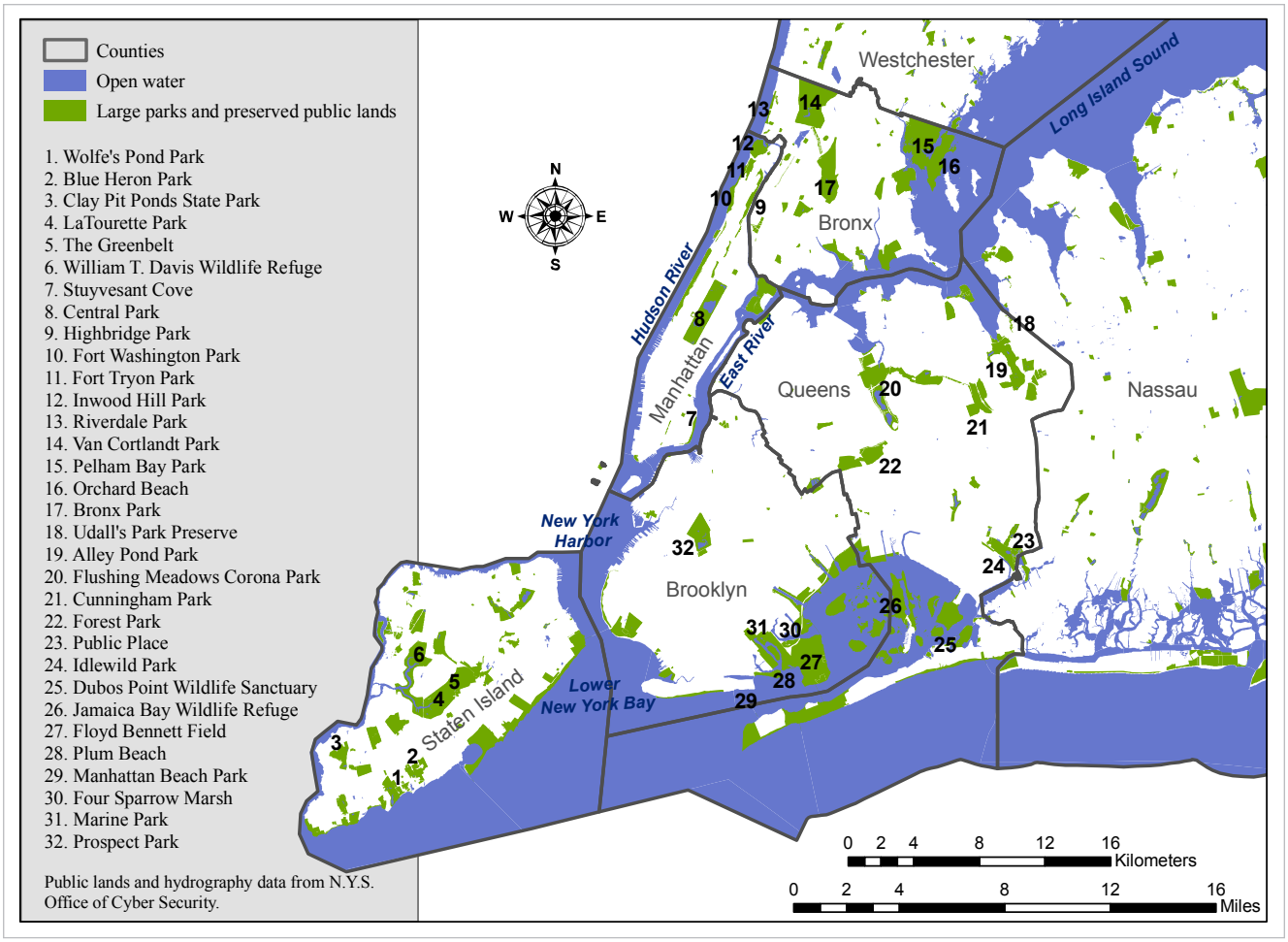


Figure 3—Map of Selected Parks and Preserves in New York City.

Invasive and Overabundant Species

Nonnative species are those that have been introduced to a place but did not originate there. In some cases, plants or animals were brought here intentionally. For example, early colonists brought honey bees (*Apis mellifera*) and many herbs, plants were imported by the horticulture industry, and game animals like ring-necked pheasant (*Phasianus colchicus*) and brown trout (*Salmo trutta*) were introduced by wildlife and fishery managers.

Other nonnative species arrived accidentally, as stowaways in soils, on imported plants, in packing material, or in ship ballast waters. With busy shipping industries and the movement of millions of tons of cargo, coastal port cities like New York are major points of entry for nonnative insects, pathogenic bacteria, fungi, viruses, and seeds. In many cases, these nonnative arrivals do not survive or remain localized. However, others do become established, spread widely, and have a disproportionate impact on native species and local ecosystems—they become invasive.

It is these invasive nonnative species that are considered one of the most serious threats to natural areas. In New York City these include plants such as Japanese knotweed (*Polygonum cuspidatum*) and Oriental bittersweet (*Celastrus orbiculatus*), which shade out and compete for nutrients with native forest and understory plants, and Eurasian watermilfoil (*Myriophyllum spicatum*), which dominates shallow lake or pond habitats. Efforts to prevent the spread of Asian long-horned beetle (*Anoplophora glabripennis*), recently introduced to the New York metropolitan area via wooden shipping pallets, have necessitated

the removal of numerous trees. These beetles feed on many tree species and will be a serious threat to forest trees in the Northeast if they become established and spread beyond urban centers into the wild. For a more detailed discussion about when and how to manage invasive nonnative species, see the Management, Restoration, and Monitoring chapter.

Another challenge to local plants, animals and habitats occurs when certain species become overabundant. For example, "subsidized" predators such as native crows (*Corvus* species), raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), and striped skunks (*Mephitis mephitis*) as well as nonnative feral house cats (*Felis sylvestris*) benefit from proximity to humans and the food we provide in urban and suburban settings. As populations of these species increase in certain areas, ground-nesting birds and other ground dwellers such as snakes and amphibians often decline. In Jamaica Bay, raccoon predation on diamondback terrapin (*Malaclemys terrapin*) nests and adults is affecting terrapin population dynamics and may threaten the long term viability of this species (Feinberg and Burke 2003). Another regionally overabundant species, the white-tailed deer (*Odocoileus viginianus*) is returning to the City. In some areas, such as Staten Island, high numbers of deer are heavily browsing native as well as garden plants. Deer are known to adversely affect reproduction of certain forest trees and native understory herbs outside of the City (Schuster 2011), and it is anticipated that this will occur on Staten Island and elsewhere in New York City as the deer population increases. Deer also play a role in the spread of Lyme disease (Allan et al. 2003), which may become more prevalent in the outer boroughs as the species returns.

Anthony Ciancimino

White-tailed deer numbers are increasing on Staten Island.

Pollution

Pollution affects biodiversity by contaminating the soil, water, or atmosphere with harmful substances or altering processes through increases in heat, light, etc. The effects of air and water pollution are best known, but noise and light pollution also affect species and their habitats. Artificial night lighting has been shown to interfere with animal navigation, reproduction, and courtship as well as plant germination and flowering (Rich and Longcore 2006), whereas noise pollution affects animals' ability to communicate and avoid predators. For example, artificial lighting attracts night-migrating songbirds, causing them to land in inappropriate places, like the middle of Manhattan. When daylight comes, they often crash into windows that reflect images of the sky and trees, which they perceive as habitat. New York City Audubon established Project Safe Flight in New York City to help reduce bird mortality in part by encouraging managers and owners of large office buildings to turn off the lights during peak periods of the spring and fall migration (NYC Audubon 2012).

Adriana Palmer

Scarlet tanager found dead by Project Safe Flight volunteer during spring migration.

Air and water pollution were first addressed in the early 1970s with passage of the National Environmental Policy Act (NEPA) and the Clean Air and Clean Water Acts, which subsequently have been updated and significantly strengthened. State and

city regulations also address pollution (see Appendix A for more information). As a result, there has been a significant reduction in point source pollution (pollution originating from a single, identifiable source), and many aspects of water quality have improved. Clean air regulations as well as New York City's upgrades to its extensive public transportation system have contributed to substantial improvement of air quality over the years. However, pollutants remain an ongoing challenge (City of New York 2012a). Air pollution by sulfur dioxide, nitrogen oxides, and other substances in urban areas adversely affects not only human health but also the diversity of other species. Many flowering plants are particularly sensitive to damage from ozone, and the diversity and abundance of lichens and mosses are severely reduced in urban settings due in large part to poor air quality.

One of the most critical threats facing the water quality of New York Harbor today is the combined sewer and stormwater system, which carries polluted stormwater as well as raw sewage directly into local waterways during heavy rainfall (City of New York 2012b). The City Department of Environmental Protection's Bluebelt Program addresses this problem on Staten Island by channeling stormwater into either natural or created wetlands. Creating wetlands to capture runoff and allow the stormwater to infiltrate through the soil and into the groundwater is beneficial to the City's natural wetlands. However, when the stormwater is channeled directly into existing natural wetlands without an intervening buffer, the resulting erosion and high pollutant loads reduce habitat quality and species diversity.

In former industrial areas, the soil and underwater sediments are often contaminated with toxic substances. Even soils in non-industrial areas can be contaminated by toxins that are deposited by wind or rain. For more on the characteristics of urban soils, see Table 1. Remediating contaminated soil and restoring healthy soil structure in New York City are ongoing challenges.

Kate Boicourt/NY-NJ Harbor Estuary Program

Runoff from combined sewer outlets and overland runoff harm New York City's waters.

The use of toxic chemicals by industry and by homeowners removing weeds from their yards or spraying unwanted insects affects the health and quality of the City's environment for people and wildlife. Rodenticides used to control nonnative rats and mice, for example, can poison native animals, including predators and scavengers that feed on the poisoned rodents. The spring 2012 deaths of three red-tailed hawks (*Buteo jamaicensis*) in New York City have been attributed to poisoning by newer, more toxic anticoagulant rodenticides, which work by interfering with the animal's blood clotting ability (NYS Department of Environmental Conservation 2012, Okoniewski 2012).

Unsustainable Use

We tend to think that unsustainable use, the over-harvest of a plant or animal species and resulting population decline, occurs only in distant locations, like the bushmeat trade in Africa. But it has occurred and continues to occur in New York City. Some Hudson River fisheries, such as American shad (*Alosa sapidissima*) and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), were decimated in the early 1900s due to overfishing in combination with harbor pollution (Limburg et al. 2006). Populations of some local reptiles and amphibians are still threatened by collection for the pet trade and food industry. In fact, a 2009 undercover operation in New York State called Operation Shellshock resulted in the arrest of a number of individuals illegally collecting and selling reptile and amphibian species, including thousands of local hatchling snapping turtles (*Chelydra serpentina*) (Caifa and Solan 2009, Sulzberger 2009).

Al Breisch/NYS Department of Environmental Conservation

Baby snapping turtles confiscated during Operation Shellshock.

Local plants are threatened by illegal collection as well. Fern fiddleheads and other plants and plant parts are taken from the City's parks and natural areas for food and medicinal purposes, while orchid populations have been decimated by collectors who prize these rare plants (see the Pink Lady's Slipper and Other Orchids profile for details).

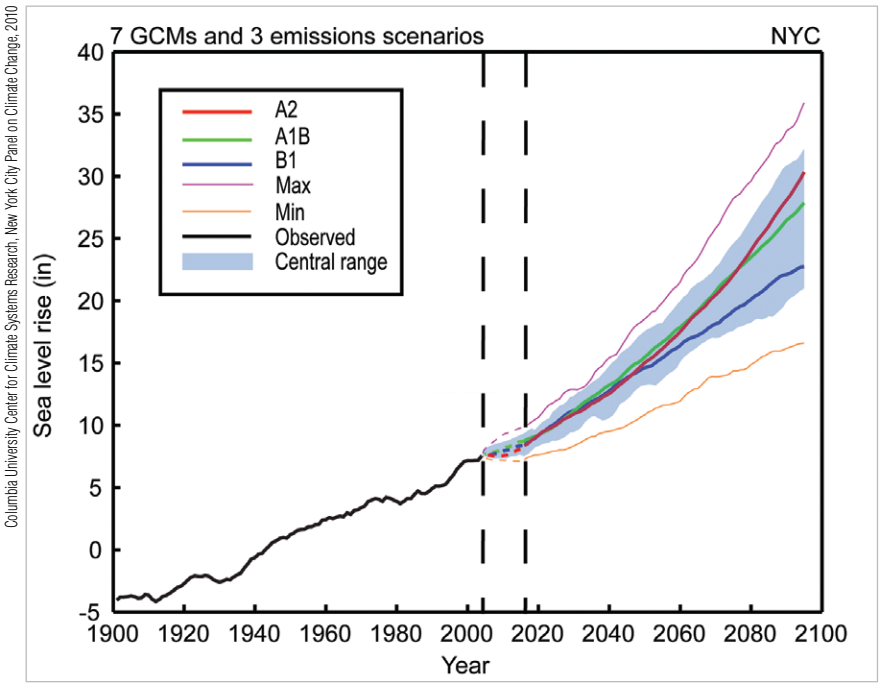
Climate Change

The Earth's climate has changed over the millennia, albeit slowly. Today, however, the overwhelming majority of climate scientists agree that the climate is changing more rapidly than ever before in recorded history. The decade 2000 to 2010 was the warmest on record, and 2012 was the warmest year ever for the U.S. and for New York City (as measured in Central Park) (NOAA 2013).

Among the most likely impacts of a changing climate are warmer temperatures, especially in the winter in our region, more severe droughts and floods, more extreme weather events, and sea level rise. The combination of sea level rise and more severe storm surges (the rise in sea level associated with storms) poses a particularly severe threat to coastal communities such as New York City (NYS Sea Level Rise Task Force 2010). This was clearly evidenced with Hurricane Sandy. A rise in sea level also results in a variety of impacts to habitats, including more frequent and deeper flooding and increased salinity in low-lying coastal areas. Although tidal wetlands are often able to build up gradually as the sea level rises, the current rapidly increasing rate of sea level rise threatens to cause the loss of many of the City's tidal marshes.

A further complication for planners is that these impacts may differ from location to location and are likely to be magnified in urban centers that are already warmer than surrounding regions due to the urban heat island effect. Various studies (Rosenzweig and Solecki 2001, Frumhoff et al. 2007) have shown what is likely to be in store for New York City as the climate changes.

PlaNYC and the Mayor's Task Force on Climate Change have developed plans to address these issues to help protect infrastructure and human well-being. However, climate change also affects biodiversity. The changing distribution of various species in the New York City region is already being observed.



This graph shows projected sea level rise along New York City's coast under three emissions scenarios. Even the most conservative model predicts a substantial rise in sea level over the next 100 years.

The Carolina wren (*Thryothorus ludovicianus)* and red-bellied woodpecker (*Melanerpes carolinus*) have moved northward, becoming two of the most common birds in the urban forest. The great spreadwing damselfly (*Archilestes grandis*) has colonized Staten Island from farther south (E. Pehek, personal communication, 29 January 2012). More southerly plant species such as the tulip tree (*Liriodendron tulipifera*) and willow oak (*Quercus phellos*) are surviving better in recent years (M. Feller, personal communication, 15 March 2012). Climate change has contributed to these range changes.

At the same time, higher temperatures are placing stress on native species adapted to cooler conditions, such as sugar maple (*Acer saccharum*) and American hemlock (*Tsuga canadensis*), and those whose ranges reach their southernmost point in New York City or adjacent areas, like the American lobster (*Homarus americanus*) (New England Aquarium 2012). Habitats that tend to be cooler in summer than other habitats, such as north-facing slopes, springs and spring seeps, and areas that are densely shaded by vegetation or structures or flooded by estuarine tides, may be critical for the survival of these species in this area.

Warming temperatures have already altered the timing of many plant and animal activities. Certain plants are leafing out and flowering earlier in the spring, and this altered timing may no longer match the emergence of their pollinators or the arrival of migrating birds that depend on flower nectar and associated insects for food. In addition, cities may be harboring potentially invasive species that are more adapted to warmer urban climates, and which could spread out into the surrounding landscape once the climate changes there. Kudzu vine (*Pueraria montana*) is a good example in New York City and other nearby areas.

For more detailed discussion about specific threats to New York City's biodiversity, see the individual species and habitat profiles.

Planning for Biodiversity Conservation

Although New York City has developed an exemplary portfolio of parks and greenspaces throughout the five boroughs, more can be done to protect and promote biodiversity. Some greenspaces with important habitats are not yet preserved or managed for biodiversity, and the legal status of protected land should be strengthened overall. In addition, green corridors must be established among certain sites to accommodate the need of many plants and animals to move from one habitat to another at different times of the year; to connect them with nearby populations so that genetic interchange can occur; and to enable them to respond to climate change as habitat shifts and the sea level rises.

Land acquisition has been a key tool for protecting the water quality in the upstate watershed, the source of much of New York City's water supply. However, active land conservation and management for biodiversity are also vital in the five boroughs to protect and maintain the water quality of estuarine habitats as well as the City's green infrastructure—its natural lands, communities and processes.

Daniel Avila/NYC Department of Parks and Recreation

Urban Park Ranger at Marine Park (Brooklyn). Educating about the environment is a vital component of successful conservation.

Successful conservation of biodiversity, especially in highly developed areas like New York City, requires first and foremost a long-range vision that clearly articulates goals and desired outcomes. Implementing this vision in turn depends on the following:

- A biodiversity conservation plan that identifies, assesses, and maps habitats that support plant communities and the plant and animal species of conservation concern in the City and also the threats to them;
- Effective laws, regulations, and policies that promote environmental protection of species, habitats, and the ecosystem services they provide—and adequate enforcement of those laws;
- Hands-on restoration and long-term monitoring and management where needed and appropriate; and
- Education and effective outreach to enlist the public's cooperation and support.

The first two requirements are discussed in this chapter. The following chapter addresses management, restoration, and monitoring. Although beyond the current scope of this Handbook, public education and outreach about the nature of biodiversity and its conservation in New York City are crucial components of a biodiversity conservation strategy.

Laws and Policies

Many excellent federal, state, and city regulations promote the protection of biodiversity. At the federal level are laws such as the National Environmental Policy Act (NEPA), the Clean Air and Clean Water Acts, and the Endangered Species Act. New York State has also implemented important legislation and established programs to benefit biodiversity. Among these are the New York Environmental Conservation Law that established the Department of Environmental Conservation in 1970, the New York Endangered Species Act, and the Freshwater Wetlands Act. Federally initiated projects in the City need to be in compliance with NEPA requirements, while city projects initiated by a state agency go through a state environmental assessment process (SEQR). Other proposed development projects go through a detailed city environmental review process (CEQR). In addition, there are special regional conservation programs such as the New York-New Jersey Harbor Estuary, Hudson River Estuary, and Long Island Sound programs, and the Jamaica Bay Watershed Protection Plan, which afford extra protection and management opportunities.

Although it is not a law or regulation, New York City also has implemented PlaNYC, a sustainability plan that emphasizes protection of natural systems. Supplementing PlaNYC are several targeted environmental protection strategies such as the New York City Green Infrastructure Plan and the Wetlands Strategy, released in May 2012. For a more detailed list of these and other laws, policies, and programs affecting biodiversity, see Appendix A.

In some cases, laws and policies related to land use, zoning, development, and redevelopment affecting biodiversity need strengthening; in other cases, the creation of new regulations or guidelines may be appropriate. For example, zoning text amendments have already been approved for green initiatives, including street tree requirements, parking lot standards, and enhancement of yards and open space throughout the City. The City's special zoning districts provide additional control over land use and development in ecologically or otherwise significant landscapes (such as those "with unique characteristics"). For example, the Special Natural Area District and the Special Hillsides Preservation District in Staten Island provide extra protective

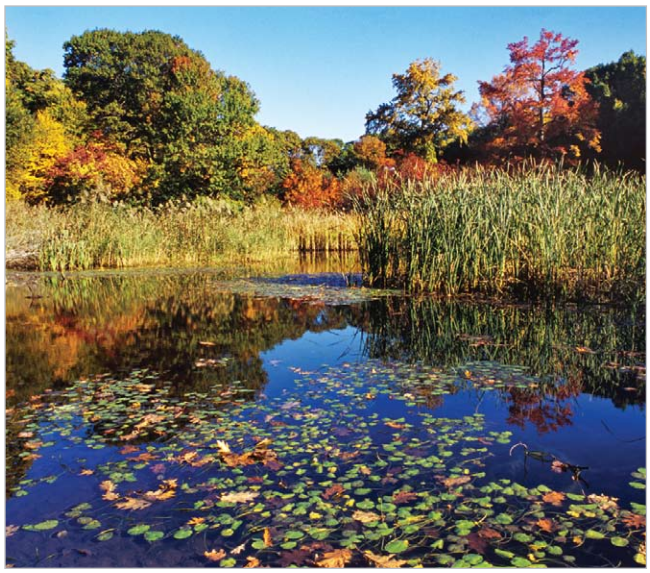
Kate Boicourt/NY-NJ Harbor Estuary Program

Brooklyn Bridge Park.

measures for development in sensitive areas.

Providing permanent protection for the City's Forever Wild Nature Preserves, the 10,000 acres of unique forests and wetlands featuring some of New York City's most special plants and animals, is also critically important. Other parks and publicly owned greenspaces identified as important habitat for either high biodiversity or rare and sensitive species also require legal protection from commercial, residential, road, and recreational development, modification for stormwater management, and other projects allowed under current regulations governing New York City Parks and Economic Development Corporation lands. In addition, clarification of the definition of "open space" is sorely needed to distinguish greenspace—seminatural habitat that supports or enhances biodiversity—from other forms of open space such as expansive lawn areas, developed ballfields, or other active recreation areas that are less valuable for biodiversity.

Carl Heilman II/Wild Visions, Inc.



Alley Pond Park, one of New York City's Forever Wild Preserves.

Adequate enforcement of existing environmental laws and regulations and comprehensive follow-up are essential to successful conservation. For more information, see the Management, Restoration, and Monitoring chapter.

Biodiversity Conservation Plan

An important first step in developing an over-arching biodiversity conservation plan would be a comprehensive survey of New York City's lands and waters to locate, identify, and map important species and habitats. Coupled with this would be an assessment of existing greenspace to show which lands and waters are already protected; where connecting corridors exist and what habitats are included; where corridors could be established either by securing currently unprotected habitat by using urban green infrastructure such as median strips and green roofs or by restoring degraded lands like brownfields (abandoned contaminated sites); and where protection needs to be expanded to provide buffers to protect species or accommodate adaptation to climate change. Oasis (Open Accessible Space Information System) provides a good interactive base map of greenspaces, brownfields, and much more, but a more detailed map with species and important populations identified and natural communities specified is required for more focused planning efforts.

Selected species of birds, amphibians, dragonflies and other animal groups have been surveyed and vegetation units have been mapped in some city parks. However, we still know little about many species—whether populations are extant (still present) for example, or whether populations are stable or declining. Surveys and monitoring are critically needed. Ideally, all remaining greenspace, public and private, terrestrial and aquatic, including brownfields, should be assessed for biodiversity and surveyed for particular species where appropriate so that the most important areas can be conserved, whether through acquisition, management, or restoration. This includes existing city, state, and national park lands as well as other city-owned properties such as those held by the Economic Development Corporation or other agencies. Significant habitats identified by the Local Waterfront

Revitalization Program and Forever Wild sites would be priorities for survey and assessment.

An understanding of the life history needs of species should guide what kinds of habitat to protect, and whether large contiguous areas are required or smaller, linked patches of habitat are sufficient. Even species and habitats that have been studied extensively outside of New York City, such as the red-backed salamander (*Plethodon cinereus*) or the East Coast salt marsh, are likely to have different ecological contexts and conservation needs in the City itself.

Robert T. Zappalorti/Nature's Film and Photo Images

Northern red-backed salamander.

Planning also must include the conservation of habitat complexes—protecting forests, for example, yet not neglecting the fields and shrublands that are key to a diverse mosaic of ecosystems. Fields and shrublands are critical habitat for pollinators, grassland bird species, and reptiles in particular. Wetlands are greatly enhanced by conservation of adjoining buffer zones that help keep pollutants and other stressors out and serve as complementary habitats for wildlife that require both wetlands and uplands. For additional discussion, see the Management, Restoration, and Monitoring chapter.

Planning at a regional scale, not just locally, is also key. The focus on local communities and their greenspaces should be linked to the larger borough, then to the City as a whole and beyond. The conservation of Raritan Bay, for example, depends on actions taken in both New York City and New Jersey. Bronx River conservation relies on collaborations among agencies and organizations in both New York City and Westchester County. Likewise, the habitat quality of Jamaica Bay and Long Island Sound also depends on regional conservation initiatives because these estuaries overlap political boundaries and are regulated by a complex mixture of federal, state, and local jurisdictions. Of course, collaborations among the various public agencies and organizations involved in land management are vital.

Risk management grounded in the precautionary principle is fundamental for all planning efforts. This principle states that in the absence of adequate scientific data, activities are assumed to be harmful until proven otherwise (Cooney 2004). Essentially, this means that if we don't fully understand the risks inherent in an action we are considering (be it land management or development or other activity that affects the environment) we should act carefully and take safeguards to prevent or mitigate potential harm. As Mark Hostetler states (2009): "An ounce of protection is worth a pound of restoration. Protecting rapidly diminishing primary habitats has to be a priority. These are benchmarks, reference points, seed sources for restoration. Patches of original native vegetation (no matter how degraded) are a precious heritage and are essentially irreplaceable." See the Waste Ground habitat profile for further discussion.

It is important to keep in mind that developing a biodiversity conservation plan is not a one-time exercise. Plans are living documents to be used, revised, and updated as new information comes along.

Frequently Asked Questions

Some general conservation planning recommendations are given in the individual habitat and species profiles later in the handbook. Below are responses to frequently asked questions about planning for biodiversity conservation.

When is it appropriate for greenspace (broadly defined as any unbuilt area) to be developed, and when should whole sites be protected from development?

Although it has many fine parks and preserves, the City has a finite supply of greenspace. Greenspace can be created, but this is difficult, and riskier than conserving existing greenspace. Created habitat is often lower in quality than extant, functioning habitat. As more areas in and near the City are developed, the remaining greenspaces will become increasingly valuable for preserving biodiversity and providing environmental services, yet the pressure to use them for other purposes will intensify.

Ideally, there would be no net loss of greenspace. At the very least, sites that support a rare habitat or species (or species or habitats common elsewhere but uncommon in the City) should be protected if development would contribute substantially to their decline or loss in New York City. It may be necessary to assess the distribution of the habitat or species in areas adjoining as well as within the City in order to decide when preservation is necessary. In some cases, a rare species is transitory or can be relocated to an existing preserve. Some years ago, red-rooted flatsedge (*Cyperus erythrorhizos*) was found on sandy fill in a lot intended for development at Battery Park City (E. Kiviat, personal observation, ca. 1995). This flatsedge is rare in New York State but comes and goes on bare, moist, or wet soil, and preserving a site may not contribute for long to the conservation of the species. By contrast, the preservation of an extensive marsh complex on Staten Island where northern harriers (*Circus cyaneus*), a threatened species in New York State, nest and other marsh birds and leopard frogs occur would be a significant contribution to biodiversity conservation in the City.

Dan Pancamo/Wiki Images

Northern harrier.

What portions of development sites should be protected?

In some cases, it is sufficient to protect a small area supporting a rare habitat or species while the rest of a site is developed. However, this is difficult to evaluate because development may have unforeseen negative consequences, and a species may not be able to persist or reproduce if its habitat or the surrounding landscape no longer meets all of its needs. Nutrients, organic matter, water, and other materials from the surrounding area may be good or bad for the species in question. At Kreischer Hill on Staten Island, for example, a large area of thickets and barrens has been built over while a small patch (perhaps 500 square feet) of a very rare plant, Torrey's mountain-mint (*Pycnanthemum torrei*), was fenced for preservation. Although this measure was clearly better than allowing the plant to be destroyed during development, it seems unlikely that it will survive for the long term. Impacts from cars, dogs, and curious people outside the fence may quickly degrade the protected patch of habitat.

Stephen M. Young/NY Natural Heritage Program

Torrey's mountain mint.

In fact, in sections of the City where new developments are being built with conservation areas set aside as part of the design, developers and planners should consider an even broader scale perspective to increase habitat value by ensuring that the conservation areas in different developments are linked to each other across the landscape rather than set aside as small, fragmented, and isolated pockets of habitat.

Where can new greenspace be created?

Of course, the amount of land available for the creation of greenspace is limited, but this option should always be kept in mind for abandoned industrial and transportation sites, vacant lots, and locations where buildings are to be razed. For economic reasons, brownfields or hazardous waste sites are typically slated for redevelopment following remediation of the contamination. However, in certain instances, such as where newly created habitat will provide connectivity between protected lands, provide much-needed habitat for critical species of conservation concern, or provide respite for community members as a park, conversion of brownfields to greenspace can be a useful conservation tool. Brownfields can support significant biodiversity (Harrison and Davies 2002), such as grassland or shrubland birds or butterflies, or rare plants. For this reason, before commitments are made to a particular redevelopment path, brownfields should always be assessed for biodiversity by conducting appropriate biological surveys.

Examples of this "brownfields to greenfields" concept, which was articulated by Megan Callus and colleagues at the NY/NJ Baykeeper (2006), include 400 acres of landfill in Brooklyn on Jamaica Bay that were remediated and converted to grassland and maritime coastal forest by the New York City Department of Environmental Protection in 2006. The Fresh Kills landfill on Staten Island is in the process of being converted to a city park.

Courtesy of The City of New York

Fresh Kills Park, Staten Island, is being developed on 2200 acres. This will be the City's largest park in 100 years on what was formerly the world's largest garbage landfill.

Other examples of greenspace creation include portions of Floyd Bennett Field, the former airfield in Brooklyn that is now part of Gateway National Recreation Area, which have been allowed to develop grassland and shrubland vegetation, important to nesting grassland birds such as savannah sparrow (*Ammodramus savannarum*) and overwintering birds such as northern harrier (*Circus cyaneus*) and horned lark (*Eremophila alpestris*) (Bourque 2007). The site was also used for experimental reintroduction of native turtles (see the Dredge Spoil habitat profile). A section of Governors Island, the former Coast Guard and Army base, will be replanted with dense woodlands attractive to migrating songbirds, and a new oyster reef has been created on its shoreline by the island's public high school, the New York Harbor School (Kamp 2010). Another example is Mariner's Marsh Park in Staten Island, which includes a diverse

array of habitats, including wetlands, grasslands, and swamp forest, and is currently being studied for possible remediation (New York City Department of Parks and Recreation 2006).

Greenspace can also be created in the form of green roofs, green walls, gardens, median plantings, retention basins, and other small but potentially significant habitats (see the Gardens, Green Roofs, and Green Walls profile). Keep in mind that creating connections among new and existing areas is as important as establishing new greenspaces.

How can habitats and other greenspace be connected?

Depending on how they are managed, street medians (so-called greenstreets) and roadsides, street trees and curbside plantings, green roofs, pocket parks, shorelines, urban farms, and even community and residential gardens can support small organisms or visiting songbirds, or provide green corridors connecting larger habitat areas for other species. If some habitat is left untilled and hedgerows are created to support native biodiversity, especially pollinators, urban farms and community gardens can become a critical part of the greenspace matrix. A small community garden in the Bronx with only a few trees and a rock outcrop, for example, has a surprisingly large population of red-backed salamanders. (E. Pehek, personal communication, 29 January 2012). The Brooklyn Greenway Initiative is working with the Brooklyn Navy Yard to replant a 1.7-acre memorial site with plants that can support native pollinators (R. Pirani, personal communication, 2 April 2012).

It is important to note that in some circumstances corridors can be detrimental—when they facilitate the movement of problematic species such as mile-a-minute vine (*Persicaria perfoliatum*) and porcelainberry (*Ampelopsis brevipedunculata*), for example, or allow the spread of amphibian and reptile pathogens from one freshwater wetland to another. In the outer boroughs, where corridors have enabled deer to recolonize, forest wildflowers are threatened by overgrazing. Therefore connectivity needs to be addressed on a site- and species-specific basis.

How can development or redevelopment sites be designed to promote biodiversity?

A number of excellent resources that guide site design planning with biodiversity in mind are available (see Appendix C). They emphasize measures such as designing portions of development sites reserved for stormwater control and ornamental landscape plantings to provide food, cover, and other resources for pollinators and songbirds. Depending on which plant species are used, green roofs and green walls can also provide resources for native bees, butterflies, songbirds, and other animals (see the Gardens, Green Roofs, and Green Walls profile). Other ideas for reducing the impact of development on biodiversity include providing so-called stopover habitats for migrating songbirds and butterflies, not just breeders or year-round residents; paying attention to road width, types of curbing, and stormwater management that will not adversely affect reptiles and amphibians; conserving wetlands with adequate buffers to protect water quality and provide overwintering sites for amphibians and other wildlife; and using "green transportation" strategies (animal passages, street plantings, reduced speed) to link greenspaces. If appropriate, the biological character of nearby greenspaces should be considered during selection of plant species and soil materials to facilitate natural dispersal of seeds and other organisms.

In addition, during the past few decades much has been learned about designing structures to minimize hazards to wildlife, including modifying windows to lessen reflections and reducing artificial night lighting to help reduce bird mortality (Klem 1990, Seewagen 2010). There are also design features that help keep unwanted birds such as rock pigeons from nesting or roosting on buildings (Geis 1976).

Identifying Species of Conservation Concern

While both common and rare native species and communities are important to the maintenance of diverse and resilient urban ecosystems, those that are rare are of particular conservation concern because they are in greatest danger of disappearing. (Rarity in this case refers to species and communities that are rare in New York City even if common outside the City, as well as to species considered rare throughout their range.) Moreover, the decline or disappearance of a rare species is often a warning of environmental deterioration, and may be part of (or may trigger) collapses in other parts of the ecosystem.

Although some species are naturally rare throughout their ranges, most of the rare species in any given region consist of small populations of otherwise well-established species living near the margins of their geographical ranges. Populations of species at their range margins often subsist close to the limits of their environmental tolerances and therefore may be more vulnerable to natural or human-caused stress. Conservation at the margins of a species' range is important because that is where significant genetic variation in a species is frequently found. New York City has several species that fall into this category, such as the barn owl (*Tyto alba*) and American persimmon tree (*Diospyros virginiana*); the City is at the northern edge of their respective ranges. It is also at the southern edge of the northern rocky intertidal coastline community. Understanding and protecting such species and biological communities will be increasingly important as habitats and species shift due to climate change. Genetic diversity is an important component of biodiversity, and preserving as much diversity in the gene pools as possible within populations of plant and animal species is the key to adaptation and persistence as environments change.

Also of import are those species that only call New York City home during part of the year. Some rare or special species do not breed in the City but migrate through on their way north or south to summering or overwintering grounds. They depend on critical stopover habitat where they rest and feed en route before continuing their journey. Red knots (*Calidris canutus rufa*) rely on sandy beaches that support spawning Atlantic horseshoe crabs (*Limulus polyphemus*), where the birds replenish their fat stores by feeding on the crab eggs. Millions of songbirds, including many rare species, rely on the greenspace in and around the City as they fly northward each spring and southward in the fall. Monarch butterflies (*Danaus plexippus*) that breed in the area depend on milkweeds (*Asclepias*) for egg-laying, while those migrating through in the fall rely on coastal nectar plants like seaside goldenrod (*Solidago sempervirens*). Although the monarch is not a protected species, many scientists consider monarch migration a threatened phenomenon, due in part to the loss of stopover habitat as well as critical overwintering sites (e.g., in Mexico). Uncommon or rare migratory fishes such as American shad (*Alosa sapidissima*) pass through New York Harbor on their way to their spawning grounds farther up the Hudson, and their

Don Riepe/American Littoral Society

A monarch butterfly nectars at seaside goldenrod during migration.

young pass by on their way to the ocean where they grow and develop. The American eel (*Anguilla rostrata*) has the opposite migratory life cycle, spawning in the Sargasso Sea east of the Caribbean, and maturing in estuaries and fresh waters, including those in and around New York City.

Many species currently on lists of endangered and threatened species were once more prevalent, but deteriorating ecological conditions, natural and human-caused, eventually caused their ranges to contract and local populations to decline. This is also happening to species that are not listed as endangered or threatened in New York, but nonetheless are disappearing from New York City. For example, as development has surrounded a stand of eastern hemlock (*Tsuga canadensis*) at the New York Botanical Garden over time, the environment has changed, becoming hotter and drier. These conditions stress the hemlocks, which favor cool, moist environs, making them more susceptible to insect attack (Rudnicky and McDonnell 1989). By the time species have become rare enough to be listed statewide or nationally, recovery can be impossible. If conservation efforts begin when a species becomes regionally and locally rare, however, it is more likely that it can be stabilized and restored.

As discussed in the chapter on Urban Biodiversity, rare species, like all species, may be important to humanity in numerous ways, including physical and mental well-being. They can also be crucial to the survival of other plants and animals. For example, American oysters (*Crassostrea virginica*) are often considered a keystone species, one that provides important functions for ecosystems and species alike. Although uncommon today in New York City waters, in the past New York's extensive oyster reefs provided habitat for many other sedentary species such as barnacles, offered hiding places for crabs and fish to avoid predation, and filtered and cleansed harbor waters. Due to the effects of overharvest, pollution, and disease, oyster numbers plummeted in the early 1900s; however, there are now active restoration projects underway to bring them back for their important ecological role (Hudson River Foundation 2010).

In this handbook rarity and ecological significance are considered at all geographic levels — national, state, and regional. Lists and evaluations of species at the national and state levels integrate information from many sources and provide a perspective that is not available on a regional or local level. Regional lists can help alert biologists and planners to species and communities of regional significance, and perhaps help to avert the decline or extirpation of species that precede eventual listing at the national or state level. However, a species that is rare at the national or state level should normally receive the highest conservation priority. Some of the better-known lists of threatened, endangered, and regionally rare species are presented in Appendix B.

How to Perform a Habitat Assessment

A habitat assessment is an assessment of the biodiversity potential of a site, based on habitats and the rare species they are likely to support. This type of assessment does not attempt to find all the species that use a site, thus is an efficient first step. A habitat assessment can be done at any season (except when there is a lot of snow or ice covering the ground), whereas many individual plant or animal species are only detectable at certain times of the year and day, or require special experience and techniques to find. A habitat assessment of a development site, park, nature reserve, or other greenspace in New York City can help guide decisions about conservation, planning, and management. The assessment is the first step in acquiring and analyzing biological information and may need to be followed by targeted surveys for particular species or groups of organisms. Following is an outline of how to do a habitat assessment. You may need help from an expert field biologist with experience studying biodiversity in the City, but you can at least begin the process on your own.

For those who are not conducting an original assessment but rather reviewing another's assessment, the following information can also be useful as a guide for what to expect in a report. We have presented the optimal steps and information that should be included in a detailed assessment, however, note that legal requirements (e.g., SEQR or CEQR) may be less.

Step 1:
Acquire existing information about the site.

This may include remotely gathered information such as maps and aerial photographs, as well as information previously gathered onsite pertaining to the environment and the species occurring there. You will also need to know the landowner's name and contact information because you will need permission to enter most private lands and some public lands.

Key sources of site information are listed in Table 2. It is important to note that maps and other remote images may contain errors, and onsite information is likely to be very incomplete or nonexistent.

Table 2. Sources of information about sites in New York City.

Type of Information		References
REMOTE INFORMATION		
Topographic map	U.S. Geological Survey 7.5 minute topographic map sheets	http://topomaps.usgs.gov/
Bedrock geology map	Bedrock geology map of New York State, bedrock map of New York City region	Schuberth 1968, Fisher et al. 1970 (http://www.nysm.nysed.gov/nysgs/resources/index.html); for a simplified map see Figure 2

Type of Information		References
Surficial geology map	Surficial Geologic Map of New York	Cadwell & Dineen 1987 (http://www.nysm.nysed.gov/nysgs/resources/index.html)
Soils map	Reconnaissance Soil Survey	New York City Soil Survey 2009: www.nycswcd.net (not sufficiently detailed for site-specific information)
Wetlands and waterways maps	Various wetlands maps (wetland mapping may be incomplete and should be checked in the field)	NYS Department of Environmental Conservation Freshwater Wetlands Maps: http://www.dec.ny.gov/lands/5124.html; NYS DEC Tidal Wetlands Maps: http://twi.ligis.org/; National Wetlands Inventory Maps: http://www.fws.gov/wetlands/
Aerial photographs, satellite imagery		Google Maps; Google Earth; Bing Maps; NYS GIS clearinghouse: www.gis.ny.gov; ESRI's GIS data sources: www.esri.com; etc.
Street map		Google Maps; various maps and atlases
General information	Many kinds of information, including block/lot, property ownership, community boards, recreational facilities, community gardens, greenspaces, waste remediation sites, pollution sources, and land cover	www.oasisnyc.net
ONSITE INFORMATION		
Rare species occurrences	NYS DEC Region 2	New York Nature Explorer http://www.dec.ny.gov/animals/57844.html; U.S. Fish and Wildlife Service 1997
Environmental documents	Environmental assessments; management plans	May be available from property owner, community board, or Mayor's Office of Environmental Coordination for CEQR documents
Various	Scientists and naturalists	College faculty; museum and botanical garden staff; nature club members or records
Various	Natural history and scientific literature	See Pouyat 1991 bibliography, Google Scholar or other databases to search for literature on an individual site

Information gathered during the preliminary offsite phase of a biodiversity assessment should be used to determine the extent (size) of the site and its shape, adjoining land uses, characteristics of surface waters, vegetation, and evidence of human activity such as roads and dumps. With reference to the Habitat Profiles in this Handbook, you can then use the New York City Soil Survey map, aerial photos or satellite imagery (see Table 2), and other information you are able to glean to predict habitats likely to be present at a site. For example, the soil map identifies sandy dredge spoil. The soil map and remote imagery (aerial photos or satellite imagery) will identify most areas of tidal marsh by their sulfihemist and sulfaquent solid soil types (those that are frequently flooded and contain an abundance of reduced sulfur) and dendritic (tree-like) branching tidal creeks or grid-like pattern of old mosquito ditches and fine texture indicating low and relatively even vegetation. Once you have identified potential habitats, the habitat profiles in this handbook will tell you about typical species and species of conservation concern likely to occur in them.

Step 2:
Walk the site.

Even someone who is not a naturalist or biologist can discern much useful information from a reconnaissance. Nonetheless, unless there is already a lot of biological information about the site, it is a good idea to take a naturalist or biologist along. Biodiversity assessment is an expert activity analogous to repairing a car; a non-expert can start the process and handle simple tasks, but in most cases it is best carried out in collaboration with an experienced professional biologist or naturalist. Table 3 lists some of the things non-experts and experts should look for.

Keep in mind that permission for site access must be granted by the landowner prior to beginning this phase of the assessment. Of course, surveyors should be mindful of potential risks to their safety, including hazardous substances or structures, and crime.

Table 3. Features to look for during a walking reconnaissance of a site.

General category	Non-expert	Expert	Significance
Surface waters	Extent and depths of standing water; flow; precise locations of water bodies and streams.	Extent and depths of standing water at observation time and seasonal maximum; flow; tidal influence; turbidity/clarity; salinity	Different water patterns support different species
Soil exposure	A lot or a little bare (non-vegetated) soil is present	Estimate percentage of bare soil	Many bees and wasps nest in sparsely vegetated soil; certain lichens, mosses, and vascular plants occur there

General category	Non-expert	Expert	Significance
Soil characteristics (a few inches below surface)	Firm or loose; size of particles; presence of rock fragments or masses; light or dark color; presence of garbage	Judge compaction, texture, organic matter content, nature of rock fragments or bedrock, nature of refuse, if any, etc.; hydric or non-hydric soil, infiltration rates	These soil characteristics influence its use by plants and animals
Soil moisture	Is soil dry, moist, or wet?	Soil moisture levels (based on appearance and feel of soil and presence of indicator plants and soil maps)	One of the most important characteristics determining habitat functions
Trees	Are trees present? How numerous? Small or large? Live or dead? Cavities visible in trunks?	Tree species list (as complete as time permits), forest type (defined by dominant species, relative abundance of each species), mean and range of dbh (diameter at breast height), density, canopy cover, health (disease, insect infestation, etc.), presence of seedlings or saplings, etc.	Large trees potentially support unusual mosses, lichens, bats, and birds, and are generally important for cavity-using animals and foraging by birds and bats; are trees replacing themselves naturally?
Shrubs	Present? How numerous? Low or tall? Live or dead? Hard to see into or move through?	Shrub species list (as complete as time allows), relative abundance of each species, height, density, crown diameter, health	Affect shrubland animals such as certain songbirds; species can indicate wetland vs. upland habitat
Herbaceous (non-woody) plants other than vines	Present? How abundant? Grass-like or broad-leaved? Height? Variety?	Herb species list (as complete as time allows), relative abundance of each, distribution, height, health	Indicate nutrient and wetland status of soil and likelihood of rare plant occurrence; are host and nectar plants for insects, seed sources for birds
Woody and herbaceous vines	Present? How abundant? Small or large? Overgrowing trees and shrubs?	Vine species, size, etc.	May stress trees by making them more susceptible to windthrow or competing for nutrients; provide food and shelter for many other organisms; may suppress growth of other plants

General category	Non-expert	Expert	Significance
Fungi, lichens, mosses, liverworts	Presence and abundance (to the extent the non-expert is familiar with these organisms, the identification of which is generally best left to experts)	Presence, abundance/cover, microhabitats (downwood, soil, trunks, etc.), species	May include rare species
Downwood (coarse woody debris)	Logs or branches on ground? Size and abundance? Dry or moist?	Size and abundance of CWD (coarse woody debris); moisture status; state of decay	Important for small mammals, snakes, salamanders, many invertebrates, mosses, liverworts, lichens, and fungi
Human activity	Observations of human activity or its signs such as presence of containers that might hold (or have held) chemicals; other evidence of dumping; signs of mowing or other vegetation management; planted or pruned trees, shrubs, or herbs; vandalism of trees; presence of shell casings or other evidence of hunting or target shooting; signs of fishing; signs of vehicular or foot traffic, etc.	Similar to non-expert observations plus assessment of impacts on biota	Potentially strong effects on species occurrence and health
Anthropo-genic (human-caused) features influencing biota	Presence and extent of features such as dirt or paved roads, abandoned buildings, stone walls, wood piles, brushpiles, board dumps, brick dumps, other construction and demolition debris, mining or other excavations, discarded containers, nest boxes, duck-hunting blinds, etc., that can provide habitat for fauna or flora, or act as ecological traps for fauna	Same as for non-expert with assessment of effects on biota	Can indicate habitat for a number of interesting species including the rare feminine clam shrimp, certain lichens, and a variety of other small animals

General category	Non-expert	Expert	Significance
Fauna	Animals present; kinds (if known)	Species, abundance, size, evidence of reproduction, etc. (recognizing that brief observations may not be representative of site).	
Animal signs	Presence and abundance of nests or other structures, tracks or trails, damage to leaves and trunks, scats, dust baths or wallows, feathers or hairs, etc.	Same as for non-expert, with species identifications as feasible	
Surroundings	Character of habitats adjoining the site	Same as for non-expert, plus considering the kinds of animals likely to be moving between the site and nearby areas	May provide complementary habitats for various life history activities, may support predators, etc.

Step 3:
Document your observations.

Onsite observations should be documented with sketches, photographs, field notes, and in some cases specimens collected by an expert. Habitat assessment is not as comprehensive as a species survey. It may indicate the importance of performing expert biological surveys for particular rare plants or animals that could occur in the habitats identified. An expert survey requires specialists in particular groups of organisms and may need to be performed at certain seasons or times of day (and tide), using the appropriate methods. Experts should be aware of the rare or uncommon species that potentially occur in the habitat types on the site, and how to identify them. Specimens should be collected only if necessary for identification and documentation, if the specimens will be handled properly and accompanied by appropriate data, and if the necessary permits have been obtained. New York State permits are required for collection of aquatic invertebrates and most vertebrate animals, and federal permits for collection of bird nests, feathers, dead or live birds, or federally endangered species. Landowner permission (or a permit from the appropriate government agency, in the case of public land) is required for collecting plant specimens.

If multiple sites are to be visited or there will be multiple visits to a single site, it is advisable to design and use a printed data form for recording observations (or use it in electronic form on a tablet or laptop computer). Photographs are very important, even if taken with cellular phone cameras. Keep detailed notes on when and where photographs were taken and the nature of the subjects. Record geographic coordinates for observations and photographs, either by using a GPS device in the field, or by locating the site on Google Earth, which displays coordinates.

("Smart phones" may also have GPS capability.) Compile all the documentation in a report in electronic or paper form.

A few rare animal and plant species need to be protected from collectors, vandals, or unintentional disturbance by nature-watchers. This is often done by keeping locations secret. There may be a conflict between conservation that depends on the public knowledge of a location, and the need to protect a species from those who would harm it for pleasure or profit. It is often important not to divulge the locations of, for example, nursery colonies of bats, nesting locations of the rarer birds of prey (bald eagle [*Haliaaetus leucocephalus*], peregrine falcon [*Falco peregrinus*], barn owl [*Tyto alba*]), great blue heron (*Ardea herodias*) nests, rare ground-nesting birds (common nighthawk [*Chordeiles minor*]), snake dens, larvae of rare showy moths and butterflies (Cecropia moth [*Hyalophora cecropia*], giant swallowtail [*Papilio cresphontes*]), adult rare butterflies, and showy rare plants or plants of certain groups that are attractive to gardeners and collectors (rare ferns, orchids, insectivorous plants).

Step 4:
Interpret what you saw.

Analyzing information about a site will yield a list of habitats and their condition or quality. Habitats may not always match those profiled in this handbook, either because we have omitted a type of habitat, or due to variation within a habitat type. (Habitats are challenging to classify, and what you see in the field is not likely to exactly match what you read here or elsewhere.) We have also made an effort to include a number of anthropogenic habitats in this handbook, such as dredge spoil, structures, gardens and green roofs, etc. However, the development of a more detailed classification scheme for urban habitats that includes their associated flora and fauna is needed. Each habitat type has the potential to support particular common and rare species. For example, in shrub thickets the gray catbird (*Dumetella carolinensis*) is a common species while the brown thrasher (*Toxostoma rufum*) is uncommon or rare.

The highest quality habitats or sites are typically those with less evidence of human activity, a higher proportion of native plants, less intensive adjoining land uses, more coverage of lichens and mosses, and presence of uncommon or rare species (however, although nonnative plants are an indication of habitat degradation, they can still support important native biodiversity). In general, sites with higher quality habitats are more important for conservation or management. Yet sites with lower quality habitats may be amenable to management or restoration, or may support a rare species that is worth protecting.

The plant diversity (number of species) or diversity of habitats on a site are not indicators of quality or importance per se. Some sites, such as salt marshes, do not support a highly diverse plant community yet have a diverse aquatic animal community and are very important in the larger biodiversity picture in part because they support species that do not occur in other habitats. Nonetheless, the diversity of habitats on a site can be valuable for protecting certain species.

Step 5:
Assess threats.

An assessment of the threats to biodiversity at the site is important. Some threats will be obvious to a non-expert whereas others may require analysis by an expert. Table 4 lists some of the potential threats to look for, using both offsite and onsite observation.

Table 4. Some indicators of threats to biodiversity.

THREAT	INDICATORS	IMPLICATIONS
Direct human disturbance	People onsite; litter; dumping; human trails; shell casings, targets; tents, bedding, etc.; graffiti or other vandalism to trees, rocks, etc.; digging; planting of marijuana or other crops; traps; ruins or structures	Plants or animals may be damaged or removed; animals may be scared off
Contamination	Drums or other chemical containers; stains on soil; dying or dead plants; seepage from dumps or landfills (in many instances, there are no visible signs)*	Toxicity to organisms
Poor water quality	Strong odors of sewage, rotten eggs, etc. (in nontidal waters or wetlands); numerous dead fish or other dead animals; oily sheen on water surface that pulls together rather than shattering when touched with a stick (in many cases water quality problems are not visible and do not create distinctive odors or kill animals outright); presence of litter, particularly sanitary waste as indicator of CSO (combined sewer overflow) discharge	Adverse effects on health, survival, or reproduction of plants and animals
Land development	Information from State Department of Environmental Conservation website; signs of land surveying, engineering tests, or site preparation (land development or infrastructure improvements on neighboring parcels may also have impacts on a site)	Loss and degradation of habitats; hazards to wildlife from vehicles and other equipment; soil compaction, erosion, and siltation; many other problems
Nontarget impacts of ecological restoration	Earthmoving, herbicide application, planting, etc. associated with restoration project	Loss of habitats or species of concern; herbicide toxicity; wildlife entanglement in fencing, geotextiles, or bird and deer netting; injury or mortality of nontarget animals and plants from vehicles and equipment; loss of soil stability; etc.
Invasive species	Observations of specific organisms or signs of them	Changes in habitat structure or function that support desirable species; competition, predation, parasitism, or disease; toxicity
Local air quality impairment	Air pollutant damage to leaves (consult an expert); death of lichens or mosses	Loss of sensitive species

*Do not touch drums or other features that may be associated with chemical contamination.

Step 6:
Develop a prioritization scheme.

As desirable as preservation of all remaining greenspaces for biodiversity may be, there will be conflicts with other human endeavors and it will often be necessary to prioritize among sites. In general, rare species and habitats should receive priority. A globally-rare species (whether officially listed or not) should take precedence over a state-rare species, which should take precedence over a city-rare species. Higher quality occurrences of a species (those with more and healthier individuals, constituting a population that has a better chance of thriving in the long term) and higher quality habitats (more intact in terms of the expected species, fewer nonnative species, physical conditions more "natural") should also have priority.

In addition, a good prioritization scheme will include some level of threats assessment — identification of sites where biodiversity is at great risk and that therefore requires more urgent attention.

It may be possible to compare several sites; more often, however, a single site will be assessed apart from other sites. This makes the biodiversity assessment, and where appropriate biological surveys, especially important.

See Appendix C for additional resources related to priority planning.

Carl Heilman II/Wild Visions, Inc.

Autumn in Pelham Bay Park.

Management, Restoration, and Monitoring

Effective habitat management is critical to ensuring the long-term biological integrity of New York City's natural habitats and biodiversity. This is particularly important as the City's parks and other greenspaces face many stresses and challenges since most of them are relatively small, surrounded by intense development, and in some cases visited by millions of people each year. Effective management requires continuing investment and resources to support the restoration of degraded habitats and management of species, as well as the ongoing monitoring that assesses the success of particular management or restoration efforts.

"Restoration" is a complex and confusing concept. Literally, restoration means returning a site or habitat to a previous, presumably more ecologically intact, condition. Yet the term restoration includes many kinds of actions intended to make some part of nature better, and what constitutes "better" varies according to the motivations and goals of the particular restoration project. Because urban habitats have been substantially altered by human activities, surrounding conditions (including the climate) have changed, many plant and animal species have been lost, and others have been introduced, literal restoration is impossible. However, it is often feasible to remove certain stressors (such as nonnative plants, garbage, or hazardous materials), reestablish some of the appropriate native organisms, and to increase certain ecosystem services such as stormwater absorption by forests or wetlands. This kind of restoration (or, more broadly speaking, management) requires assessment of the habitat quality and biota, funding and labor, monitoring to determine the outcome of management efforts, and usually continual maintenance to prevent deterioration after the initial management work has been completed.

There are a few important steps to take when beginning management or restoration:

- Identify the management goals for a particular site. Is the goal to increase the population of a nesting bird species, or a rare plant? Or to improve ecological function so the site can better provide important ecological services? (See the Urban Biodiversity chapter for more information on ecological services.) The goals will determine what the most effective strategies are. For example, the New York/New Jersey Harbor Estuary Program has compiled a set of Target Ecosystem Characteristics to guide restoration efforts;
- Develop a plan for how to accomplish these goals;
- Manage adaptively, meaning that once a management action has been implemented, it is important to regularly assess what is working and what is not and modify the strategies accordingly; and
- Monitor conservation progress to determine success over the long term. This will also assist in the design of other management projects.

In addition to these general steps, management decisions must be responsive to the characteristics of each particular site (or group of sites), because they can vary greatly. As mentioned earlier, independent expert advice on particular types of habitats and species will often be needed to make good conservation and management decisions. Consultation with restoration ecologists or conservation agencies about best management strategies and practices is also critically important. Detailed natural history observations on a site ideally should be combined with existing data and expert opinions as the basis for site management planning. For further information about species- and habitat-specific management guidelines, see the habitat and species profiles in this handbook.

Following are responses to some frequently asked questions about biodiversity management, restoration, and monitoring in New York City.

Should we manage species or ecosystems?

For many years there has been a discussion about the merits of conserving ecosystems compared to conserving individual species. There are many rare but little-known species that are vulnerable to the impacts of human activities, including, for example, thousands of insects whose life histories and ecological requirements are poorly understood (Raphael and Molina 2007). It is impossible to manage each species individually. Therefore, many ecologists have advocated an ecosystem-based approach—the assumption being that that this will also protect and conserve the species that are part of the system. Ecosystem management is often thought to be more efficient and cost effective. However, what is good for one species or group of species may be bad for another species or group. Ultimately, many species still must be managed individually if they are to persist in viable populations over the long term. This is especially true for species such as the piping plover (*Charadrius melodus*) that are particularly sensitive to human impacts, requiring constant management to protect their eggs and young from public beachgoers and their dogs as well as from the elevated numbers of predators attracted by humans. It may also increasingly be the case for species sensitive to large-scale changes such as climate warming and the resulting sea level rise.

Barabara Saunders

Piping plover.

Can all parks be managed for biodiversity?

Although the City's parks may have a primary mission other than conserving biodiversity or may have been established for one specific purpose, there is no reason why they can't also benefit biodiversity—indeed, if biodiversity is to survive in the City they will need to.

There are, of course, challenges. Parks do have to balance the needs and safety of the public and the public's expectations with the needs of nature, but these challenges can be overcome. Parks established principally for aesthetic and recreational purposes now serve to protect native plant and animal life as well. For example, the wetlands and forests of Van Cortlandt Park are exemplary in their extent and the presence of many species that are rare or absent elsewhere in New York City. In woodland restorations in Central Park and Prospect Park, snags, fallen logs, and leaves have been left on the ground in certain areas to restore soil health and provide wildlife habitat. Public outreach through educational signage as well as strategically placed fencing around sensitive areas has helped ensure the success of these woodland restoration projects.

Anne Wong

Prospect Park woodland. Fencing allows the area time to regrow after restoration.

How do we begin thinking about restoring ecosystem structure and function in the long term?

Ideally, greenspaces will be protected while they are still ecologically intact. But in most cases, habitats have been degraded and no longer support viable

populations of typical native species or natural ecological processes. In these situations, restoration can be an important management activity. As discussed above, very few if any habitats can be literally "restored" to what would have been living there 100 or 500 years ago (and in some cases a historic condition would not even be considered desirable). However, it is often possible to improve ecosystem structure and function and to manage for individual species considered typical or of conservation concern.

Ecosystem structure is made up of the physical and chemical, as well as biological, features of an environment. For example, restoring structure in a woodland restoration project includes reestablishing understory species such as small trees, shrubs, and herbs. Replacing these vertical layers of vegetation provides more habitat niches for wildlife. Generally, the more layers, the more species diversity the woodland can support. In addition, the more layers, the more biomass, which is important for ecosystem functions such as carbon sequestration. The additional vegetation also slows runoff, increasing water infiltration and decreasing pollution in streams.

Other ecosystem functions (often known as ecosystem services; see the Urban Biodiversity chapter) can sometimes be restored or improved as well. For example, fill can be removed to recreate a tidal wetland; the resulting wetland will have some of the ecological functions of a natural wetland, such as tidal hydrology and tidal marsh vegetation, that may provide foraging and nursery areas for fish and shelter and food for wintering waterfowl. However, this wetland may lack other functions such as some of the biogeochemical processes (nutrient cycling, etc.) that occur in the soil of an undisturbed marsh; a full range of biogeochemical functions may take decades or centuries to reestablish (see, for example, Craft et al. 2003 and Moreno-Mateos et al. 2012). It is important to keep in mind that restoration is a long-term proposition.

In many cases natural processes such as regular or periodic flooding or fire are essential for maintaining habitat suitable for the plants and animals found there. Floodplain forests along Tibbetts Brook in Van Cortlandt Park, for example, as well as Richmond Creek and other Staten Island headwater streams benefit from periodic flooding, which deposits rich sediments and scours vegetation, allowing riverside plants to gain a foothold. Trees such as American sycamore (*Platanus occidentalis*) and common hackberry (*Celtis occidentalis*) readily germinate on the scoured shorelines of the Bronx River and East River. However, urban streams may also deposit large amounts of sediment from urban runoff, making conditions favorable for nonnative weeds such as Japanese knotweed (*Polygonum cuspidatum*) (M. Feller, personal communication, 15 March 2012). Fire historically has maintained not only the well-known pine barrens of Long Island but also the lesser known serpentine barrens on Staten Island. Periodic fires thin understory vegetation, release nutrients into the soil, and expose bare mineral soil—all required by the rare plants found in these serpentine areas. For more information, see the specific habitat profiles.

Although allowing natural processes to occur is critical to maintaining certain species and habitats, this is not always possible in urban areas. When fire is not an option, for example, periodic mowing or prescribed livestock grazing may sometimes be used to restore grassland or shrubland habitats. These techniques can also be effective for managing undesirable nonnative plants if they are done correctly and maintained long enough.

Once the overall goals of a project have been identified, the many specific issues can be addressed, including: What particular restoration techniques will be used? Does soil fertility need to be increased

Ferdie Yau

Hurricane Irene floodwaters on the Bronx River enrich a floodplain forest with sediment.

or reduced? Will the site be revegetated with local native seeds or plants, or will revegetation rely on the local seed bank (the seeds that remain onsite, in the ground)? Do herbivores like rabbits and voles need to be controlled? Because there is so much to consider in planning and implementing successful restoration projects, covering this topic in detail is beyond the scope of this handbook. For more information about ecological restoration, see Appendix C.

When do nonnative species need to be managed to conserve biodiversity in the City?

Some nonnative species are harmless or can even provide important habitat that otherwise would be lacking in the city (Ewel and Putz 2004, Kiviat 2010). Other nonnative species are harmful in certain places and not in others. Across-the-board attempts to kill nonnative species may divert scarce management resources from problems of higher priority where management actions can accomplish more. There is an urgent need for research on the effects of most nonnative organisms, effective ways of monitoring and tracking new arrivals, and a better understanding of when such species could become invasive.

Nonnative plants and animals should be managed when they become invasive and impede the conservation goals at a particular site—for example, when they threaten the survival of a rare plant or animal, or they alter the structure or function of an ecosystem and impair its ability to provide important ecosystem services. Certain high salt marsh habitats, for instance, support breeding birds such as the saltmarsh sparrow (*Ammodramus caudacutus*) that require short grass. If these habitats become densely overgrown by common reed (*Phragmites australis*), the sparrows may no longer be able to nest in them.

More and more, decisions that need to be made about eradication or control of a major new introduced pest are complicated by conflicts with the management needs of other species, even rare species. A recent example occurred when the recommended control for the Asian long-horned beetle (*Anoplophora glabripennis*) involved the removal of critical historic nesting and roost trees for herons on Pralls Island in the Arthur Kill (S. Elbin, personal communication, 29 January 2012). The key to resolving these issues in an ecologically sound manner is proactive thinking and

ongoing discussion among land managers and all interested parties. Such conflicting situations will inevitably become more common, as there are many potential new species invasions on the horizon for New York City, including the emerald ash borer (*Agrilus planipennis*) and southern pine bark beetle (*Dendroctonus frontalis*).

Preventive action can avoid or reduce some harmful plant invasions. Once established, invasive plants are often extremely difficult—and expensive—to control, so it is important to avoid planting them in the first place. Yet many invasive plants are still being sold as garden specimens or even for wildlife plantings and erosion control, despite their documented ability to degrade natural areas. Legislation was passed in 2012 to prohibit the sale of certain invasive plants in New York State. For additional information see Appendices B and C.

Is it important to use local, not just native species?

New York City's native plant species have declined significantly since the mid-19th Century. It is estimated that many of the City's native herbaceous species and almost 30% of its native shrub species have been lost (DeCandido et al. 2004). For this reason, whether the goals of a restoration project are to return a site to historic conditions or mainly to restore habitat function, it is important to use not only native species but also, when possible, local genotypes (genetically distinct individuals) adapted to a particular area. This can be challenging as not all native species do well in urban environments and it can be difficult to find local seed sources for restoration if the original seed bank at a site is no longer viable. However using local species and genotypes, instead of, for example, purchasing seeds or plants from a nonlocal supplier, helps maintain regional genetic diversity. Moreover, commercial meadow native plant seed mixes may contain undesirable weed seeds. The Greenbelt Native Plant Center is spearheading the formation of a Mid-Atlantic seed bank to preserve genotypes of species native to the region as part of a larger Seeds of Success seed conservation initiative with goals of preserving seed diversity in the United States and providing regionally-sourced restoration plantings.

Greenbelt Native Plant Center

Greenbelt Native Plant Center (Staten Island) staff collect grass seed.

Should chemical pesticides, herbicides, and fertilizers be used in greenspaces?

When restoring or managing greenspaces, it is important to take great care to limit negative impacts to the environment. One way to is to minimize or eliminate the use of pesticides (herbicides, insecticides, fungicides, and rodenticides) and other chemicals where possible. For small-scale projects, it is often possible to remove or control problematic species by non-chemical means such as hand-weeding, frequent cutting, prescribed grazing, manipulation of soils and water levels, reducing nutrient levels in soil, etc.

However, for larger sites or extensive infestations of a nonnative species, or when there is a high probability of human health risk (such as West Nile virus) it may be necessary to use chemical means. Integrated pest management (IPM) approaches can minimize the use of pesticides, and least-toxic materials can be substituted for more harmful pesticides. For example, instead of malathion, which was used after the West Nile outbreak, New York City has substituted pesticides such as pyrethroids for adult mosquito control and Bti (*Bacillus thuringiensis israelensis*) for control of mosquito larvae. Although still toxic to many species, they are less so, and more targeted, but still should be used judiciously. Integrated pest management also emphasizes the use of non-chemical methods. For mosquitoes in New York this includes actions such as the elimination of artificial container breeding habitats (clogged gutters, old tires, bird baths not regularly cleaned) and the use of bacterial larvicides (Bti or Bs) in containers that cannot be eliminated or emptied such as storm drain catch basins. Effective use of window screens, personal repellents, and protective clothing can greatly reduce mosquito nuisance, and avoidance of certain places and times where mosquitoes are abundant is also important.

Herbicides, although commonly used, are toxic to animals as well as plants (Kiviat 2009) and should be applied with care to avoid harming nontarget organisms. In some cases herbicides can be applied in a limited manner to cut stems or injected directly into stems, reducing the risk to nontarget species. Sometimes rare plants or other valued native plants are growing beneath or among unwanted weeds, so the latter need to be reduced in abundance using highly selective means such as hand-pulling or hand-cutting.

In some restoration projects, especially nutrient-poor sites, limited applications of fertilizer may be required, such as in planting holes.

Barbara Saunders

Barn owl young in nest box at Breezy Point (Queens).

What should be done with abandoned structures?

Although they may be ugly or even hazardous to public safety, some abandoned or underused buildings provide important habitat for species of conservation concern, including rare plants (see the Cliff Ferns profile), barn owl, or a colony of little brown bats (*Myotis lucifugus*), whose numbers have recently been decimated by white-nose syndrome. For this reason, it makes sense to survey the structures for species of concern before deciding to raze or rebuild. It may be possible to stabilize or renovate structures without harming rare or threatened species. In other cases, it may be possible to erect substitute structures such as barn owl nest boxes or bat boxes (see page 50).

When should public access to an area be prohibited?

Encouraging public access to parks and greenspaces is essential to developing a constituency for these vital areas. In fact, providing park access is a goal of PlaNYC. Public education is important: visitors need to better understand the full range of management activities that takes place at a park, beyond the necessary care and maintenance of infrastructure and amenities for human comfort and safety. Interpretation of nature management activities offers important opportunities to educate visitors about the organisms that live in parks and what is being done to conserve them.

Equally important, however, is ensuring that public use does not become an ecological liability and reduce biodiversity. Public access can introduce ecological disturbance to parks and other greenspaces—in the worst cases, managers have had to deal with abandoned vehicles, vandalism, and arson. It requires that park managers put greater focus on visitor safety. Developing and implementing a thoughtful public access plan—one that ensures visitor enjoyment and safety while allowing for the protection of sensitive species and habitats, even if that requires restricting public access in certain areas or at different times of the year—is an important component of overall site planning and management.

Is monitoring important?

Monitoring is a critical component of any habitat or species management and restoration program. Support for monitoring efforts is essential for maintaining biodiversity and ecological processes in New York City. Monitoring not only determines whether measures have been successful but also provides important lessons for future projects. Often, however, the time frame over which monitoring is supported by agencies is too short to assess how well projects are working and whether plants and animals are thriving. Moreno-Mateos et al. (2012) found in an analysis of more than 600 wetland projects that even after 100 years plant community structure and carbon storage in soils were on average one-fourth lower than in reference wetlands. Since restoration projects will outlive their creators, baseline conditions should be documented regularly and updated in the plan. Reference sites (sites that will not receive management and are used for comparison with the managed site) should also be documented regularly so that accurate comparisons can be made in the future.

Carl Heilman II/Wild Visions, Inc.

Native plants such as asters attract pollinators in the home garden.

What role can homeowners play in conserving biodiversity?

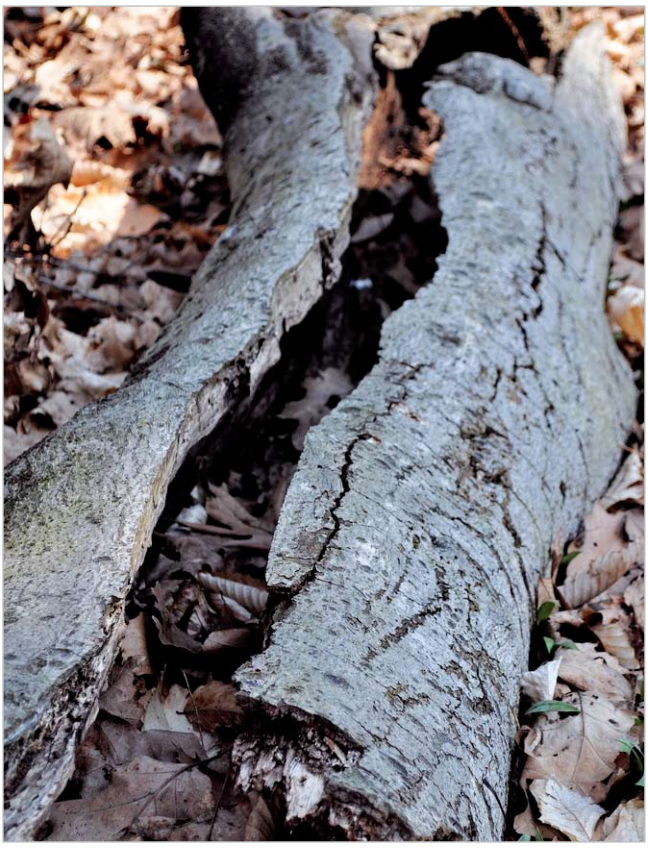
Much of the land in New York City is privately owned and its management is in the hands of citizens. How individuals manage their properties affects not only their own land but also adjacent land, and can have a major impact on the persistence of native biodiversity. Ecological management is particularly important for homeowners living adjacent to parks or other greenspaces since what they do on their property directly affects these habitats. Stormwater runoff, pollution from lawn fertilizers and pesticides, and even yard waste dumped in parks have a negative impact on habitat quality (in part for this reason, it is illegal to dump yard waste or garbage in any New York City park). If properly managed, however, these small patches of habitat, especially if connected over entire neighborhoods, can serve as beautiful living spaces while helping to preserve biodiversity by providing habitat for native plants, pollinators, songbirds, and small mammals (Kendle and Forbes 1997); conserving water while reducing stormwater runoff; sequestering carbon; and mitigating the urban heat island effect.

For resources see Appendix C.

Should nesting boxes or other wildlife shelter be provided?

Provision of nesting sites is a form of management or restoration. Wooden nest boxes may be useful for birds such as barn owl, eastern screech-owl (*Megascops asio*), wood duck (*Aix sponsa*), and eastern bluebird (*Sialia sialis*), and mammals such as the southern flying squirrel (*Glaucomys volans*). New roosting towers have been constructed on Staten Island for chimney swifts (*Chaetura pelagica*). Such nesting structures need to be built according to technical guidelines and maintained annually. Artificial nesting areas may be constructed for turtles that need sandy or gravelly, sparsely vegetated, sunny soil to lay their eggs in, along with safe passage to these sites. Existing nesting areas can be mowed or tilled to reduce weed overgrowth and loosen soils, as Dowling et al. (2010) did for the Blanding's turtle (*Emydoidea blandingii*) north of the City.

Shelter during non-nesting periods is also important. Logs, stumps, and piles of cut brush (shrubs and tree branches) on land or snags (standing dead trees) in water provide shelter for many animals. Brush piles are beneficial for small- to medium-size mammals, turtles, snakes, ground-foraging birds, and many wood-associated invertebrates. Retaining snags provides important nesting, sleeping, and winter shelter for animals such as woodpeckers, bats, treefrogs, and invertebrates. Roosting boxes are useful for some bat species. Stumps and logs decaying on or near the ground also support many kinds of mosses, liverworts, lichens, ferns, and vascular plants, as well as beetles and many other invertebrates. Bark slabs or lumber that is not painted or chemically treated can be laid on the soil to create "cover" for amphibians, reptiles, small mammals, and many invertebrates.



Marielle Anzelone

Decomposing logs provide important habitat for plants, animals, and fungi and return nutrients to the soil.

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Introduction to the Habitat and Species Profiles

The purpose of these profiles is to help identify and understand some of the salient biodiversity resources in New York City. These profiles explain how to recognize special habitats and species, where they are, why they are important, and what their sensitivities are to human activities. Most of all, these profiles will introduce you to the diverse natural world of New York City, and show you ways to think about identifying, assessing, and conserving biodiversity in the City.

The sets of profiles are not comprehensive listings of all the habitats and species of conservation concern. More profiles will be added to the Handbook as it evolves as a living document, and we will also correct and update profiles at intervals as new information becomes available.

Corrections and comments may be addressed to Erik Kiviat <kiviat@bard.edu> or Elizabeth Johnson <ejohnson@amnh.org>.

Upland brittle bladder-fern (*Cystopteris tenuis*), Jaknouse/Wiki Images

Screech Owl, Greg Hume/Wiki images

Mike Feller

Habitat Profiles

A habitat is the area or environment in which a particular species or group of species of plants, animals, fungi, or other organisms live. A habitat is also an ecosystem, the sum of all the species and the non-living environment in a place, including their relationships. Although some habitats have relatively sharp and clear boundaries (such as the border of a pond), most habitats blend into one another in ecotones or transition zones. Furthermore, although types of habitats and their assemblages of species can be described, many of the actual habitats seen in nature will not exactly match their descriptions, and some may be truly intermediate between two types of habitats. Nonetheless, habitats are a useful way of conceptualizing nature for conservation purposes.

In addition, a habitat type may differ in different places. For example, an intermittent woodland pool in Queens is probably a bit different from one on Staten Island, and one on Staten Island may be very different from one in southern New Jersey. Yet they are all intermittent woodland pools, and many of them will support egg laying and larval development of pool-breeding salamanders and frogs. Habitats also change over time. They change seasonally, between wet and dry years, and over longer periods as different species of plants become established, mature, and die. Habitats can also change suddenly as a result of traumatic events such as windstorms, fires, floods, or disease outbreaks. Of course human actions, including vandalism, clearing or mowing of vegetation, building or razing structures, planting or pruning, pesticide applications, and grading can change habitats.

A set of descriptions of some common and rare New York City habitats follows. These are some of the habitats that support rare species or other noteworthy elements of biodiversity.

Erik Kiviat

Upland Forest

By Marielle Anzelone

General Description

The New York metropolitan region receives on average about 44 inches (112 cm) of rain per year, enough to support the growth of trees. Deciduous forests are the predominant natural forest habitat in New York City. Given enough time, woody vegetation will become established on undisturbed sites in most soils. Deciduous forest development is prevented in sites that are too wet or brackish, such as salt marshes, or too dry, such as rock ledges or sandy soils. Of course, areas that are kept cleared or mowed do not develop forest.

Deciduous forests are dominated by tree species that shed their leaves in autumn, become dormant in winter, and leaf out again in spring. In these forests the competition for sunlight is a critical limiting factor for plants that grow below the tree canopy.

Distribution in New York City

Upland forests are found widely in the five boroughs.

Examples on public land:

- Brooklyn: Prospect Park (the Ravine)
- Bronx: Van Cortlandt Park (Northwest Forest), New York Botanical Garden (Hemlock Forest), Pelham Bay Park
- Manhattan: Highbridge Park, Inwood Hill Park
- Queens: Alley Pond Park, Cunningham Park, Forest Park
- Staten Island: Blue Heron Park, Greenbelt, Wolfe's Pond Park

Marielle Anzelone

Understory shrubs and the herbaceous layer of the forest floor are important layers of deciduous forests.

Marielle Anzelone

Corson's Brook Woods on Staten Island.

Vegetation

Mature forests often have several vertical layers. Within each layer, the vegetation distribution is influenced not only by the availability of sunlight but also by soil nutrients, acidity, and moisture. Plants on the forest floor are the first to emerge in spring. They receive full sunlight for a limited amount of time and must maximize photosynthesis before the taller woody plants leaf out. This ground layer is composed of wildflowers, ferns, and graminoids (grasses, sedges, and rushes). These herbaceous plants vary in height, from the low-growing Canada mayflower (*Maianthemum canadense*) to tall woodland sunflowers (*Helianthus*) and Joe-Pye-weed (*Eutrochium purpureum*), which can reach 7 feet (2 m) in height. Other characteristic herbaceous species include white snakeroot (*Ageratina altissima*), trout lily (*Erythronium americanum*), blue-stemmed goldenrod (*Solidago caesia*), and sessile-leaved bellwort (*Uvularia sessilifolia*). The understory includes small trees like flowering dogwood (*Cornus florida*) and sassafras (*Sassafras albidum*). Shrubs range in size from about knee-high to 10 or more feet (more than 3 m). Common species include lowbush blueberry (*Vaccinium angustifolium*), spicebush (*Lindera benzoin*), pinkster azalea (*Rhododendron periclymenoides*), and mapleleaf viburnum (*Viburnum acerifolium*).

Canopy trees are the tallest and most prominent plants in the forest. The oak-hickory forest is the most widespread forest community in the City, with white, red, and black oaks (*Quercus alba, Q. rubra, Q. velutina*), bitternut (*Carya cordiformis*), and occasionally pignut and mockernut hickories (*C. glabra, C. tomentosa*).

Mariella Anzelone

Tulip trees in spring.

Forests on rich, fertile, well-drained, moist soils are dominated by trees such as red maple (*Acer rubrum*), sugar maple (*A. saccharum*), American beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), and red oak. Shrubs include spicebush, arrowwood (*Viburnum dentatum*), and blackhaw (*Viburnum prunifolium*). The herbaceous ground layer includes Canada mayflower, New York fern (*Thelypteris noveboracensis*), wild geranium (*Geranium maculatum*), mayapple (*Podophyllum peltatum*), and smooth Solomon's seal (*Polygonatum biflorum*). Little is known of the bryoids in the City's forests; old forests and isolated large trees or large down logs may support rare species.

Young forests feature less shade-tolerant trees such as black birch (*Betula lenta*), black cherry (*Prunus serotina*), and sassafras.

Fauna

Animals are vertically stratified along with the vegetation layers. Many invertebrates are found in or on the leaf litter: spiders, mites, worms, beetles, and others. Vertebrates include the eastern red-backed salamander (*Plethodon cinereus*), eastern chipmunk (*Tamias striatus*), northern short-tailed shrew (*Blarina brevicauda*), white-footed mouse (*Peromyscus leucopus*), and eastern cottontail (*Sylvilagus floridanus*). The ovenbird (*Seiurus aurocapillus*) and American woodcock (*Scolopax minor*) nest on the forest floor. The northern cardinal

(*Cardinalis cardinalis*), gray catbird (*Dumetella carolinensis*), and wood thrush (*Hylocichla mustelina*) inhabit the shrub layer. Cavities in larger, older canopy trees serve as nest sites for the raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), eastern gray squirrel (*Sciurus carolinensis*), and great horned owl (*Bubo virginianus*). Some birds found on upper tree trunks and limbs are the northern flicker (*Colaptes auratus*), red-bellied woodpecker (*Melanerpes carolinus*), downy woodpecker (*Picoides pubescens*), black-capped chickadee (*Poecile atricapillus*), tufted titmouse (*Baeolophus bicolor*), and great crested flycatcher (*Myiarchus crinitus*). Birds high in the canopy include the eastern wood-pewee (*Contopus virens*), red-eyed vireo (*Vireo olivaceus*), and, less often, scarlet tanager (*Piranga olivacea*) and Baltimore oriole (*Icterus galbula*). The top of the tree canopy is home to a wide variety of insects, especially caterpillars and leafhoppers.

Indicators and Identification

Upland deciduous forests are identified by the predominance of deciduous trees, shrubs, and a well-developed herbaceous layer on well-drained, usually somewhat acidic soils. In high-quality forests, the presence of invasive plants such as oriental bittersweet (*Celastrus orbiculatus*), Norway maple (*Acer platanoides*), and garlic mustard (*Alliaria petiolata*) is limited.

Biodiversity Values

Many of New York City's remaining open spaces are forests, so they are important biological preserves. Trees alone do not make a forest; the greatest biodiversity in these ecosystems is on the forest floor. The City's forests are home to a number of rare species, including many plants that are state-listed as exploitably vulnerable, such as goldenseal (*Hydrastis canadensis*), American ginseng (*Panax quinquefolius*), black cohosh (*Actaea racemosa*), bloodroot (*Sanguinaria canadensis*), and wild leek (*Allium tricoccum*). Some plants are threatened by collecting for medicine or food.

Substrates

Forest floor substrates consist of mineral soils overlain with decomposed organic material and leaf litter. Soils are shallower on hilltops and deeper at the bases. Urban soils have higher levels of heavy metals and nitrogen than rural soils. They have more nonnative earthworms and fewer mycorrhizal fungi, which are some of the factors contributing to more rapid leaf litter decay and nutrient cycling, and less accumulation of humus.

Surface Waters

There are few surface waters in the well-drained soils of upland forests. Where soils are compacted from human overuse, standing water may accumulate. Some forests also have intermittent woodland pools (see Profile) or ephemeral streams.

Quality

Old-growth forest is uncommon in New York City. Most woodlands were cleared in the past to make way for agriculture or other development. Only a 50-acre (20 ha) remnant of old-growth forest remains in what is now the New York Botanical Garden in the Bronx. Some high-quality mature forest remains elsewhere, but in small portions of larger tracts.

Human Uses

Beginning with European colonization, large expanses of the region's virtually continuous forest were cleared for agriculture, timber, and fuel. By the late 1800s the forest had been reduced to small, discontinuous fragments, and this fragmented configuration persists in New York City.

Threats

Small, widely separated, forest fragments may lose herbaceous populations that are not readily dispersed from one fragment to another, or whose pollinators or mutualistic fungi are missing. Many herbaceous species such as sedges and spring wildflowers have seeds that are carried by ants, for example, so dispersal is limited. As the remaining isolated populations die out, they are not replaced and the flora becomes increasingly impoverished.

In addition, these forest fragments have been colonized by invasive plants that restrict the growth of less aggressive native herbs and shrubs. It is common to see regenerating woodlands with a ground layer composed almost entirely of invasive nonnative species such as Japanese honeysuckle (*Lonicera japonica*), garlic mustard, lesser celandine (*Ranunculus ficaria*), and wild garlic (*Allium vineale*). Since these are all either shade-tolerant or spring ephemerals, they are likely to remain permanent residents of the newly-developing forest floor, replacing shade-tolerant native species.

Even old forests, particularly in the Bronx and Queens, with trees over 150 or 200 years old, have been altered by urbanization. Old forests are usually invaluable as repositories of rare species and examples of more intact ecosystem function. However, these urban forest remnants have disturbed understories containing only fragments of the pre-colonial shrub and herb assemblages once found throughout the City. It is the herbaceous community that acts as a "canary in the coal mine" warning of degraded ecosystems. Because trees can be long-lived, the individuals that have been growing on these sites for a century and a half or more may be the last traces of the pre-European old-growth forest. Forest pests and pathogens are an increasing threat to both rural and urban forests.

Marielle Anzelone

Forest fragments are often overgrown with nonnative species, like Japanese honeysuckle.

Conservation and Management

The City's open spaces, including upland forests, face great development pressure. Unlike other ecosystems such as coastal wetlands, upland forest is not legally protected. Intact, healthy tracts must be protected from active recreation, especially all-terrain vehicle use. The most important forest stands, if feasible, should be kept free of nonnative weeds and replanted with native species.

Additional information on New York City forests may be found in the References.

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Maritime Beach, Dune, Grassland, and Shrubland

By Marielle Anzelone

General Description

Maritime beach, dune, grassland, and shrubland occur on and above sandy beaches along the Atlantic Ocean as far north as some barrier islands in Massachusetts and south through Florida. In response to wave energy, beaches shift and change and sand is continually lost and replenished. Gently sloping beaches rise out of the ocean, and dunes are created where sand accumulates above the reach of the tides and is shaped by the wind. Farther back from the ocean are coastal grasslands and shrublands.

Distribution in New York City

Beaches once formed 20 percent of Manhattan's shoreline, stretching up the western side from The Battery to what is now 42nd Street. The eastern side had barrier beaches that continued up to Harlem (Sanderson 2009). Today, all of these are gone due to shoreline development.

Maritime communities are found along the south shores of Queens, Brooklyn, and Staten Island. They are also extensive along the south shore of Nassau and Suffolk counties on Long Island and along the eastern coast of New Jersey.

Ellen Pehek

Dune grass, Coney Island Park.

Mike Feller

Marine Park.

Examples on public land:

- Brooklyn: Canarsie Beach Park, Marine Park, Plumb Beach
- Queens: Idlewild Park, Rockaway Beach, Breezy Point
- Staten Island: Conference House Park, Wolfe's Pond Park

Vegetation

Maritime communities are stressful environments for plants since they are exposed to tides, winds, salt spray, and full sun in low-nutrient sandy substrates. Typically the plants growing closest to the water are annuals like American sea rocket (*Cakile edentula*), seabeach orache (*Atriplex arenaria*), and Russian thistle (*Salsola kali*).

American beach grass (*Ammophila breviligulata*) is found farther back from the influence of daily tides. This species reproduces vegetatively, and its extensive root and rhizome system quickly stabilizes loose sand. A single large plant can create a dune nearly 2 feet (0.6 meters) tall containing 70 to 106 cubic feet (2 to 3 cubic meters) of sand. As beach grasses grow taller and denser, organic material accumulates in the soil and creates a favorable environment for other species. Some maritime grassland species commonly seen are switchgrass (*Panicum virgatum*), little bluestem (*Schizachyrium scoparium*), beach pinweed (*Lechea maritima*), eastern prickly-pear cactus (*Opuntia humifusa*), evening primrose (*Oenothera biennis*), and seaside goldenrod (*Solidago sempervirens*). At slightly higher elevations more woody plants are present. Maritime shrubs and woody vines include poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), northern bayberry (*Morella pensylvanica*), beach plum (*Prunus maritima*), pasture rose (*Rosa carolina*), and winged sumac (*Rhus copallina*). Trees may include black cherry (*Prunus serotina*), pitch pine (*Pinus rigida*), and American holly (*Ilex opaca*).

Fauna

Birds characteristic of these maritime communities include savannah sparrow (*Passerculus sandwichensis*), northern harrier (*Circus cyaneus*), yellow-rumped warbler (*Setophaga coronata* [formerly *Dendroica coronata*]), horned lark (*Eremophila alpestris*), and song sparrow (*Melospiza melodia*). Other animals include the meadow vole (*Microtus pennsylvanicus*), eastern cottontail (*Sylvilagus floridanus*), and Fowler's toad (*Anaxyrus fowleri*).

Indicators and Identification

Oceanfront stretches of sandy soil in exposed coastal areas are indicators of maritime habitats. Plants such as American beach grass, eastern prickly-pear, and beach plum are diagnostic of naturally-occurring sand (as different from dredge spoil).

Biodiversity Values

New York City's maritime communities are home to a number of rare species, including the federally-listed piping plover (*Charadrius melodus*), seabeach amaranth (*Amaranthus pumilus*), and the New York State-endangered least tern (*Sternula antillarum*), seabeach knotweed (*Polygonum glaucum*), and southern sea-blite (*Suaeda linearis*).

Substrates

Sand is the main substrate in maritime habitats.

Surface Waters

Waters are saline and tidal. Small nontidal pools may form in dune slacks (depressions between dunes); water level and salinity may vary in these pools due to rain and marine overwash.

Quality

Extant maritime areas vary in quality. Some have more ecological integrity than others, but all have suffered from urbanization, including the loss of coastal ecosystems to fill for development.

Human Uses

New York City's maritime areas have long been used intensively for commercial and recreational purposes.

Threats

Beach and dune ecosystems are highly sensitive to human disturbance, including active recreational use. Even low levels of foot traffic can kill beach grass and other plants and allow sandy soils to erode. Foot and vehicle traffic can also disturb birds that nest at the upper edges of beaches and in the dunes.

Conservation and Management

Public lands with sites buried under sanitary landfill should be considered for restoration. Shoreline development and beach stabilization projects (such as sea walls, jetties, and other hard stabilization structures) should be limited. Beach nourishment (addition of sand to eroding beaches) projects should be carefully assessed for

their impacts on biodiversity. Active recreational use of beaches and associated management practices (like intensive use by off-road vehicles and wide paved trails) should be restricted. Rare plants and animals may need to be fenced seasonally or permanently to protect them from trampling or other human disturbance.

Information on maritime habitats and their organisms may be found in Anderson (1994), Barlow (1971), Duncan and Duncan (1987), Gargiullo (2007), and Luttenberg and Feller (1993).

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Freshwater Swamp

By Marielle Anzelone

General Description

Freshwater swamps are freshwater wetlands dominated by woody plant species (trees or shrubs). Swamps are found in a variety of areas, such as around ponds, in undeveloped depressions, and along the edges of streams and rivers.

Distribution in New York City

Many of New York City's freshwater wetlands have been destroyed. Of an estimated 224,000 acres in the late 1700s, only 1 percent or about 2,000 acres remain today. Approximately one-half of this area is forested. The island of Manhattan once had freshwater wetlands on 2 percent of its land area; today, most of these are gone.

Naturally occurring swamps are found in the Bronx, Queens, and Staten Island. As the least-developed borough, Staten Island still has a significant number of freshwater wetlands, comprising about 9 percent of its land area. Swamps make up 17 percent of these wetlands. Even so, nearly two-thirds (about 3,500 acres) of Staten Island's original wetlands have been filled (Tiner 2000).

Examples on public land:

- Bronx: Van Cortlandt Park (The Swamp), Riverdale Park
- Queens: Alley Pond Park (Alley Creek, Oakland Lake, Decodon Pond)
- Staten Island: Clay Pit Ponds State Park Preserve, Reeds Basket Willow Swamp Preserve, Blue Heron Park, Mariners Marsh (vernal pools, sweet gum swamps, pin oak swamps, and several freshwater ponds), the Bluebelt area (portions of Richmond Creek, Sweet Brook, Blue Heron, Seguine Pond, Arbutus Creek, Wolfe's Pond, Lemon Creek, Sandy Brook, and Mill Creek, and all of Jack's Pond and Wood Duck Pond)

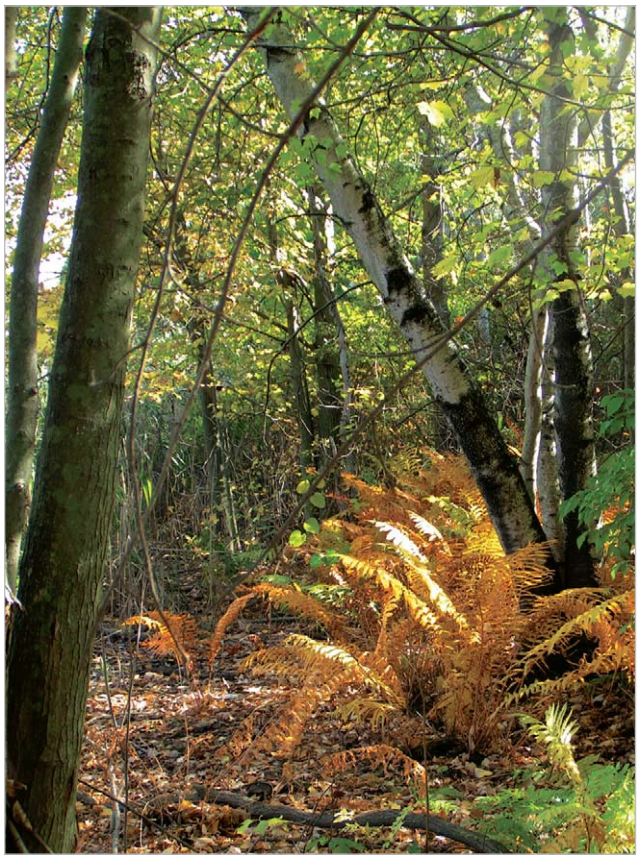
Ellen Pehek

Ridgewood Swamp, Queens, in autumn.

Ellen Pehek

Skunk cabbage is a common plant found in swamp forests.

Ellen Pehek



Cinnamon fern in a swamp forest wetland.

Vegetation

About half of New York City's remaining freshwater wetlands are deciduous forested wetlands (tree-dominated swamps). Trees present include red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), black willow (*Salix nigra*), pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), and eastern cottonwood (*Populus deltoides*). Red maple, sweetgum, and cottonwood appear to be the most frequent species.

Much freshwater swamp habitat is dominated by woody plants less than 20 feet (6 m) tall, many of them shrubs. Typical species of these shrub swamps include arrowwood (*Viburnum dentatum*), common elderberry (*Sambucus canadensis*), silky dogwood (*Cornus amomum*), and sweet pepperbush (*Clethra alnifolia*). Smartweeds (*Polygonum*), spotted Joe-Pye-weed (*Eutrochium maculatum*), boneset (*Eupatorium perfoliatum*), broom sedge (*Carex scoparia*), and blunt spikerush (*Eleocharis obtusa*) are herbs (non-woody plants) that may occur in the more open wet thickets.

Beneath the trees, many forested wetlands have shrub swamp species, as well as other shrubs and herbs, including spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), swamp azalea (*Rhododendron viscosum*), and red chokeberry (*Photinia pyrifolia*). Ferns, such as cinnamon fern (*Osmunda cinnamomea*) and sensitive fern (*Onoclea sensibilis*), are common in many swamps. Other non-woody plants include marsh marigold (*Caltha palustris*), skunk-cabbage (*Symplocarpus foetidus*), jewelweed (*Impatiens capensis*), jack-in-the-pulpit (*Arisaema triphyllum*), Canada mayflower (*Maianthemum canadense*), false nettle (*Boehmeria cylindrica*), white panicle aster (*Symphyotrichum lanceolatum*), white grass (*Leersia virginica*), and tussock sedge (*Carex stricta*).

Fauna

Shrub swamps attract many bird species. Common yellowthroat (*Geothlypis trichas*), yellow warbler (*Setophaga* [*Dendroica*] *petechia*), swamp sparrow (*Melospiza georgiana*), and other songbirds can be found in swamps. Birds that frequent the trees of swamp forests include blue-winged warbler (*Vermivora cyanoptera*) and Baltimore oriole (*Icterus galbula*), while the American woodcock (*Scolopax minor*) searches for worms in, and nests on, the moist ground. The red-spotted newt (*Notophthalmus viridescens*) also lives in swamp forests.

Small woodland pools are found occasionally within forested wetlands (see Intermittent Woodland Pools habitat profile). Because these shallow pools are seasonally dry and do not harbor fish or other potential predators, they serve as vital breeding grounds for many woodland amphibians such as the spotted salamander (*Ambystoma maculatum*) and spring peeper (*Pseudacris crucifer*). Reeds Basket Willow Swamp Preserve on Staten Island supports two uncommon salamanders: the northern dusky salamander (*Desmognathus fuscus*) and northern red salamander (*Pseudotriton ruber*). Both of these species are rare on Staten Island and extirpated from the other four boroughs (see Stream Salamanders profile).

Beavers (*Castor canadensis*) were once so common in New York City that they were featured on the City's official seal and flag. Yet the beaver was extirpated in the five boroughs for nearly 200 years. However, in 2007, a young male beaver built a lodge 12-foot (3.7 m)in diameter in the Bronx River and he was joined by a second beaver in 2012.

Indicators and Identification

Key indicators include the presence of fresh water or saturated soil at least seasonally, dominant woody vegetation that is adapted to wet soils (hydrophytic plants), and water-logged (hydric) soils (Tiner 2000).

Biodiversity Values

Swamps support New York State-listed rare and endangered species. Many of these are southern plant species; New York City, especially Staten Island, is the northernmost extent of the geographic range for many (Tiner 2000). They include trees such as willow oak (*Quercus phellos*), sweetbay magnolia (*Magnolia virginiana*), common persimmon (*Diospyros virginiana*), and swamp cottonwood (*Populus heterophylla*); shrubs like possumhaw (*Viburnum nudum*) and American strawberry-bush (*Euonymus americanus*); and two parasitic herbaceous dodder vines, buttonbush dodder (*Cuscuta cephalanthi*) and southern dodder (*Cuscuta obtusiflora var. glandulosa*) (see the Dodder species profile). Red maple – tupelo swamp is a rare plant community in New York State, concentrated on Staten Island, and ranked S1 by the New York Natural Heritage Program.

Substrate

Freshwater wetlands have seasonally or perennially water-saturated, oxygen-deficient (anoxic) soils. Habitats with mostly still water, such as swamps and woodland pools, typically have high amounts of organic matter from decayed plant material in a surface layer above mineral matter.

Surface Waters

Surface waters are usually present, especially in spring. They may result from river overflow, accumulated runoff, or a high groundwater table.

Quality

Human activity has destroyed many freshwater wetlands, including swamps, outright and degraded the quality of those that remain. On Staten Island approximately 300 acres of former tidal wetlands were filled, restricting water flow and creating nontidal freshwater marshes and swamps, mostly in the Midland Beach and South Beach neighborhoods (Tiner 2000).

New York City's wetlands have been channelized for flood control, excavated for navigation, and filled with household garbage, construction debris, and ship ballast to create land for development. Wetland habitats continue to be degraded through the loss of native species and the increasing dominance of nonnative species such as Japanese knotweed (*Polygonum cuspidatum*) and purple loosestrife (*Lythrum salicaria*) These weeds, when abundant, indicate habitat degradation although they still provide food and habitat for many native organisms. Other factors affecting swamp quality include off-road vehicle use and polluted stormwater runoff. Chemicals used to control mosquitoes, weeds, or other pests can adversely affect non-target plants and animals in swamps. Trees may be harmed by vandalism or nonnative pests and diseases. See Ehrenfeld (2000) and Tiner (2000) for further discussion of impacts to wetland quality.

Human Uses

The arrival of British colonists in New York City marked the beginning of draining and filling wetlands on a large scale to create buildable land (and, formerly, land for cultivation or grazing) (Sanderson and Brown 2007, Sanderson 2009). This continued into the 1970s when legislation protecting some wetland habitats was passed. Existing wetlands are mostly in Staten Island, where the New York City Department of Environmental Protection has created the Bluebelt program, using wetlands and other existing waterbodies for flood control and stormwater management (Tiner 2000).

Erik Kiviat

Small constructed swamp, Brooklyn Bridge Park.

Threats

Urban wetlands are characterized by overall drier conditions, reduced rates of nitrogen cycling, and higher levels of pollutants than those in less developed watersheds. Nutrient enrichment may shift the balance from native species or rare species to nonnative or more common species of plants and animals. With more paved areas, urban wetlands are vulnerable to increased runoff which may raise water levels and thus change plant communities in their watersheds. The high volume and velocity of this runoff may cause erosion (Ehrenfeld 2000). These and other impacts of human activities may be contributing to the loss of flora in wetlands, where plant species are disappearing more quickly than in uplands.

Conservation and Management

Wetland habitats on public lands need to be protected, including small wetlands or wetlands isolated from stream systems that may not be regulated by federal or state laws. Management plans for specific sites that account for the species present, parcel size, wetland type, urban impacts, and the surrounding matrix should be developed. Small wetlands should not be discounted from priority rankings for preservation on the basis of size alone.

Additional information can be found in Anderson (1994), Barlow (1971), DeCandido et al. (2004), Gargiullo (2007) and Mockler (1991).

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Freshwater Marsh and Wet Meadow

By Marielle Anzelone

General Description

Freshwater marshes and wet meadows, also known as emergent wetlands, are habitats with hydric soils that are saturated or flooded at least seasonally. These habitats also have vegetation in which non-woody (herbaceous) plants are dominant. Marshes are flooded for much of the year. Wet meadows are seasonally wet fields. They may have standing water in winter and spring, and sometimes in fall, but not in the heat of the summer. In New York City, freshwater emergent wetlands are found along the margins of lakes and ponds, along creeks, adjoining the upper edges of salt marshes, and where runoff accumulates in depressions or on an impermeable soil.

Distribution in New York City

As is the case with its forested wetlands (see the Freshwater Swamp habitat profile), New York City's emergent wetlands have largely been destroyed. Naturally occurring marshes and wet meadows are still found in the Bronx, Queens, and Staten Island. Created habitats are found in Brooklyn (Prospect Park, Brooklyn Bridge Park) and Manhattan (Central Park). As the least-developed borough, Staten Island still has a significant number of wetlands, comprising about 9 percent of its land area. Emergent wetlands and ponds make up 14 percent of these wetlands (Tiner 2000).

Erik Kiviat

Freshwater marsh dominated by common reed with central pond, Highland Park, Brooklyn.

Mike Feller

Freshwater marsh vegetation in center surrounded by shrub swamp. Seaton Falls Park.

Examples on public land:

- Bronx: Van Cortlandt Park, Seton Falls Park
- Brooklyn: Prospect Park, Brooklyn Bridge Park, Highland Park
- Manhattan: Central Park
- Queens: Alley Pond Park (Alley Creek, Oakland Lake, Decodon Pond)
- Staten Island: Clay Pit Ponds State Park Preserve (Sharrots Pond), Blue Heron Park (Spring Pond),the Bluebelt (portions of Richmond Creek, Sweet Brook, Blue Heron, Seguine Pond, Arbutus Creek, Wolfe's Pond, Lemon Creek, Sandy Brook, and Mill Creek, and all of Jack's Pond and Wood Duck Pond)

Vegetation

Emergent wetlands are characterized by different zones, which are determined by the depth and seasonal duration of the water and the associated vegetation. In the deeper portions of marshes, typical native plants include cattails (*Typha*), swamp loosestrife (*Decodon verticillatus*), broad-leaved arrowhead (*Sagittaria latifolia*), bulrushes such as wool-grass (*Scirpus cyperinus*), and grasses such as rice cutgrass (*Leersia oryzoides*). In the shallower areas, blue flag (*Iris versicolor*), pickerelweed (*Pontederia cordata*), northern water plantain (*Alisma triviale*), and smartweeds (*Polygonum*) are found.

Dominant plants of wet meadows include grasses such as switchgrass (*Panicum virgatum*), sedges such as broom sedge (*Carex scoparia*), and blunt spikerush (*Eleocharis obtusa*). Other herbaceous plants include blue vervain (*Verbena hastata*), jewelweed (*Impatiens capensis*), spotted Joe-Pye-weed (*Eutrochium maculatum*), boneset (*Eupatorium perfoliatum*), New York aster (*Symphyotrichum novi-belgii*), swamp milkweed (*Asclepias incarnata*), ditch stonecrop (*Penthorum sedoides*), nodding beggarticks (*Bidens cernua*), tall meadow rue (*Thalictrum pubescens*), and water horehound (*Lycopus americanus*). Woody species include buttonbush (*Cephalanthus occidentalis*). As the elevation rises, hydrophytic shrubs and trees are found more frequently.

Erik Kiviat

Marsh vegetation, Central Park.

Fauna

Open water in pools and creeks within or adjoining emergent vegetation provides habitat to many varied animals, such as dragonflies and damselflies (Odonata), mosquitoes (Culicidae), aquatic beetles (Coleoptera), water striders (Gerridae), turtles, bullfrog (*Lithobates catesbeiana*), and various fishes. Bird species include the great blue heron (*Ardea herodias*), great egret (*Ardea alba*), black-crowned night-heron (*Nycticorax nycticorax*), glossy ibis (*Plegadis falcinellus*), wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), Canada goose (*Branta canadensis*), common gallinule (*Gallinula galeata* [formerly common moorhen, *Gallinula chloropus*]), pied-billed grebe (*Podilymbus podiceps*), belted kingfisher (*Ceryle alcyon*), osprey (*Pandion haliaetus*), and herring gull (*Larus argentatus*).

Fauna of the deep marsh includes the red-winged blackbird (*Agelaius phoeniceus*), marsh wren (*Cistothorus palustris*), and muskrat (*Ondatra zibethicus*). In wet meadows, one can find the northern rough-winged swallow (*Stelgidopteryx serripennis*), northern flicker (*Colaptes auratus*), painted turtle (*Chrysemys picta*), common snapping turtle (*Chelydra serpentina*), and green frog (*Lithobates clamitans*).

Indicators and Identification

Key indicators include the presence of fresh water, permanently or seasonally flooded or saturated (hydric) soils, and dominant non-woody vegetation that is adapted to the presence of water (hydrophytic vegetation) (Tiner 2000).

Biodiversity Values

Freshwater ponds, marshes, and streams are critical to the web of life. Freshwater marshes produce more plant biomass than cultivated areas, and this biomass in turn supports high densities of certain animals. These habitats support regionally-rare or state-listed rare and endangered plants such as round-leaved sundew (*Drosera rotundifolia*), soapwort gentian (*Gentiana saponaria*), squarestem spikerush (*Eleocharis quadrangulata*), eastern gamagrass (*Tripsacum dactyloides*), and American featherfoil (*Hottonia inflata*). Many animals of

conservation concern also use freshwater emergent wetlands, including pied-billed grebe (*Podilymbus podiceps*), American bittern (*Botaurus lentiginosus*), and spotted turtle (*Clemmys guttata*). (See Freshwater and Land Turtles of Conservation Concern and Secretive Marsh Birds profiles.)

Substrate

Freshwater wetlands have seasonally or permanently water-saturated, oxygen-deficient (anoxic) soils. Soils may be organic or mineral soils.

Surface Waters

Marshes receive most of their water from the surface (streams and runoff) and in some cases from groundwater. Water in wet meadows comes from precipitation and runoff. Emergent wetlands bordering streams or ponds may be flooded at times of high water levels.

Quality

Human activity has destroyed freshwater wetlands outright or degraded the quality of those that remain. For example, in Staten Island approximately 300 acres of former tidal wetlands were filled, restricting water flow and creating non-tidal freshwater marshes and swamps, mostly in the Midland Beach and South Beach neighborhoods (Tiner 2000).

Similar to other types of wetlands, freshwater marshes and wet meadows have been channelized for flood control or mosquito control, drained for cultivation or grazing, excavated for navigation, and filled with household garbage, construction debris, and ship ballast to create land for development. Wetland habitats continue to be degraded through the loss of native species and increases in the dominance of nonnative species such as Japanese knotweed (*Polygonum cuspidatum*) and purple loosestrife (*Lythrum salicaria*). These weeds, when abundant, indicate habitat degradation although they still provide food and habitat for many native organisms. Other factors affecting the quality of emergent wetlands include off-road vehicle use and polluted stormwater runoff. Chemicals used to control mosquitoes, weeds, or other pests can adversely affect non-target plants and animals in emergent wetlands. See Ehrenfeld (2000) and Tiner (2000) for further discussion of impacts to wetland quality.

Human Uses

The arrival of English colonists in New York City marked the beginning of draining and filling wetlands on a large scale to create buildable land (Sanderson 2009, Sanderson and Brown 2007). This continued through the 1970s until legislation protecting wetland habitats was passed. On Staten Island, the New York City Department of Environmental Protection has created the Bluebelt program, using wetlands for flood control and stormwater management (Tiner 2000). Freshwater marshes and wet meadows are good areas for birdwatching.

Threats

Marshes and wet meadows, like other urban wetlands, are subject to higher levels of pollutants than those in less developed watersheds. With more paved areas in urban watersheds, they are also vulnerable to increased runoff that alters the pattern of water levels and flows. The high volume and velocity of this runoff may cause erosion and damage vegetation (Ehrenfeld 2000). Nonnative weeds may form dense stands and degrade habitat

for certain native organisms (while favoring others). Small wetlands, and especially those isolated hydrologically from stream systems, have little or no legal protection and in many cases may be legally destroyed or altered (e.g., for building a road or trail). In places dumping may still occur, even in protected wetlands. Pesticides used for controlling mosquitoes, weeds, or pests of ornamental plants may harm nontarget animals and plants in wetlands. Treated posts or planks such as are often used to build boardwalks or observation blinds leach toxicants into water. Recreational vehicles and heavy equipment can damage wetlands. Human activity on trails or boardwalks may disturb birds and other wildlife.

Conservation and Management

Wetland habitats on public and private lands need greater protection. Management plans are needed for specific sites that account for the species present, parcel size, wetland type, urban impacts, surrounding matrix, and management goals. Wetlands of all sizes and types should be studied and managed because both small and large wetlands have important biodiversity values as well as providing other valuable ecosystem services that include stormwater treatment, flood control, carbon sequestration, water quality amelioration, and microclimatic cooling in summer (Tiner 2000).

Additional information can be found in Anderson (1994), Barlow (1971), DeCandido et al. (2004), Gargiullo (2007) and Mockler (1991).

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Salt Marsh

By Marielle Anzelone

General Description

Salt marshes are characterized by the mixing of salt and fresh waters. Their brackish (somewhat salty) water and characteristic vegetation are found in bays and coves along the coast that are partly sheltered from ocean tides by inlets or barrier beaches. Salt marshes typically have three elevation zones—mud flat, low marsh, and high marsh. These zones are defined by salinity gradients and duration of inundation. Mud flats have no vegetation. Low and high marshes are dominated by salt-tolerant plants (halophytes). Both mud flat and low marsh are flooded twice daily by tides, submerged at high tide but exposed at low tide. The high marsh is periodically flooded by spring tides (the higher high tides near the times of the full moon and new moon).

Distribution in New York City

Regionally, salt marshes are found throughout coastal Long Island and in Westchester County on the Long Island Sound, as well as in northeastern New Jersey. They become less saline moving north along the Hudson River and gradually transition to freshwater tidal marshes at about Beacon and Newburgh, N.Y. Well-developed cordgrass salt marshes require seasonal maximum salinity of about one-third to one-half seawater salinity (i.e., about 12-18 parts-per-thousand salinity; seawater is 35 ppt salinity).

Salt marshes occur along the coast in the five boroughs. Only 5,000 acres of salt marsh still exist in New York City, however, 84 percent of the original salt marshes have been destroyed. Only one salt marsh remains in Manhattan, in Inwood Hill Park. Many of the salt marshes on Staten Island have been filled or otherwise altered (Tiner 2000).

Ellen Pehek

Jamaica Bay Beach with salt marsh vegetation.

Mike Feller

Pelham Bay high salt marsh.

Examples on public land:

- Brooklyn: Marine Park, Spring Creek Park, Dreier-Offerman Park
- Bronx: Pelham Bay Park
- Manhattan: Inwood Hill Park
- Queens: Idlewild Park, Udalls Cove
- Staten Island: Lemon Creek, William T. Davis Wildlife Refuge

Vegetation

Salt marshes are stressful environments for plants. They must tolerate salinity, submersion, and a muddy soil containing little oxygen. The low marsh is dominated by a monospecific stand of smooth cordgrass (*Spartina alterniflora*). This grass quickly grows to nearly 5 feet (1.5 m) tall. It also reproduces vegetatively, sending shoots out into adjacent areas. Occasionally, macroalgae are present; sea lettuce (*Ulva lactuca*) is the most

common. Plant diversity in a salt marsh increases with elevation. In the high marsh, saltmeadow cordgrass (*Spartina patens*) dominates. This grass grows in matted, "cowlick" clumps. Also present are saltgrass (*Distichlis spicata*) and black rush (*Juncus gerardii*). Among other species occasionally found in the high marsh include graminoids (grass-like plants) such as big cordgrass (*Spartina cynosuroides*), saltmarsh bulrush (*S. robustus*), and forbs (broad-leaved herbaceous plants) such as swamp rose-mallow (*Hibiscus moscheutos*) and sea-lavender (*Limonium carolinianum*). The shrubs marsh-elder (*Iva frutescens*), and groundsel bush (*Baccharis halimifolia*) are found at the upper edges of the marsh. Where marshes are disturbed and not too salty, common reed (*Phragmites australis*) often grows in place of, or in patches among, the native high marsh plants. Because physical and chemical impacts on salt marshes are pervasive in urban areas, common reed is widespread in New York City salt marshes. Information on plants of the salt marshes may be found in Gargiullo (2007).

Fauna

Fiddler crabs (*Uca pugnax*) and ribbed mussels (*Geukensia demissa*) have a mutualistic relationship with smooth cordgrass. The crabs and mussels feed on the accumulated decaying organic material around the roots of the plants. Crab burrows aerate the soil and increase the marsh's ability to break down organic pollutants. Where abundant, ribbed mussels may filter all the water passing through the marsh, and they deposit rejected materials on the soil surface improving the soil and providing food for other invertebrates (Weis and Butler 2009). These effects encourage the growth of the cordgrass.

The City's salt marshes are feeding and roosting habitat for a variety of waterbirds. Common visitors include great blue herons (*Ardea herodias*), great egrets (*Ardea alba*), belted kingfishers (*Ceryle alcyon*), and Canada geese (*Branta canadensis*). Resident birds that nest in the salt marsh include saltmarsh sparrows (*Ammodramus caudacutus*) and seaside sparrows (*A. maritimus*) (see Salt Marsh Birds profile). Meadow voles (*Microtus pennsylvanicus*) live in the high marsh, and muskrats (*Ondatra zibethicus*) occur where salinity is not too high.

Indicators and Identification

The best indicators are protected coastal areas with expanses of tall smooth cordgrass and matted cowlicks of saltmeadow cordgrass. Some marshes have low marsh with smooth cordgrass but no high marsh with salt-meadow cordgrass. In less saline water, common reed may be present.

Biodiversity Values

Salt marshes provide organic matter to surrounding waters and thus form the basis of substantial portions of the coastal and estuarine food webs. New York City's salt marshes provide habitat for a number of regionally rare species, including birds such as the great egret, snowy egret (*Egretta thula*), glossy ibis (*Plegadis falcinellus*), and black-crowned night-heron (*Nycticorax nycticorax*), and plants such as seashore mallow (*Kosteletzkya virginica*), southern sea-blite (*Suaeda linearis*), annual saltmarsh aster (*Symphyotrichum subulatum*), and perennial saltmarsh aster (*S. tenuifolium*).

Substrates

Substrates are primarily marsh peat and mud. Peat is soil that is composed predominantly of partly decayed plant matter; "mud" is mineral soil with less organic content.

Surface Waters

Waters are tidal, with the mud flat and low marsh zones flooded twice daily. The high tides flood the high marsh for a few days around the full moon and new moon. Pannes may hold brackish water on the high marsh even during periods when high tides are lower (neap tides).

Quality

New York City's salt marshes suffer from intense urbanization, including the loss of habitat due to commercialization of the shoreline for industry and transportation. An abundance of common reed or reduced diversity of native salt marsh flora and fauna indicate habitat degradation. Wel-developed high marsh dominated by native plants indicates good quality. Presence of certain species, such as sea-lavender, saltmarsh sparrow, and seaside sparrow are also indicators of quality. Degraded marshes are still valuable for biodiversity support and the provision of other ecosystem services (including protection of the shoreline from wave energy and sequestration of carbon in the soil).

Human Uses

Early Dutch settlers grazed cattle on the high salt marshes. Many high marshes were partly drained or diked and used for harvesting salt hay. Later human uses were more destructive. By the 1950's, approximately 20,000 acres (8,094 ha) of salt marsh had been destroyed to create buildable land around the City's edges. For example, John F. Kennedy Airport in Queens was built on 4,500 acres of salt marsh. Salt marshes have been, and to some extent still are, used for fishing, hunting, and fur trapping. Because they attract birds not seen in other habitats, they are also of interest to birdwatchers. The most important uses of salt marshes are indirect, via their ecosystem services, including support of commercial fisheries, carbon sequestration in soils, and protection of shorelines from wave-caused erosion.

Threats

Urban ecosystems may recover ecological function more slowly after disturbance than comparable systems in less altered environments. Threats include oil spills, non-point source pollution, urban runoff, degraded water quality, floating debris, bank erosion, and illegal dumping. These can smother existing salt marshes and restrict their recolonization by cordgrasses. Salt marsh dieback, a syndrome of uncertain cause, is affecting many marshes east and south of New York City and may soon damage the City's marshes.

Conservation and Management

Given that most of New York City's salt marshes have been lost to development, public lands with sites buried under sanitary landfill or other fill should be considered for restoration. The New York City Department of Parks and Recreation has restored a number of formerly filled marshes around the City. Their most recent such project is Dreier-Offerman Park in Brooklyn. Restoration and management of salt marshes is complex, expensive, and subject to many problems. Bergen et al. (2000) described a major restoration project on Staten Island. Niedowski (2000) provided restoration and monitoring guidelines for New York salt marshes.

Additional information on salt marshes may be found in Anderson (1994), New York/New Jersey Harbor Estuary Program (2001), and Weis and Butler (2009).

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Streams

By Susan Stanley

General Description

Streams are bodies of fresh water characterized by their dynamic, linear water flow, often with riffles, rapids, pools, and backwaters. The flow of water may be permanent, ephemeral or intermittent. Streams are categorized in numerical order by the number of connections they have to other waterways. First order streams, which can include headwater streams, lack connection to other tributaries. Second order streams have one connection to another stream or tributary, while third order streams link two second order streams. Lower order streams flow into larger streams, which increase in size as they join together, eventually reaching rivers or other larger water bodies. In general, streams are considered smaller than rivers and are characterized as "wadeable" (U.S.EPA 2012).

Ellen Pehek

Stream at Silver Lake Golf Course.

Ellen Pehek

Stream at Silver Lake Golf Course.

Distribution in New York City

Many streams in New York City, especially headwater streams, have been lost since the earliest settlers arrived and began to alter the landscape. Streams in some boroughs run under pavement or have been forced into cement channels that restrict their movement. Although streams are found in all boroughs of New York City, the vast stream network that once covered the area has been reduced to a fraction of its former size (see The Welikia Project for historic maps).

Manhattan, Brooklyn, Staten Island, Queens, and the Bronx all have streams that are above ground. However, the only remaining streams in heavily-developed Manhattan and Brooklyn were constructed in Central and Prospect Parks. Natural streams remain in the other boroughs; less-developed Staten Island has the highest number of them.

Examples on public land:

- Bronx: Van Cortlandt Park (Tibbet's Brook)
- Brooklyn: Prospect Park
- Manhattan: Central Park (The Loch)
- Queens: Alley Pond Park (Alley Creek)
- Staten Island: Arden Woods Creek

Vegetation

As streams flow through forested areas, leaves that fall into the water accumulate behind rocks and branches. These masses of leaves and other organic debris are the main source of energy for the stream ecosystem. Trees prevent erosion and shade streams, keeping water temperatures cool. In New York City these trees include green ash (*Fraxinus pennsylvanica*), American sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), silver maple (*Acer saccharinum*), yellow birch (*Betula alleghaniensis*), and pin oak (*Quercus palustrus*). Shrubs such as highbush blueberry (*Vaccinium corymbosum*), spicebush (*Lindera benzoin*), and sweet pepperbush (*Clethra alnifolia*) are commonly found along the stream corridor.

Stream current is a limiting factor for the growth of vegetation. In saturated soils where water forms pools, skunk cabbage (*Symplocarpus foetidus*) and jewelweed (*Impatiens capensis*) may be present. Mosses and liverworts (see Bryoids profile) may cover rocks, while various types of algae inhabit the streams. Sedges are uncommon along New York City streams.

Fauna

The City's streams provide habitat, food, protection, and routes of dispersal and travel for a number of fish, amphibian, and benthic (bottom-dwelling) invertebrate species. The blacknose dace (*Rhinichthys atratulus*) is a small fish commonly found darting about the streams of Staten Island. American eels (*Anguilla rostrata*) are catadromous, utilizing Staten Island's streams as adults and spawning at sea. Green frogs (*Lithobates clamitans*) make use of quiet pools, while larvae of the two-lined salamander (*Eurycea bislineata*) and northern dusky salamander (*Desmognathus fuscus*) inhabit slow-moving water. After transforming into their terrestrial (land-dwelling) stage, stream salamanders inhabit banks and moist woods near the water's edge (see the Stream Salamander profile for more information). Northern red salamanders (*Pseudotriton ruber*) have a slightly different lifestyle, utilizing running water not only as larvae but as terrestrial adults that overwinter in streams.

The larvae of odonates (dragonflies and damselflies) are aquatic as well. These invertebrates have adopted different strategies for maintaining their position in moving water, such as burrowing into the substrate or clinging to branches and other debris. The ebony jewelwing (*Calopteryx maculata*), a black-winged, emerald-colored damselfly, can be observed perching on vegetation along streams in New York City. Less often seen is the brown and yellow fawn darner (*Boyeria vinosa*), a dragonfly that patrols long stretches of stream, perching high in trees when at rest (see the Dragonfly and Damselfly profile for more information). Other invertebrates that inhabit the City's streams include scuds (Gammaridae), water pennies (Psephenidae), worms, leeches, fly larvae, water striders (Gerridae), freshwater mussels, snails, and crayfish.

These species are able to exist because of a complex food web, which is based on the decomposition of organic matter by microorganisms. Invertebrates consume these microorganisms and are then consumed themselves, and this process continues up the food chain. In addition, birds, raccoons, and small mammals may forage in streams or along the banks to take advantage of these aquatic resources.

Indicators and Identification

The presence of moving fresh water in a linear channel can indicate a perennial stream, although headwater streams, the smallest waterways, may be intermittent. When completely dry, intermittent streams can be

recognized by scouring of the streambed and erosion along the banks. Clumps of leaves and woody debris may be observed behind rocks along the bed or bank of the stream.

Biodiversity Values

Many benthic invertebrates that live in small or headwater streams cannot survive in larger waterways due to a lack of suitable habitat, changes in water velocity and temperature, or the presence of predators. Microorganisms play an important ecological role in smaller streams that are shaded from sunlight. They convert leaves, woody debris, and other organic material into forms usable by other organisms throughout the stream network (Wipfli et al. 2007). These resources allow higher order streams to support vertebrates such as freshwater and anadromous fish (those fish that migrate up streams or rivers from the sea to breed in fresh water) and salamanders. Streams enable the movement of organisms for foraging, migration, or dispersal. Dispersal of organisms is vital to maintaining the genetic diversity and persistence of populations.

Substrates

Stream beds in New York City consist of sandy soils, pebbles, and rocks. In pools and backwaters, a layer of fine organic sediment may cover the stream bottom. In forests, stream banks are comprised of sandy loam covered by a dark humus layer that is rich in nutrients.

Surface Waters

Surface water is present in perennial streams but may be absent at some time of the year in intermittent streams. Groundwater may help recharge streams when levels are low.

Quality

New York City's streams have been altered, channelized, dammed, filled, and piped underground. Those that remain are subject to degradation from pollution and flooding, which is exacerbated by a high percentage of impervious surface area that increases runoff into the water. This accelerates erosion, causing turbidity and sedimentation, and has a negative impact on the food web by removing organic matter. Despite such human-induced changes, some streams still support a diverse array of aquatic and semi-aquatic organisms.

Human Uses

Early settlers of New York City modified streams for agriculture and milling, creating ponds and lakes that can still be seen today. Subsequently, the City rapidly urbanized and streams were filled in or covered over to create more suitable land to build upon. Recently, a number of streams on Staten Island have been converted into stormwater retention ponds through the NYC Department of Environmental Protection's Bluebelt Program.

Threats

Dams and culverts can isolate populations of organisms and decrease the genetic diversity they maintain by moving throughout the stream corridor. Once populations have been separated, they are more vulnerable to chance (stochastic) events that can cause local extirpation. Ponds created by damming reduce the overall habitat for organisms that require the colder temperatures of streams. Introduced species can become over-abundant, displacing native plants and aquatic wildlife and reducing biodiversity.

Conservation and Management

"Blue line" streams on current U.S. Geological Survey maps usually do not include headwaters. In a study of a watershed in Massachusetts, Brooks and Colburn (2011) estimated an average of 0.6 mile (1 km) of unmapped lower order streams upgradient for each 2.3 miles (3.7 km) of mapped stream. Mapping and assessment of headwater streams are urgently needed to inform land-use planning.

Given that vegetation is key to the ecological health of streams, maintaining a vegetated buffer zone is vital. Native flora, where it can be maintained, has higher conservation value than nonnative plants. Some nonnative plants, such as Japanese knotweed (*Polygonum cuspidatum*), can form dense stands containing few native plants and may degrade riparian habitat for some wildlife. It is also important to control the amount and proximity of impervious surfaces, development, and activities that may increase flooding and erosion.

Steams are dynamic ecosystems that may expand and contract or change direction in response to events such as storms with heavy rainfall. When the volume of water exceeds the channel's capacity, water overflows onto the adjacent floodplains where it may pool and create temporary habitat for some organisms such as beetles, frogs, and turtles. Because of the changes in size and shape of streams, they should be allowed, as much as possible, to take their natural course.

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Springs and Seeps

By Ellen Pehek

General Description

Springs and seeps occur where groundwater comes to the surface, either because a slope intersects the water table, or there is a break in the bedrock that allows water from an aquifer below the surface to escape upward. There is much confusion about the difference between a spring and a seep. Seeps can appear as a muddy area on a slope, as water dripping from a rock wall, or as the headwaters of a stream. Springs can be the source of a pond or contribute to stream flow, in which case they are not easily observed. A "boiling" spring occurs where water bubbles up from a break in bedrock, suspending sandy or silty soil (Sanford 1913).

Because both seeps and springs are discharging groundwater, they share the distinctive chemical composition conferred on the groundwater by rock and soil. If the water travels through quartz sand, it will be acidic. Sand may also filter the water, and it will emerge extremely clear and clean. If it travels through organic matter, it may be brown with tannins. If the bedrock is limestone, the water will be high in calcium (Sanford 1913).

Ellen Pehek

Great Swamp seep.

Distribution in New York City

Springs and seeps are found in the Bronx, Manhattan, Queens, and Staten Island. The current extent of springs and seeps in New York City is unknown, although the Parks Department has documented several in all boroughs except Brooklyn.

Examples on public land:

- Bronx: Van Cortlandt Park, Spuyten Duyvil Shorefront Park
- Manhattan: Fort Tryon Park, Fort Washington Park
- Queens: Alley Pond Park
- Staten Island: Greenbelt (including the Clove Valley)

Vegetation

Springs and seeps often support diverse vegetation, including lichens, mosses, liverworts, ferns, sedges, grasses, and broad-leaved plants (Miller et al. 2005). Shrubs and trees do not usually grow in seeps, but a canopy of surrounding trees may provide dense shade. Typical plant species include sensitive fern (*Onoclea sensibilis*), mannagrass (*Glyceria*), jewelweed (*Impatiens capensis*), and skunk cabbage (*Symplocarpus foetidus*)(Thompson and Sorenson 2005). The mosses, liverworts, and lichens of New York City seeps are not well known.

Fauna

Springs and seeps are the primary habitat for the northern dusky salamander (*Desmognathus fuscus*) and the northern red salamander (*Pseudotriton ruber*). The northern two-lined salamander (*Eurycea bislineata*) is also found in springs and seeps. These waters are habitat for invertebrates such as amphipods (tiny crustaceans known as "scuds") and several dragonflies, including the tiger spiketail (*Cordulegaster erronea*) and the gray petaltail (*Tachopteryx thoreyi*). Other invertebrates of seeps are not well known and deserve further study.

Indicators and Identification

Springs and seeps can be identified by the presence of fresh water flowing downslope or bubbling up to the surface, by dominant herbaceous vegetation that is adapted to the presence of this water (hydrophilic vegetation), and by waterlogged (hydric) soils. The primary indicator is groundwater discharge. The groundwater feeding seeps and springs is approximately 50˚F year-round, making seeps and springs cooler in the summer and warmer in the winter than wetlands or streams fed by surface water. Springs and seeps tend to be perennial (always flowing), although there may also be some intermittent springs and seeps.

Biodiversity Values

Springs and seeps in New York City support the northern red salamander, a New York State Species of Greatest Conservation Need (see Appendix B), as well as two S1 ranked (endangered) dragonflies, the southern pygmy clubtail (*Lanthus vernalis*) and the yellow-sided skimmer (*Libellula flavida*). Unless the groundwater is contaminated, springs and seeps provide the very clean water required by many rare species. Springs and seeps also provide ice-free drinking water for wildlife in the winter, due to their nearly constant temperature (Healy and Casalena, no date). The plants in these habitats in New York City deserve further study, since rare species have been found in similar habitats elsewhere. Because groundwater cools springs and seeps in summer, they might support species at their southern range limits and provide refuge from climate warming.

Substrates

Springs may arise from within rock, sand, mud, or muck substrates. Seeps are usually mucky due to undecayed organic matter that accumulates on the surface. They are often covered with leaf litter and logs, and may have rocks on or beneath the surface.

Surface Waters

Springs may form ponds or small puddles, or contribute to streams. Seeps usually appear as a thin film of water emerging from a rock or from the forest floor on a slope. Seeps may enlarge downslope and become the headwaters of a stream, or they may disappear again underground.

Quality

Springs and seeps in New York City range from those with waters that are contaminated and filled with sediment from stormwater runoff, to those with crystal clear waters that are safe for human drinking (Bindley 2008). They are often very small, and may be found in small habitat patches surrounded by dense development. In fact, two of the biologically most intact seeps in New York City are in Manhattan (Smith 1938). The flora of seeps varies from vegetation dominated by native species in less disturbed areas to nonnative species such as Japanese knotweed (*Polygonum cuspidatum*) in areas with soil and tree canopy disturbance. Only a few of the City's seeps have the high quality required by the northern dusky and northern red salamanders. Seeps supporting sensitive salamanders and rare dragonflies are found on heavily forested land in New York City parks, but pressure for recreational development within parks, and road widening and commercial development adjacent to parks, may threaten water quality.

Springs and seeps are threatened by foot, bicycle, or motor vehicle traffic, stormwater contamination, groundwater contamination, falling groundwater tables due either to exploitation or excavation, and invasive plant species. Amphibians of springs and seeps are sensitive to diseases introduced by contaminated footwear or sampling equipment. A major threat to these small wetland habitats is a lack of mapping and regulation, because most sites are below the 12.4-acre threshold required for automatic legal protection under the Freshwater Wetlands Act in New York State (see Appendix A).

Human Uses

Early colonists used springs as drinking water sources, and at least one spring, in the Clove Valley of Staten Island, is still used as a source of potable water.

Threats

Urban springs and seeps may survive relatively unaltered as long as the groundwater supply is not disrupted or polluted, and an undisturbed vegetated buffer is preserved. However, relatively small amounts of stormwater and sediment may destroy the quality of these waters, and the large amount of pavement and other impervious surfaces in cities increases the volume of runoff. High demand for land for recreation and development, as well as the lack of knowledge of spring and seep locations and values, make them extremely vulnerable in an urban environment.

Conservation and Management

Identify, map, and assess the condition of remaining springs and seeps. Protect buffer zones at least 100 feet wide around seepage areas and springs (Pennsylvania DCNR 2007, New York DEC 2008), and restrict access by foot, bicycle, or motor vehicle traffic. Seeps should be considered along with other wetlands for regulatory protection, without bias due to their often small size.

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Intermittent Woodland Pools

By Susan Stanley and Erik Kiviat

General Description

Typically, these are shallow pools, surrounded by upland forest, which usually retain standing water during winter and spring but dry up by mid- to late summer. Because in most years these pools dry, they do not support fish, which is critical to most amphibian species that breed in the pools and cannot tolerate fish predation on their eggs and larvae. Often referred to as "vernal pools" or "ephemeral pools," they contribute to biodiversity, are a vital component of the forest food web, and help to prevent flooding by absorbing runoff, rainwater, and snowmelt. Small wetlands such as intermittent woodland pools are particularly vulnerable to loss as their size and temporality make them sensitive to changes in land use and hydrology (Gibbs 1993, 2000; Colburn 2004; Brooks 2005; Leibowitz and Brooks 2008).

Because they have no legal protection, they are often damaged since landowners do not appreciate their value and they are often overlooked in the environmental reviews of development projects (Calhoun and Klemens 2002; Calhoun et al. 2005).

Distribution in New York City

Intermittent woodland pools are found in the Bronx, Queens, and Staten Island. They are usually small, from well under 0.25 acre (0.1 ha) to perhaps 0.2 to 1.2 acres (0.5 ha). They may be isolated from other wetlands

Susan Stanley

Vernal pool in winter.

and waters or found grouped together. Dense clusters of pools are present in the knob and kettle terrain of parks in Queens and Staten Island. Intermittent woodland pools may also be part of larger swamps or wetland complexes.

Examples on public land:

- Bronx: Van Cortland Park
- Queens: Cunningham Park, Queens, Alley Pond Park
- Staten Island: Blue Heron Pond Park, High Rock Park

Vegetation

There may be a fringe of large trees at the pool edge, even if the surrounding forest is less mature. The bordering trees are most often hardwoods such as red maple (*Acer rubrum*), red oak (*Quercus rubra*), pin oak (*Q. palustris*), and sweet gum (*Liquidambar styraciflua*). Woody plant "hummocks" (raised root-pedestals) from 6 to 24 inches (15 to 60 cm) high and 6 to 80+ inches (15 to 200+ cm) across are sometimes present at pool edges or in mid-pool. Hummocks support red maple, highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), some small herbs, and often a profusion of mosses. Buttonbush (*Cephalanthus occidentalis*) may be present, even dominant. Sedge tussocks (*Carex stricta*) may be present where shade is not too deep. Duckweeds, including common duckweed (*Lemna minor*), watermeal (*Wolffia*), and sometimes greater duckweed (*Spirodela polyrhiza*), are usually present when water temperature warms in late spring. The moss flora can be diverse, especially in pools with abundant rocks, woody hummocks, and down wood. Floating filamentous algae typically occur in small, ephemeral patches (a few square yards/meters) where there is more light penetration through the woody canopy; more extensive and long-lasting algal blooms may indicate

Susan Stanley

Intermittent pond drying out in early summer.

James P. Gibbs

Spotted salamander (*Ambystoma maculatum*).

James P. Gibbs

Wood frog (*Lithobates sylvatica*).

nutrient enrichment or other pollution.

Fauna

Common resident animals include microcrustacea such as water-fleas (Cladocera) and copepods, water sowbugs (Asellidae), fairy shrimp (Anostraca), caddisfly larvae (Trichoptera), predaceous diving beetles (adults and larvae) (Dytiscidae), water scavenger beetles (adults and larvae)(Hydrophilidae), water striders (Gerridae), backswimmers (Notonectidae), water boatmen (Corixidae), mosquitoes (larvae) (Culicidae), water mites (Hydracarina), fingernail clams (Sphaeriidae), and snails (Gastropoda). Permeant ("commuting") animals include spotted salamander (*Ambystoma maculatum)*, red-spotted newt (*Notopthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Lithobates sylvaticus*), green frog (*L. clamitans*), gray treefrog (*Hyla versicolor*), spotted turtle (*Clemmys guttata*), mallard (*A. platyrhynchos*), and wood duck (*Aix sponsa*). Raccoons (*Procyon lotor*) and other mammals may visit the pools to forage.

Indicators and Identification

At high water levels, water depths are normally 10 to 50 inches (25 to 125 cm). Hydroperiod (duration of standing water) is six to nine months in an average year. The presence of fairy shrimp is a good indicator that the standing water is temporary. For successful breeding of spotted salamanders, the pool should hold water through July. The pool is moderately to heavily shaded when woody plants are in full leaf, and the perimeter is substantially wooded. When standing water is not present, the leaf litter will be a darker color than that of the surrounding forest floor. The lower portion of trees in or around the edge of pools will be stained darker where water was present in past seasons.

Biodiversity Values

Intermittent woodland pools are best known as amphibian breeding and nursery habitats. They are virtually the only significant spawning areas for spotted salamander and wood frog, and are also favorable spawning areas for

spring peepers. Fairy shrimp require vernal pools for their survival, while a number of other invertebrate species may use this temporary habitat rather than permanent waters. The invertebrate community composition differs with the duration of standing water; therefore the presence of short, medium, and long hydroperiod pools can contribute significantly to biodiversity. Some woodland pools may be used by spotted turtles and eastern box turtles (*Terrapene carolina*). Mallard and wood duck (and potentially American black duck) generally use these pools and may nest or rear broods there (mallard and black duck nest on hummocks in mid-pool; wood duck nests in tree cavities). An apparently rare pouch snail, the springtime physa (*Physa vernalis*), is reported in pools farther north in New York State but has not been collected in New York City to date. The mulberry wing (*Poanes massasoit*) and black dash (*Euphyes conspicua*) butterflies may be present in woodland pools with tussock sedge. Other invertebrates bear investigation. Swamp cottonwood (*Populus heterophylla*) and featherfoil (*Hottonia inflata*) are two rare plants of woodland pools in the Hudson Valley; those species and rare sedges should be sought in New York City.

Substrates

Vegetation usually suggests a neutral to moderately acidic water and soil pH. Pool bottoms normally have a layer of decomposing woody plant leaves (leafpack) at least several centimeters deep.

Surface Waters

At highest water levels and in the deeper parts of the pools, standing water is about 10 to 50 inches (25 to 125 cm) deep and is present from about November to June or longer. The hydroperiod (duration of standing water) varies from year to year depending on precipitation, soils, and other factors. Some intermittent woodland pools are flooded through summer and fall in the wettest years, but dry up by early- to mid-summer in a normal-precipitation year. Inlets and outlets are very small or absent, and surface water throughflow is generally absent or negligible. Surface water is usually moderately acidic, and moderately to heavily stained by organic substances from decaying leaves The leafpack usually remains wet or damp during seasonal drawdowns.

Quality

Higher quality is indicated by the vegetation and surface water characteristics noted above, and by the absence or insignificance of alterations and impacts (drainage, filling, dumping, dredging or impoundment, tree removal, pollution with nutrients or chemicals, pesticide application). The presence of intact mature forest habitat surrounding the pool is important to the habitat value for amphibians (Windmiller 1996; deMaynadier and Hunter 1999; Windmiller and Calhoun 2008). Because some of the amphibians, particularly the spotted salamander, have larvae that are sensitive to low pH, there has been concern over the impact of acidic precipitation on their populations.

Human Uses

Many pools have been partially or entirely filled or drained to accommodate development or past agricultural uses. Some have been used as dump sites for landscaping, construction and demolition debris, or even household garbage.

Threats

Because intermittent woodland pools are usually small, they are often overlooked by wetland regulatory agencies, and are easily filled or drained. Although some meet the federal jurisdictional criteria for wetlands, they are too small—under 12.4 acres (5 ha)—to be protected under the New York State Freshwater Wetlands Act. Woodland pools are vulnerable to the application of pesticides for mosquito control; these materials vary in their toxicity to associated fauna. The presence of fish (such as by release of aquarium fish) reduces or precludes the successful reproduction of the spotted salamander and wood frog. Destruction of the surrounding forests will eliminate the non-breeding habitat for these two species. Excessive nutrient input, such as that from fertilizer in runoff, could be harmful to the plants and animals of woodland pools. Pools are sometimes destroyed or damaged by fill, drainage, or channelization, excavation or damming to create ponds, and other construction. Climate change may have severe impacts on intermittent woodland pools as both rising temperatures that increase evapotranspiration and lower rainfall amounts mean the pools will dry sooner, excluding organisms that require longer hydroperiods (Brooks 2004, 2005; Bauder 2005; Pyke 2005; Liebowitz and Brooks 2008). It is very likely that temperatures will continue to increase with climate change; however, predictions of precipitation are less certain.

Conservation and Management

Intermittent woodland pools and the surrounding forests should be preserved in an unaltered state wherever possible. Negative impacts noted above should be prevented or removed. Applications of pesticides for control of nuisance mosquitoes should be minimized. Intermittent woodland pools are not likely to be a significant source of disease-carrying mosquitoes, and even the least toxic materials may be harmful to larval amphibians or their food supply. Artificial construction of intermittent woodland pools may be possible, given appropriate hydrological conditions, if care is taken to prevent contamination with soil and nutrients (Biebighauser, no date).

This profile was adapted from Kiviat and Stevens (2001).

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Serpentine Barrens

By Marielle Anzelone and Roger Latham

General Description

Serpentine barrens have soils that are high in magnesium and low in calcium, a predominance of grasses, forbs (herbaceous plants), and shrubs, and small areas of exposed serpentinite bedrock. Soils are nutrient-poor and high in metals that are toxic to many plants. "Barrens" refers to the sparse vegetation and inability to support crops. The habitat occurs only in areas where the soil is shallow over serpentinite rocks. General discussions of the geology, ecology, and botany of serpentine may be found in Brooks (1987), Dann (1988), and Rajakaruna et al. (2009).

Distribution in New York City

This habitat is found in only a few places in the world (New York Natural Heritage Program 2011). Serpentine barrens have restricted distribution because serpentinite bedrock is geographically restricted, occurring only as scattered outcrops. In New York City, serpentinite outcrops are restricted to high ridges on Staten Island. Serpentinite bedrock runs through Staten Island like a spine, and its resistance to weathering is responsible for the high elevations at Todt Hill and adjacent Heyerdahl, Richmond, and Grymes Hills. The resulting serpentine barrens are fragmented and small. Of five known sites, only one remnant, totaling just a few acres (Seaview), is vegetationally intact. Serpentine barrens likely occupied a much larger area on Staten Island before most were obliterated by forest succession in the absence of wildfire and later, by conversion to urban uses.

Mike Feller

Seaview serpentine barrens.

Examples on public land:

- Staten Island: Eibs Pond Preserve, Greenbelt (LaTourette Park, Mt. Moses), Clove Lakes Park, The Serpentine Commons (in Todt Hill). (The only remaining site with intact serpentine barren vegetation is at LaTourette Park. Altered or degraded serpentine barrens occur at the other four sites.)

Vegetation

Serpentinite is poor in calcium and unusually high in magnesium, an essential nutrient for plants that nonetheless can be toxic at high levels. Nickel and chromium concentrations are also high enough to adversely affect plant life (New York Natural Heritage Program 2011). Where the soil is shallow over bedrock, exposure to the inhospitable combination of minerals limits plant growth, resulting in the perceived barrenness of the landscape.

There are plants that are endemic to serpentine soils, but these species are not found on Staten Island. Plants found in the Island's serpentine barrens are typical of a grassland community. The two dominant species are Indiangrass (*Sorghastrum nutans*) and little bluestem (*Schizachyrium scoparium*). Although historically known

Elizabeth Johnson

Scattered shrubs in serpentine grassland.

from other boroughs, green milkweed (*Asclepias viridiflora*) now occurs exclusively in serpentine grasslands in Staten Island. Other characteristic herbaceous species are common yarrow (*Achillea millefolium*), small white snakeroot (*Ageratina aromatica*), poverty oatgrass (*Danthonia spicata*), common hairgrass (*Deschampsia cespitosa*), shrubby sundrops (*Oenothera fruticosa* ssp. *glauca*), old-field cinquefoil (*Potentilla simplex*), bristly foxtail (*Setaria parviflora*), switchgrass (*Panicum virgatum*), white heath aster (*Symphyotrichum ericoides*), and white old-field aster (*Symphyotrichum pilosum*). Trees and shrubs are scattered and stunted. They include gray birch (*Betula populifolia*), black oak (*Quercus velutina*), sassafras (*Sassafras albidum*), quaking aspen (*Populus tremuloides*), northern bayberry (*Morella pensylvanica*), winged sumac (*Rhus copallina*), and highbush blueberry (*Vaccinium corymbosum*). The flora of Staten Island serpentine habitats was discussed by Willis and Feller (1991), Edinger et al. (2002), Levine and Greller (2004), and Gargiullo (2007).

Elizabeth Johnson

Serpentinite bedrock.

Fauna

The native grassland plants found in Staten Island's serpentine barrens are food for the larvae of specialist-feeding insect species, many of which have become increasingly rare as native grasslands have declined. The native meadow forbs provide nectar for butterflies and other pollinators. Butterflies may include the monarch (*Danaus plexippus*), great spangled fritillary (*Speyeria cybele*), question mark (*Polygonia interrogationis*), eastern comma (*Polygonia comma*), mourning cloak (*Nymphalis antiopa*), red admiral (*Vanessa atalanta*), painted lady (*Vanessa cardui*), American copper (*Lycaena phlaeas*), black swallowtail (*Papilio polyxenes*), eastern tiger swallowtail (*Papilio glaucus*), and falcate orangetip (*Anthocharis midea*). Birds likely to be seen include American kestrel (*Falco sparverius*), red-tailed hawk (*Buteo jamaicensis*), northern flicker (*Colaptes auratus*), barn swallow (*Hirundo rustica*), tree swallow (*Tachycineta bicolor*), northern rough-winged swallow (*Stelgidopteryx serripennis*), eastern bluebird (*Sialia sialis*), eastern kingbird (*Tyrannus tyrannus*), house wren (*Troglodytes aedon*), cedar waxwing (*Bombycilla cedrorum*), indigo bunting (*Passerina cyanea*), American goldfinch (*Spinus tristis*), song sparrow (*Melospiza melodia*), chipping sparrow (*Spizella passerina*), and field sparrow (*Spizella pusilla*). Ground-dwelling animals in the serpentine barrens include the meadow vole (*Microtus pennsylvanicus*), eastern cottontail (*Sylvilagus floridanus*), and Fowler's toad (*Anaxyrus fowleri*).

Indicators and Identification

Serpentine barrens are herbaceous upland communities of native grasses and other grassland species occupying shallow soils underlain by serpentinite bedrock. They have been reduced to small remnants in the northern portion of Staten Island. The flora is dominated by forbs and grasses such as Indiangrass and little bluestem. Woody plants are scattered and tend to be stunted.

Biodiversity Values

Serpentine barrens are critically imperiled globally and endangered in New York State. The exposed serpentinite bedrock and areas of shallow soil also support a number of rare plants, including the state-rare purple milkweed (*Asclepias purpurascens*), green milkweed, and globose flatsedge (*Cyperus echinatus*). Serpentine may also support unique genetic variation in plants (Dann 1988), although this has not yet been discovered on Staten Island.

Substrates

Staten Island boasts the highest natural point in New York City, Todt Hill. This hilltop is a massive outcrop of serpentinite bedrock, a greenish metamorphic rock formed a half-billion years ago beneath the ocean and thrust upward onto the continental margin in a slow collision between North America and Africa. The rock is rich in iron and magnesium. Serpentine barren soils are derived from weathered serpentinite bedrock, creating a loamy, chemically unusual soil that strongly influences the plant community.

Surface Waters

Surface waters are not present.

Quality

Human activity has degraded the serpentine barrens. Development in areas around Todt Hill has destroyed the

habitat outright. Remnants are small and tend to be overrun by invasive species such as Japanese knotweed (*Polygonatum cuspidatum*) and mugwort (*Artemisia vulgaris*).

Human Uses

There are no known unique or special uses of this habitat besides its importance to research, education, and biodiversity conservation.

Threats

Wildfire suppression has resulted in a shift from shrubby grassland to forest. Some of the encroaching woody species are nonnative, including autumn-olive (*Elaeagnus umbellata*), rugosa rose (*Rosa rugosa*), and black locust (*Robinia pseudoacacia*). Remaining fragments in Staten Island need intensive restoration but the largest remaining site (Seaview) is slated for development. Illegal dumping of trash and debris is also an ongoing problem.

Serpentinite is rich in asbestos (Germine & Puffer 1981), and inhaling dust from the bedrock or soil may be a health hazard.

Conservation and Management

Serpentine barrens need periodic fires that enable the grassland to persist by preventing the accumulation of organic matter from leaves, bark, and fallen branches that allows woody vegetation to develop. Management can include selective cutting of woody plants, but it is believed that regular burning is required to prevent natural development of the soil that facilitates the shift to forest vegetation. Other recommendations include removing invasive vegetation, creating a clear plan for trails, and restoring vegetation on "desire lines" (short-cuts made by pedestrians through an area). Small-scale experiments might test techniques for restoring serpentine barrens vegetation on degraded sites.

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Dredge Spoil

By Erik Kiviat

General Description

Dredge spoil (dredged material) is sediment dredged from shipping channels, inter-pier areas, and other estuarine bottoms, and deposited on land or in shallows or marshes. Formerly, spoil was dumped somewhat indiscriminately in wetlands and shallows close to dredging areas, and this practice was widespread in New York City. In recent years, due to recognition of the values of estuarine wetlands and shallows, and the passage of protective laws, much dredged material is used for grading in construction projects on land.

Most dredge spoil is composed of sandy material; other types of sediments may be present as well. Sandy spoil generally does not hold much soil moisture or support many ponds or streams (except where ponds have been excavated). The soil, because of its sediment origin and young age, lacks the structure of natural soils. Because many organisms do not thrive on or in sandy spoil, other species that tolerate the unusual conditions may thrive on spoil. Dredge spoil is often in low-lying areas and therefore prone to flooding.

Distribution in New York City

Dredge spoil comprises extensive areas—thousands of acres—in and around Jamaica Bay, including portions of Rockaway Peninsula and probably John F. Kennedy and La Guardia airports. Smaller areas occur elsewhere.

Examples on public land:

- Brooklyn: Floyd Bennett Field (a component of Gateway National Recreation Area), of which 1,500 acres (607 ha) are dredge spoil
- Queens: Dubos Point Wetlands Sanctuary; Jamaica Bay Wildlife Refuge (a component of Gateway National Recreation Area)

David Taft

Dredge spoil, Jamaica Bay Wildlife Refuge.

David Taft

Dredge spoil, Jamaica Bay Wildlife Refuge.

David Taft

Dredge spoil, Jamaica Bay Wildlife Refuge.

Vegetation

Despite the droughty, flood prone, unstable young soils, many species of plants do well on these areas. The nonnative subspecies of common reed (*Phragmites australis australis*) is a major colonizer. Reedbeds form on dry soil as well as in wet areas. Switchgrass (*Panicum virgatum*), a large, tufted, native grass, also colonizes dry or damp spoil. Many other plants, generally weedy, native or nonnative species, also occur on dredge spoil. Trees include eastern cottonwood (*Populus deltoides*), silver maple (*Acer saccharinum*), and boxelder (*Acer negundo*). Vegetation is patchy and may seem chaotic because it lacks the belting (zonation) typical of natural shorelines, and perhaps also due to uneven subsidence of the soil (Greller, personal communication, 2011; see Kiviat 1995).

Nonnative and native species were extensively planted at Jamaica Bay Wildlife Sanctuary in the 1950s to stabilize newly deposited spoil and create diverse food and cover for birds (Graham 1970). Japanese black pine (*Pinus thunbergii*), autumn-olive (*Elaeagnus umbellata*), American beach grass (*Ammophila breviligulata*), and northern bayberry (*Morella pensylvanica*) were prominent species planted on uplands (Graham 1970, Bridges 1976). Spoil areas at Jamaica Bay Wildlife Sanctuary also supported a large number of other species in the 1970s (Bridges 1976). The presence of Indiangrass (*Sorghastrum nutans*) and garlic mustard (*Alliaria petiolata*) at Dubos Point Wetlands Sanctuary in the 1990s suggested a calcium source, perhaps mollusk shells, in some areas (Kiviat 1995).

Gradually spreading, spontaneous woody vegetation at Floyd Bennett Field prominently included bayberry, bramble (*Rubus*), gray birch (*Betula populifolia*), eastern cottonwood, and mulberry (probably *Morus alba*) (Cook 1996). Jamaica Bay Wildlife Sanctuary and Floyd Bennett Field had extensive reedbeds from the 1970s into the 2000s.

In some cases the vegetation of dredge spoil habitats can change rapidly, and although this change is often in the direction of taller stature and greater dominance by woody plants, this may not always be the case. For example, shrubs or trees can be damaged or killed by insects, fungi, or storms. Although all vegetation is dynamic, the vegetation of dredge spoil may be more changeable than in certain other upland habitats.

Fauna

Most of the larger fauna in dredge spoil areas is not unusual. Common songbirds such as cedar waxwings (*Bombycilla cedrorum*) frequent the woody vegetation. Brown snakes (*Storeria dekayi*) may be found beneath cover objects on the ground. Dry, sparsely vegetated areas are generally favorable for burrowing insects including a variety of soil-nesting bees and wasps, so some of these species are likely to occur on dredge spoil sites.

Indicators and Identification

Dredge spoil is identified by dry, sandy soil just above the high tide level with open areas of sparse vegetation interspersed with thickets and trees. There is little or no surface water above the high tide level.

Biodiversity Values

Constructed ponds can be very attractive to water, marsh, and shore birds, as are the East and West Ponds at Jamaica Bay Wildlife Sanctuary and Return a Gift Pond at Floyd Bennett Field. Trees, shrubs, and woody vines that produce fleshy fruits attract many songbirds, and woody thickets are favorable for songbird nesting. Dubos Point Wetlands Sanctuary and Jamaica Bay Wildlife Sanctuary are both considered important stopover areas for migrant birds.

Northern harrier (*Circus cyaneus*), upland sandpiper (*Bartramia longicauda*), short-eared owl (*Asio flammeus*), and grasshopper sparrow (*Ammodramus savannarum*), all rare birds that breed in low, open vegetation, have nested at Floyd Bennett Field and John F. Kennedy Airport (Anonymous no date).

The 140 acres (56.7 ha) of Floyd Bennett Field managed as grassland support uncommon grassland birds. Northern harrier (occasionally), savannah sparrow (*Passerculus sandwichensis*), and American woodcock (*Scolopax minor*) nest there. Other grassland species are found in migration or irregularly, including upland sandpiper, grasshopper sparrow, bobolink (*Dolichonyx oryzivorus*), and eastern meadowlark (*Sturnella magna*), and raptors forage there in winter (Fowle and Kerlinger 2001).

Needlepod rush (*Juncus scirpoides*) has been found with grasses in a small, shallow, moist, seasonally flooded, nontidal depression at Dubos Point Wetlands Sanctuary (Kiviat 1995). This species, listed as S1 (endangered) by the New York Natural Heritage Program, was subsequently found at other locations at the site. There have been no recent reports of its status there. Records of other rare plants at and near Dubos Point Wetlands Sanctuary (Kiviat 1995) may have preceded spoil deposition or may refer to non-spoil habitats.

Floyd Bennett Field was used for experimental reintroduction of several reptile and amphibian species. Among the reptiles, painted turtle (*Chrysemys picta*) was established very successfully and eastern box turtle (*Terrapene carolina*) established with moderate success (Cook 1996).

Substrates

Dredge spoil substrates are sandy, often dry, and probably infertile, soils. Sheltered depressions or habitats protected by shrub thickets or reedbeds may accumulate organic matter from plant litter over time.

Surface Waters

Dredge spoil areas have few or no surface waters. Small depressions may support ephemeral pools at Dubos Point Wetlands Sanctuary. Jamaica Bay Wildlife Sanctuary has two large, brackish, constructed ponds: East Pond (117 acres or 47 ha) and West Pond (45 acres or 18 ha; Fowle and Kerlinger 2001). Floyd Bennett Field has the 2-acre (0.8-ha) Return a Gift Pond, also constructed (Fowle and Kerlinger 2001).

Quality

Quality is probably best determined by the extent of an area and its flora and fauna. Nonnative plants such as common reed that often dominate large patches of spoil do not necessarily indicate low quality habitat. Reedbeds have many habitat functions and can be managed for birds and other biota.

Human Uses

Spoil sites were formerly used for disposal of not only dredged material but also other wastes, and probably a variety of illicit activities that often occur in undeveloped urban-fringe environments. Now these areas are primarily used for airports, recreation such as walking and birdwatching, and biodiversity conservation. Other important environmental services include stormwater absorption.

Threats

Spoil areas are easily damaged by vehicles, which damage or destroy vegetation and may create mosquito breeding habitats when their ruts fill with fine sediment and begin to hold water. Vegetation loss may also result in blowouts (wind erosion-caused depressions). Dredge spoil seems to be highly prone to invasion by nonnative plants, especially common reed. Dumping of garbage and potentially hazardous wastes is often a problem where there is road access for vehicles and little human presence.

Conservation and Management

The major sites discussed here are either preserved for biodiversity or developed (for example, as airports). It is important for managers to recognize that the presence of nonnative plants, such as common reed and Oriental bittersweet (*Celastrus orbiculatus*), does not necessarily indicate habitat degradation and should not be removed as a matter of course (see the Management, Restoration, and Monitoring chapter).

The grassland site at Floyd Bennett Field is managed by removing woody plants (Fowle and Kerlinger 2001). This is done to maintain habitat for grassland birds.

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Gardens, Green Roofs, and Green Walls

By Elizabeth Johnson and Janet Marinelli

General Description

New York City is full of gardens ranging in size from potted plants to the large plantings at parks and public gardens such as Brooklyn Botanic Garden, the New York Botanical Garden, Queens Botanical Garden, and the Conservatory Garden in Central Park, to name a few. Between these extremes are tree pits and other streetside plantings, residential landscapes, and community gardens. In recent years, an increasing number of green roofs and green walls has become part of the City's landscape mosaic.

Distribution in New York City

Public and private gardens, including community gardens, are found throughout New York City. According to PlaNYC, there are more than 1,000 community gardens in New York City. As part of GreenThumb, the nation's largest urban gardening program, the New York Department of Parks and Recreation provides assistance and support to over 500 community gardens throughout the five boroughs. Most are the size of a single lot (just a fraction of an acre), but a few cover an acre or more.

In a study of the potential for urban agriculture in New York City, the Urban Design Lab at Columbia University calculated that in addition to more than 1,000 community gardens there are 285 school gardens, 645 New York City Housing Authority gardens, 170 acres of Greenstreets gardens, and 52,236 acres of residential yard space. The study also identified almost 5,000 acres of rooftops that are suitable for cultivation as green roofs or urban farms (Urban Design Lab 2010). Among the several hundred acres of public gardens are Brooklyn Botanic Garden (BBG, 52 acres), the New York Botanical Garden (NYBG, 250 acres), Queens Botanical Garden (39 acres), and the Central Park Conservatory Garden (6 acres).

Melanie Smith

Green roof, Cook & Fox Architects.

Some of the most diverse public gardens can be found at Brooklyn Botanic Garden and the New York Botanical Garden in the Bronx. Of particular note are BBG's Native Flora Garden and the native plant garden currently under construction at NYBG. Queens Botanical Garden's LEED Platinum Visitor & Administration Center includes a semi-intensive green roof with native plants that is accessible to the public, as well as a variety of surrounding landscapes that captures and cleanses water.

Vegetation

Most gardens are planted with ornamental varieties (cultivars) of nonnative plants, selected or bred specifically for horticultural use.

Public gardens:

Large public gardens like BBG and NYBG have native gardens specifically designed to display native plants or habitats, and some of their other thematic gardens, such as herb gardens and woodland gardens, may include some native species. Since public gardens are regularly watered, they are important habitat for moisture-loving plants such as ferns and mosses during droughts.

Community gardens:

Unlike most parks and public gardens, community gardens are often used for food production as well as growing ornamental trees, shrubs, and flowers. These gardens can be quite diverse floristically with counts ranging from 50 to over 180 species of plants in areas that are often less than 10,764 square feet (1,000 sq m) in size (Leslie 2012).

Even in the most densely built portions of the City, there are plantings on small residential properties or in courtyards and street medians, as well as large numbers of street trees. Although these consist principally

Tim Leslie

Sampling insects in a commuity garden.

of nonnative plants that are tolerant of the harsh urban conditions, they still attract many birds, insects, and other animals.

Green roofs:

Green roof professionals distinguish among three types of green roofs, based on the depth of the soil, which in turn determines the types of plants that can grow on them. In so-called intensive systems, the soil depth is typically 12 inches (30 cm) or more, capable of supporting large plants, including shrubs and small trees. Extensive green roofs have less than 6 inches (15 cm) of soil. Because the soil is so shallow, these systems are not capable of supporting large woody plants. As the name suggests, semi-intensive green roofs are a hybrid between intensive and extensive systems. They usually have a soil depth of about 6 inches, enough to support moderately-sized plants such as native perennials and grasses.

Most extensive green roofs are planted with a monoculture of nonnative sedums (*Sedum*), hardy succulents with fleshy leaves that retain water and can tolerate the shallow soils as well as the high winds, full sun, drought, and other challenging conditions found on rooftops. However, mosses as well as vascular plants can spontaneously colonize green roofs. Research in Europe and the U.S. has shown that a relatively diverse flora is possible even on extensive green roofs if varied microtopography and microclimates, especially sunny and shady areas, are created and a minimal amount of irrigation and maintenance is provided. At Fieldston School in Riverdale (Manhattan), for example, large goldenrod (*Solidago*) and other plants grow in 4 inches (10.2 cm) of planting medium (M. Smith, personal communication, 5 July 2012).

In 2010, the New York City Department of Parks and Recreation and Columbia University embarked on a five-year project to study the performance of native plant species on green roofs. Species from two different plant communities native to the New York metropolitan region — the Hempstead Plains and the Rocky

Tim Leslie

Green roof at Linda Tool & Die, Brooklyn.

Summit Grassland—have been planted in experimental plots on the rooftops of ten Parks Department recreation centers in the five boroughs. Both plant communities—a natural prairie that once covered thousands of acres on Long Island and the open clearings found on the summits of mountains in the Northeast—grow in conditions similar to those on green roofs. The plants are growing in both 4 inch- and 6 inch-deep growing media. In the meantime, the Parks Department's Greenbelt Native Plant Center on Staten Island has an online list of native species for green roofs.

Green walls:

A relatively new phenomenon, green walls differ from traditional building facades covered with ivy or other climbing plants in that the plants grow on a structural support system, not on the building itself, and receive water and nutrients from within this system rather than from the ground. A variety of different support systems is available, including metal frames that hold modular planting units with lightweight growing media, which can accommodate very low growing plants such as native groundcovers, ferns, perennial flowers, or small or prostrate shrubs.

In other systems the plants do not grow in a soil-like medium but rather in a felt fabric attached to the metal frame. Ferns, mosses, and sedums are most suitable for growing in the felt, which is irrigated from the top with supplemental water that gravitates to the base.

Fauna

Gardens can support a diverse array of wildlife—pollinators including native bees, butterflies, beetles, and flies, other insects such as ladybeetles and praying mantises, as well as birds that feed on berries and seeds. In

Melanie Smith

Vegetable boxes in a Brooklyn community garden.

shrubby plantings common birds such as American robin (*Turdus migratorius*) and gray catbird (*Dumetella carolinensis*) can nest, and these plantings also provide overwintering habitat for dark-eyed junco (*Junco hyemalis*) and other winter finches. Research by Douglas Tallamy (2009), University of Delaware entomologist and author of *Bringing Nature Home*, has demonstrated that native plants generally support many more insects and therefore birds than nonnative species. Lists of the favorite woody and herbaceous plants for Mid-Atlantic butterflies and moths are available online.

According to recent research by Kevin Matteson (Matteson et al. 2008, Matteson and Langelloto 2009, 2010) and Tim Leslie (Al-Sayegh and Leslie 2012, Miggins et al. 2012), community gardens support many pollinators. For example, the diversity and abundance of wild bees (species other than honey bees) were found to be surprisingly high, particularly given the small size of the gardens and their highly urbanized locations. From these studies, over 70 species of wild bees have been found in community gardens throughout the City, including one species — *Coelioxys porterae* — that had never before been documented in New York City. Findings suggest that community gardens with greater floral diversity and sunlight tend to support more diverse bee communities. In addition, many bee species found in community gardens are not found in other urban green spaces such as parks. This is likely due to the high number of crop species found in community gardens, which can attract a different set of pollinators. The fact that community gardens support unique assemblages of wild bees highlights the importance of maintaining different types of habitats to maximize biodiversity in the urban landscape.

Food crops growing in the City's community gardens also attract a complex of insect pests and associated beneficial arthropods that assist in biological control of these pests. Recently, Megan Gregory of Cornell University and Long Island University's Tim Leslie have been tracking the dynamics of common pests and beneficial insects found near brassicas, cucurbits, and tomatoes in community gardens in order to provide gardeners with practical guidelines for managing pests in an ecological fashion. Insect pests that are being monitored include aphids, flea beetles, whiteflies, and thrips, among others. Common biological control agents include parasitoid wasps, minute pirate bugs, spiders, and ladybeetles (Gregory et al. 2012).

Since public gardens are regularly watered and maintained, they often contain more vegetation than surrounding areas and are important habitat for pollinators and other wildlife, particularly during hot, dry periods. In addition, other animals frequent these comparatively large gardens, including white-footed mice (*Peromyscus leucopus*), eastern cottontail rabbits (*Sylvilagus floridanus*), and gray squirrels (*Sciurus carolinensis*). Often, some of these animals are kept out by fencing to prevent damage to ornamental plants.

In recent years researchers have turned their attention to the role that green roofs can play in the conservation of biodiversity. They have produced a small but growing body of evidence suggesting that green roofs can provide living space for plants and animals, at least mobile species such as some invertebrates and birds.

European researchers have found that green roofs support a wide variety of common and rare species. In Basel, Switzerland, green roofs have even become an important part of the municipality's biodiversity strategy. Natural soil as well as different soil thicknesses are stipulated in the design criteria for green roofs in Basel and other Swiss cities, based on the success of a 90-year-old green roof using native soils in Zurich, which has become an orchid meadow with high conservation value. On the most biodiverse of the Basel green roofs studied, a dense combination of microhabitats supports scores of beetle and spider species, a number of them endangered (Marinelli 2006).

New research in New York City also shows that green roofs can provide important habitat for wildlife. Research by Melanie Smith (2012) shows that green roofs offer habitat for a wide variety of arthropods. The communities of arthropods varied widely and the vegetation type did not consistently predict differences in the diversity or abundance in the arthropod community, although roofs planted with a mix of sedums and native species had a higher richness of arthropod families while bare roofs had a much lower abundance of arthropods.

A recent study also found that green roofs in the City were visited by a greater diversity of bird species than traditional roofs, including uncommon species such as the common raven (*Corvus corax*), peregrine falcon (*Falco peregrinus*), ruby-throated hummingbird (*Archilochus colubris*), willow flycatcher (*Empidonax traillii*), Carolina wren (*Thyothorus ludovicianus*), wood thrush (*Hylocichla mustelina*), cedar waxwing (*Bombycilla cedrorum*), and field sparrow (*Spizella pusilla*). In addition, arthropod invertebrates were eleven times more abundant on the green roofs (Partridge and Clark 2011).

Indicators and Identification

Gardens are typically manicured, often mulched, weeded, and irrigated, and contain a variety of herbaceous and woody plants flowering throughout the growing season.

Biodiversity Values

Although New York City has lost much natural greenspace over the years, gardens including, increasingly, green roofs provide important habitat for many animal species. Even small gardens or roofs can serve as connections or stepping stones among habitats, linking populations of birds, insects, and other animals or plants. Gardens also support migratory species, particularly birds (and some butterflies and dragonflies) moving north or south along the Atlantic Flyway. In addition, garden habitats support plant species that establish themselves, called volunteers, of both native and nonnative origin.

A number of rare and imperiled native plant species is grown at Brooklyn Botanic Garden and the New York Botanical Garden as part of the Center for Plant Conservation's National Collection of Endangered Plants, including Barbara's buttons (*Marshallia grandiflora*) and swamp pink (*Helonias bullata*).

Gardens and green roofs promote biodiversity by offering other environmental services as well, such as absorbing precipitation and reducing stormwater runoff. Green roofs also reduce a building's energy consumption and help mitigate the urban heat island effect (Orberndorfer et al. 2007).

Substrates

Garden substrates are typically soils amended with compost and other organic materials. Special growing media are used on most green roofs and walls in the U.S. Many ground-level gardens use raised beds, to avoid poor and potentially contaminated extant soils.

Surface Waters

Surface waters are occasionally present, depending on the garden. These can include ponds, manmade wetlands, swales and rain gardens, as well as garden pools (water gardens) planted with aquatic species.

Quality

From a biodiversity perspective, the highest quality gardens are those that provide resources such as food, resting, and nesting habitat for other species throughout the year, whether pollinators and other insects, small mammals, birds, or spontaneous native plants including mosses.

Human Uses

Cultivated landscapes support many human uses and are especially valued for their aesthetics and health benefits. Gardens can produce healthy, fresh produce as well as ornamental flowers, for example. Community gardens offer opportunities for social interaction. Studies also demonstrate that the contact with nature afforded by gardens can reduce stress and improve emotional well-being in both adults and children (SITES 2009).

Threats

Gardens are sensitive to compaction and other poor soil conditions, urban heat and dryness, dog urine and feces, trash, vandalism, lack of care, and air pollution.

Tim Leslie

A community garden in downtown Brooklyn.

In 1999, a consortium of activist organizations, private and corporate foundations, and concerned New York City residents came together to rescue 114 community gardens citywide that were to be auctioned to developers. The gardens were saved within hours of the scheduled auction (NYRP 2012). Gardens of all types are some of the City's most vital greenspaces and should be preserved.

At the same time, if not managed properly, gardens can be a threat to natural areas. Studies have demonstrated that more than half of the invasive plant species currently degrading natural habitats across the country were introduced for horticultural use (Randall and Marinelli 2006). Gardeners should be sure to grow native species or nonnatives that have not escaped cultivation or shown any tendency to become invasive.

Conservation and Management

Gardens should be designed and maintained according to accepted sustainability standards, such as those of the Sustainable Sites Initiative (SITES), the country's first certification system for sustainable landscapes. For example, least-toxic approaches to pest management such as integrated pest management or organic practices that use no synthetic pesticides are least harmful to insects, other wildlife, and human health.

Other management practices that benefit wildlife include refraining from applying mulch in some areas so that native bees can nest in the soil. Overzealous garden clean-up, particularly at the end of the season, can be detrimental to overwintering insects, including beneficial predators and pollinators, so it is important to allow some vegetation to remain to provide winter habitat. Modern hybrids often do not produce pollen or even nectar, so native or heirloom plants should be grown to provide food for pollinators.

Depending on the system, green roofs require at least a minimal amount of monitoring and maintenance, such as weeding and irrigation during droughts. Like traditional roof gardens, intensive green roofs are labor-intensive, requiring irrigation, fertilizing, and other maintenance. Unlike intensive systems, extensive green roofs are designed to be virtually self-sustaining and should require only a minimum of maintenance, such as a once-yearly weeding. Semi-intensive roofs require less maintenance than the intensive systems but more than the extensive roofs.

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Waste Ground

By Erik Kiviat

"Waste ground" is a botanical term for a highly altered habitat with mineral soil lacking topsoil, or with soil compromised in some other way (Kiviat and Stevens 2001). Vegetation is usually sparse and dominated by weedy herbs and woody species, many of which are nonnatives. Examples of waste ground habitats are vacant lots, areas that have been stripped of vegetation and topsoil pending construction, post-industrial "brownfields" (contaminated altered areas), highway or railroad verges, road cuts, abandoned roads and trails, abandoned parking lots, abandoned playing fields, inactive garbage landfills that have been covered or capped but not planted, dry wetland fill, dry banks of some constructed wetlands and ponds, sand traps and soil storage piles at abandoned golf courses, "infield" areas of horse or automobile race tracks, and unreclaimed surface mines (soil mines or rock quarries) including piles of tailings.

Distribution in New York City

Waste ground, especially vacant lots, construction sites, and transportation verges, is found throughout the City. These areas range from 100 square feet to many acres.

Examples on public land:

Although waste grounds are typically small or absent in parks and public recreation areas, they may include small equipment parking areas, soil storage areas, and slash or stump dumps in some parks and golf courses; areas of the Fresh Kills landfill on Staten Island in the process of capping and restoration; and portions of the area between Linden Place (west) and the New York Times building (east) in Queens.

Erik Kiviat

Waste ground between railroad tracks in Queens. Vegetation on the right has been killed with herbicide.

Erik Kiviat

Waste ground of elevated railroad verge in Queens.

Vegetation

Many species of weedy, nonnative and native herbs, shrubs, and trees occur on waste ground. Some of the common trees or shrubs are tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudoacacia*), eastern cottonwood (*Populus deltoides*), gray birch (*Betula populifolia*), Bell's honeysuckle (*Lonicera x bella*), brambles (*Rubus*), staghorn sumac (*Rhus typhina*), and smooth sumac (*Rhus glabra*). Herbs include mugwort (*Artemisia vulgaris*), common mullein (*Verbascum thapsus*), knapweeds (*Centaurea*), sweet-clover (*Melilotus officinalis*), common evening-primrose (*Oenothera biennis*), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and Japanese knotweed (*Polygonum cuspidatum*). Topsoil piles or dredged organic soil piles may support weeds such as pokeweed (*Phytolacca americana*) and jimsonweed (*Datura stramonium*). Mosses and lichens may develop on moister or older habitats. Occasional large trees or logs have important values to animals and bryoids (mosses, lichens, liverworts).

Fauna

These include mostly common species that are typically associated with bare soil or rock, or other habitat features characteristic of waste grounds. Examples are woodchuck (*Marmota monax*), which burrows in loose soil, killdeer (*Charadrius vociferus*), which nests on bare gravel or rubble, and American toad (*Bufo americanus*), which forages in areas of sparse vegetation and breeds in sunny, often intermittent shallow pools. Burrowing insects such as bee-wolves (*Phyllanthus*) and sand wasps (*Bembix*) use waste ground habitats with coarse-textured soil.

Indicators and Identification

Bare, often equipment-scarred rock with different colors and harder surfaces than nearby unweathered rocks indicate bedrock exposed by removal of soil materials. Bare, homogeneous-looking soil with contours reflecting excavation or stockpiling, and often signs of slumping, settling, or gullying, indicates soil mining or other cut-and-fill activities. Generally, the best indicators are the signs of human activities such as pavement, construction and demolition debris, garbage, other foreign materials in soils, parked or abandoned equipment, stockpiled or dumped construction materials, buildings, and an abundance of plants that are characteristically associated with infertile, altered, or disturbed soils. Also, historical information and map symbols (for example, mines, buildings, purple revision overprint on U.S. Geological Survey topographic maps) can help with remote identification of waste grounds.

Dredge spoil (see profile), with its mineral soil lacking topsoil, is related to waste ground.

Erik Kiviat

Moss and an herb on waste ground; soil is partly or entirely demolition debris.

Biodiversity Values

Unusual substrates (such as bare gravel) may attract rare species. For example, rare plants normally associated with rock outcrops, talus, sand plains, and other infertile, natural habitats may occur in waste areas. Rare animals of waste grounds are poorly documented in the City. The character of surrounding habitats may be important to the use of waste grounds by most vertebrate species. Some of the important animals that have been reported from, or are likely to occur on, waste grounds are nesting ducks (Anatidae), displaying and nesting American woodcock (*Scolopax minor*), nesting spotted sandpiper (*Actitis macularia*), rare grassland birds such as grasshopper sparrow (*Ammodramus savannarum*), nesting diamondback terrapin (*Malaclemys terrapin*) and other turtles, and, where there are breeding ponds within 1,650 feet (500 m), Fowler's toad (*Bufo fowleri*). Probably many rare invertebrate species could be found on waste grounds; the burrowing insects mentioned above could include rare species. Velvet-ants (Mutillidae) may be a waste ground-associated uncommon species in New York City. Little information is available on rare communities or species of waste grounds in the U.S., although ecologists in the U.K. have been more active in this research (see, for example, Harrison and Davies 2002, Angold et al. 2006, Lorimer 2008).

Rare plants that have been found on waste ground in the City include red-rooted flatsedge (*Cyperus erythrorhizos*) and five-angled dodder (*Cuscuta pentagona*). Waste grounds may also provide habitat for rare or uncommon bryoids.

Some waste grounds resemble sites of natural disturbances such as landslides and high banks undercut by streams or by the Hudson River. Some waste ground develops oldfield or young forest vegetation if left undisturbed. Many of Reschke's (1990) "cultural" communities are included in our general "waste ground" habitat; examples include "roadcut cliff/slope," "rock quarry," "gravel mine," "sand mine," "brushy cleared land," "construction/road maintenance spoils," "mine spoils," "urban vacant lot," "closed landfills and dumps," "riprap/erosion control roadside," "artificial beach," "riprap/artificial lakeshore," and "unpaved trail/path" communities.

Substrates

These include virtually any natural subsoil or bedrock type in the study area as well as a variety of soils brought in as fill (mapped as Udorthents in New York City soil surveys). Substrates are often dominated by coarse particles such as sand, gravel, or rock rubble. Soils are likely to be compacted or eroded. Organic matter and macronutrients (nitrogen, phosphorus) are often at very low concentrations, and water-holding capacity is often poor, making soil drought an important constraint on vegetation.

Surface Waters

Surface waters are scarce. Rain puddles may accumulate on finer-textured (such as silty) soil materials. Occasionally there are intermittent or permanent pools. Seeps may be present, for example, on road verges, road cuts, or quarry walls.

Quality

There really is no measure of "quality" in highly altered habitats. The presence of rare or uncommon species, and the habitat characteristics that help to support those species, will help to define quality on particular sites.

Human Uses

Many waste grounds are sites of illegal dumping, off-road vehicle use, or other human activities that may affect rare biota. Some areas are being reclaimed for gardens or parks, or redeveloped for industry and other uses.

Threats

Some areas may be exposed to toxic substances from illegal dumping of hazardous wastes, construction and demolition debris, household garbage, and motor vehicles and other equipment. Most waste grounds are highly disturbed and not especially sensitive to further disturbance. Many such areas gradually become dominated by tall vegetation, which shades out some of the small species. Rare species using the waste grounds may be threatened by development or changing conditions.

Conservation and Management

Because many waste ground areas are not significant for rare species conservation, it is not practical or desirable to conserve waste grounds per se. However, waste grounds are sufficiently important for a wide range of uncommon and rare species that they should always be assessed for biodiversity. Waste ground habitats where rare species occur must be identified and managed on a local, site-specific basis. It is then important to determine what conditions favor the persistence of the rare species (such as unstable, bare, or dry soils; calcareous bedrock; calcareous seepage), and maintain these conditions with tilling, mowing, fire, regulation of vehicle or pedestrian disturbance, or other means. Surveys for particular species (for example, certain rare plants, bees and certain other invertebrates, breeding birds such as American woodcock and brown thrasher *[Toxostoma rufum]*) are likely to be important, depending on the size of the waste ground area and its soils and vegetation.

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Artificial Structures

By Elizabeth Johnson and Erik Kiviat

General Description

Artificial structures abound in New York City and have been colonized readily by adaptable species and even uncommon species. Examples of structures that support plants and animals include buildings as well as sheds, gazebos, and similar structures; bridges, culverts, and tunnels; walls and fences; chimneys, rooftops, and ventilators; antennas and other towers; streetlights; old barns, silos, and other derelict buildings; statuary and monuments; old piers; abandoned barges; and even junked vehicles.

Distribution in New York City

A high prevalence of various artificial structures is found throughout the City.

Vegetation

Some structures such as old walls, cemetery tombstones, masonry bridges, and statuary and monuments provide habitats for mosses and lichens, for example rim lichen (*Lecanora dispersa*) and orange wall lichen (*Xanthoria fallax*) (Delendick 1994) and cliff ferns (see Bryoids and Cliff Ferns profiles). They may also support other vascular plants including vines, as do fences. Flat roofs also provide habitat for volunteer plant growth (see Green Roofs, Gardens, and Green Walls profile for discussion of planted roof habitat).

Abandoned piers in the Hudson River support many species of higher plants and a few mosses and lichens, a surprising proportion of which is native species. One rare plant, five-angled dodder (*Cuscuta pentagona*) was found in this habitat (E. Kiviat, personal observation, 1995). Riprap (the piled-up rocks used to stabilize shorelines) can support many vascular plants just above the mean high water line. Derelict barges and other wrecked boats may also support plant growth.

Erik Kiviat

Old roofing provides habitat for mosses on a Central Park gazebo.

An abandoned railroad bridge over Dutch Kills (Queens) and nearby artificial habitats just above the mean high water line support many vascular plants, about half of which are native species (E. Kiviat, personal observation).

Fauna

A wide variety of animals utilizes structures. Most home and apartment dwellers are familiar with common animals such as raccoons (*Procyon lotor*) and striped skunks (*Mephitis mephitis*) that may enter cellars, opossums (*Diadelphis virginiana*) that hide under porches, mice (*Mus musculus, Peromyscus leucopus*) and rats (*Rattus norvegica* and *Rattus rattus*) that live underground in the subway or enter dwellings, gray squirrels (*Sciurus carolinensis*) that seek shelter in attics, and the myriad of insects—cockroaches, brown marmorated stinkbugs (*Halyomorpha halys*), and cluster flies (*Calliphoridae*)—that find their way inside our homes. In fact, many of these are considered pests, and homeowners seek ways to remove or kill them.

In addition to nonnative rock pigeons (*Columba livia*) and house sparrows (*Passer domesticus*) that are quite at home on building walls and ledges, or English ivy (*Hedera*) that climbs up the walls, buildings also support many less common species: American kestrels (*Falco sparverius*) nest in cornices in older buildings (see American Kestrel profile) and red-tailed hawks (*Buteo jamaicensis*) nest on building ledges (including the famous individual named Pale Male). There are also birds that nest on flat roofs elsewhere, especially gravel roofs (Fisk 1978), including killdeer (*Charadrius vociferous*). Mourning doves (*Zenaida macroura*) and American robins (*Turdus migratorius*) often nest on building fire escapes in New York City (J. DiConstanzo, personal communication, 26 April 2013).

Abandoned belfries, farm silos, and other buildings have been used by barn owls (*Tyto alba*) in New York City (Ricciuti 1984) (see the Owls profile). Chimneys supported nesting and roosting chimney swifts (*Chaetura pelagica*), until the advent of metal liners and chimney guards installed to keep birds and bats out. (Recently, the New York City Audubon Society erected chimney nest towers on Staten Island in hopes of offering alternative nesting sites. Chimney swifts are in decline throughout the U.S., in part due to a lack of nesting sites, including chimneys and natural cavities in large trees.) Barn swallows (*Hirundo rustica*) and may attach their nests to the outsides of structures such as buildings and gazebos (e.g., under eaves) and bridges, and northern rough-winged swallows (*Stelgidopteryx serripennis*) place their nests in crevices and pipes above the ground. Bats also use these structures for roosting and as maternity colony habitat. Bat nursery colonies sometimes are established beneath loose slate roofing tiles as well as in other architectural elements, and bats also use expansion joints of bridges for roosting. Rooftop ventilators also may provide roosting or nesting habitat for a few species. Snakes often find their way into derelict buildings, resting under boards. Many insects also use structures for nesting, including carpenter bees (*Xylocopa virginiana*), which excavate their nest tunnels in the old wood. Paper wasps (*Polistes*) and mud dauber wasps (Sphecidae or Crabronidae) often attach their nests to structures. Others, like the mourning cloak butterfly (*Nymphalis antiopa*), may spend the winter tucked under shutters or shingles or in other sheltered parts of buildings or walls. In addition to their use by lichens, mosses, and vascular plants, old walls have interstices used by small mammals, reptiles, invertebrates, and possibly birds. Fences are used for perching by birds and squirrels. Even statues are used for nesting, as evidenced by Cal Vornberger's photograph of the American robin nest on the statue of Romeo and Juliet in front of the Delacourt Theatre in Central Park.

Streetlights are regularly used for nesting by house sparrows and probably starlings (*Sturnus vulgaris*). Monk parakeets (*Myiopsitta monachus*) have also been observed nesting on streetlights and electric power poles,

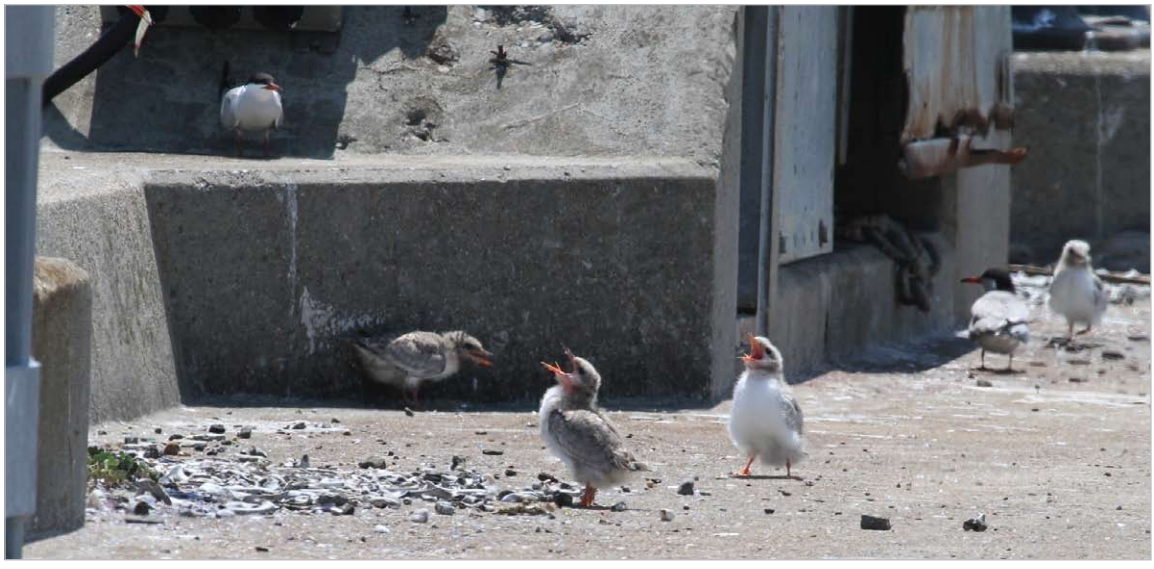
especially in Brooklyn, the Bronx, and Staten Island (Budlinger and Kennedy 2005), as well as in nearby New Jersey (Burger and Gochfeld 2009, E. Kiviat, personal observation) and in Connecticut (Silverman 2009). Many raptors use streetlights for perching. American robins (*Turdus migratorius*) nest on traffic light lens shades (Ricciuti 1984). Some spider species build their webs under streetlights, benefitting from the plentiful insects that are also attracted (Longcore and Rich 2006).

Peregrine falcons (*Falco peregrinus*) (see the Peregrine Falcon profile) nest on the larger metropolitan bridges, including the Marine Parkways Bridge and the Goethals Bridge. But smaller bridges may support nesting eastern phoebes (*Sayornis phoebe*) or barn swallows, especially if near water. Raccoons, striped skunks, and opossums "live" (probably den) in culverts (Ricciuti 1984.)

Antennas and other towers also support wildlife, although guy wires are a hazard to flying raptors and waterbirds. A pair of common ravens (*Corvus corvax*) nested successfully in 2010 on a water tower in Queens (Finger 2010). Ospreys (*Pandion haliaetus*) nest on towers and similar structures around Long Island Sound and potentially adjoining the tidal waters of New York City. Navigational signal structures, often, low towers with riprapped bases in shallow water, are used for nesting by double-crested cormorants (*Phalacrocorax auritus*). Cormorants also nest on derelict buildings on islands in the East River (J. DiConstanzo, personal communication, 26 April 2013). Shoreline structures are used for basking by diamondback terrapins (*Malaclemys terrapin*), loafing by gulls and ducks, and hauling-out by harbor seals (*Phoca vitulina*).

Old piers and pilings provide habitat for many aquatic and terrestrial organisms. Below water level, barnacles (*Cirripedia*), mussels (*Mytilus*), and other invertebrates such as crabs attach to or perch on piers and pilings. Two marine woodborers, gribbles or isopods (*Limnoria*) and bivalve shipworms (*Teredo*), have reappeared in the Hudson River as river waters have become cleaner (Levinton et al. 2006). Both have caused severe structural problems for wood piers in the City. Smaller wooden piers also serve as protective habitat for fish; the role of inter-pier areas in the Hudson River as wintering habitat for young striped bass (*Morone saxatilis*) is well-documented (Able et al. 1998). However, an analysis of larger piers as fish habitat by Able and Duffy-Anderson (2009) has shown that the intense shading effects of these large structures do not provide good habitat for most visually-feeding fish species.

Barbara Saunders



Common tern (*Sternus hirundo*) chicks begging for food. Terns are now nesting on an abandoned pier on Governor's Island, NY.

A variety of marine invertebrates is found in the lower Hudson estuary on underwater rocks and walls, including barnacles (*Balanus*), sand-builder worms (*Sabellaria vulgaris*), and sea squirts (*Mogula manhattensis*). Also abundant are bryozoans, sand shrimp (*Crangon septemspinosa*), hermit crabs (*Pagurus longicarpus*), and rock crabs (*Cancer irroratus*) (Ernst and Dietrich 2006).

Water birds and other birds perch on pilings (Ricciuti 1984) and may also use derelict barges for perching and sometimes nesting. In fact, a colony of common terns (*Sternus hirundo*) nested on an abandoned barge near Liberty Island in recent years until it was removed. Currently, the terns are nesting on an old pier on Governor's Island (J. DiCostanzo, personal communication, 26 April 2013).

Indicators and Identification

Most structures can be distinguished readily from "natural" features.

Biodiversity Values

Sometimes artificial structures are the only habitat available and provide relatively predator-free nesting sites or roosting areas (Chace and Walsh 2006). Peregrine falcons often have higher reproductive success in urban areas, possibly due to reduced nest predation and human persecution as well as abundant prey such as rock pigeons and songbirds. Some species are preadapted (i.e., genetically adapted to use natural features such as cliffs that resemble certain artificial structures) to urban structures. Examples are the lichens and wall ferns that attach and grow on walls, and rock pigeons and peregrine falcons that apparently perceive building walls as cliffs.

Substrates

Urban structures are made of a variety of materials including wood, metal, plastics, rock, masonry, concrete, and canvas or other fibers (such as in awnings). Some surfaces are painted or otherwise treated, which may inhibit organism attachment.

Surface Waters

Surface waters on artificial structures are scarce. Rain puddles may accumulate, especially on structures such as flat roofs.

Quality

The quality of particular sites is defined by the presence of rare or uncommon species, successful reproduction of desirable species, and the habitat characteristics that help to support those species. In addition, certain types of structures provide better habitat for certain species—for example, the historic type of cornice as nest substrate for American kestrels (see the American Kestrel profile). Structures can sometimes be designed or retrofitted to improve quality for target species or decrease quality for undesirable species. For instance, power poles and electrical transmission towers can be designed to discourage raptors from perching and possibly being electrocuted. Flat roofs can be improved for nesting birds (Fisk 1978). Derelict piers can potentially be modified to serve as haul-outs for seals.

Human Uses

Humans use most structures on a daily basis, including large apartments, office buildings, single-family homes, and commuter bridges.

Threats

Design, construction, maintenance, and/or demolition of structures can have big impacts on biodiversity. Effects on rare species will vary with the type of activity and the sensitivities of the rare species in question (see Conservation and Management, below, and species accounts for individual species [e.g., American kestrel]). Structures such as derelict buildings, piers, and elevated rail lines should be surveyed for appropriate species before demolition or modification. The native flora of the High Line (a former elevated rail line in Manhattan) prior to conversion into a walking trail and park (Stalter 2004) is one of many interesting examples of the diversity of native flora on structures and their potential importance for conservation.

Conservation and Management

Most structures are probably unimportant for native biodiversity, but it is crucial to identify, assess, and manage those that support uncommon or rare species. Assessment of the habitat functions of buildings and other structures should play a role in the design, maintenance, restoration, and removal of structures. To some extent, it is possible to predict that certain types of structures have potential habitat functions for rare species; however, rare and other desirable species may be found unexpectedly, which indicates that more attention should be paid to biodiversity associated with structures.

Surveys of the animal, plant, and other species that use structures also provide knowledge that can be applied to restoration of native species and habitats in the city. Artificial habitats and the species they support should not be discounted for conservation. In some cases, the City supports a population of a species, such as the peregrine falcon or American kestrel that is important for conservation statewide.

Structures important for rare species must be identified and managed on a local, site-specific basis. It is then important to determine what conditions favor the persistence of rare species (e.g., calcareous rock, lack of predator access, proximity to water or other feature, abundant food supply, or architectural features that serve critical needs), and maintain these conditions through regulation of vehicle or pedestrian disturbance, compatible building maintenance, provision of nest structures, or other means. Keep in mind that native birds and any listed species such as the Indiana bat (*Myotis sodalis*) are legally protected and the U.S. Fish and Wildlife Service or the New York State Department of Environmental Conservation must be consulted before disturbing them.

Fisk (1978) recommended how gravel roofs may be improved for breeding bird habitat, including provision of exits through parapets to allow, for example, killdeer chicks to leave the roof when ready.

Structures can also provide habitat for undesirable organisms including Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), house mouse (*Mus musculus*), rock pigeon, European starling, house sparrow, and mosquito larvae. Geis (1976) recommended how to keep undesirable birds off buildings. Flat roofs, clogged gutters, and other elements that retain water for a week or more during warm weather may provide breeding (larval) habitat for mosquitoes, including the northern house mosquito (*Culex pipiens*), which is believed to be the principal vector of West Nile virus from birds to humans. Regular maintenance and minor alterations can eliminate mosquito-breeding habitats.

When it is necessary to maintain, restore, or remove structures in ways that degrade or eliminate habitat for native species, care should be taken to avoid taking action during the nesting season or other critical time. In

addition, it may be possible to provide alternative habitats such as nesting structures for birds or roosting boxes for bats (see further discussion in the Management, Restoration, and Monitoring chapter, page 50). An appropriate expert should be consulted in such situations.

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Plant Profiles

The plant species or groups of species profiled here represent some of the rare or noteworthy plants of conservation concern in New York City. This is a small selection of the native plants that occur in the City, and is intended to give practitioners a set of species to look for and protect in City greenspaces. Some of these plants are common and others are rare outside the City, but all are worthy of attention here.

Lichens are not plants, but are included here (in the Bryoids profile) for convenience.

Many of the plants profiled can be assigned to a habitat type, although some species occur in more than one type of habitat, and other species occur in the spatial transitions between habitats. Some of the smaller plants have specific microhabitats (as well as the larger macrohabitats described in the Habitat Profiles). A microhabitat might be the top of a rotting log, the cooler, moister soil at the base of the north side of a large tree, or the earth mound at the entrance to a woodchuck (*Marmota monax*) burrow. Microhabitats may be especially important sites where a plant can germinate, become established, and undergo early stages of growth.

In addition to a macrohabitat and microhabitat, a plant may need certain soil chemical or physical properties (especially moisture and nutrients in the right amounts), the right amounts of sun and shade, pollinators, seed dispersers, and refuge from being eaten or harmed in other ways. Plants also compete with each other for these and other factors in the environment, and some species require a more "open" habitat with lower levels of competition.

Details of identification are beyond the scope of the Handbook, and readers will want to refer to the many good standard field guides and taxonomic manuals that are available, only a few of which are cited here.

Stephen M. Young/NY Natural Heritage Program

David Taft

Bryoids: Bryophytes and Lichens

By Erik Kiviat

Mosses, liverworts, and hornworts (collectively, bryophytes) are small plants that do not flower or produce seeds and in certain other ways are simpler and more primitive than flowering plants. Lichens are composite entities that include a fungus and an alga but in many respects resemble single organisms. Lichens and bryophytes are collectively known as bryoids.

Bryoids are generally sensitive to air pollution, salt, dessication, and other urban factors, thus are less diverse in urban areas than in the countryside. Nonetheless, many species occur in New York City.

Habitat

Liverworts are found infrequently in New York City, usually on very moist surfaces (substrates). Liverworts appear to be especially sensitive to water pollutants and salt. Substrates most likely to support liverworts are wet and rotting dead wood, moist bark near the bases of trees, and wet organic soil.

Mosses grow on many substrates including tree bark, rocks, soil, and artificial substrates such as mortar, concrete, brick, and wood. Mosses are more common and diverse near or on moist ground.

Lichens also colonize many substrates, especially soil, rock, and tree bark or wood, as well as artificial surfaces. Lichens and mosses are often more diverse and lush on neutral-to-alkaline substrates such as the bark of ashes (*Fraxinus*). Gravestones of certain rock types may be good substrates for lichens.

Macrohabitats for bryoids include potentially almost any natural or artificial habitat, although they are scarce in or absent from brackish habitats and newer, smoother, or drier artificial substrates. Many individual bryoid species are associated with specific macrohabitats (e.g., swamps) and microhabitats (e.g., bark on the south sides of mature ash trees).

Marielle Anzelone

Bryoids on soil in waste ground habitat.

Distribution in New York City

Bryoids are very widespread in New York City and occur in all five boroughs. They are more diverse and lush in less-built areas and areas that are moister, less acidic, and less brackish. Even small gardens may have a hardy moss species or two.

In the 1970s-1980s, 77 species of bryophytes were collected in Alley Pond and Cunningham Parks in Queens, an area totaling 578 hectares (1,428 acres). A recent survey in the two parks, however, found only 47 species, including 38 mosses, 8 liverworts, and 1 hornwort species (Morgan and Sperling 2006).

Just outside of New York City, in a survey of a much larger area, the greater New Jersey Meadowlands, 57 mosses, but only two liverwort species, and 32 lichens were discovered (E. Kiviat, unpublished data). Two of the lichens are considered rare in the northeastern states (Hinds and Hinds 2007), and 12 of the mosses are considered rare in New Jersey (Karlin and Schaffroth 1992). These data suggest that bryoids may be important components of New York City's biodiversity.

Description and Identification

Lichens appear as crusts, patches, or projections that are greenish, gray, yellow, blackish, or other usually dull colors. A few species have bright yellow or red colors overall or in small spots. Many unusual and fantasy-like shapes are visible under a 10X hand lens. Most mosses are some shade of green, and their tiny leaves are visible under a lens (although in dry weather the leaves may be contracted). Color photographs convey the appearances of bryoids much better than words. Color photographs of many lichens may be seen on Wikipedia (Anonymous 2011) and other websites. The authoritative book by Brodo et al. (2001) contains color photos of most North American lichens. Color photographs of representative bryophytes may be seen in Stotler and Crandall-Stotler

Marielle Anzalone

Shield lichens (left) and mosses (lower right) on rock.

(2011) and other websites. There is no comprehensive field guide to bryophytes, although two such books are in preparation. Munch (2006) highlighted some common species.

Species identification of most bryoids is technical and best left to specialists. This does not prevent non-specialists from appreciating and helping to conserve bryoids.

Ecology

Both lichens and bryophytes are dependent on moisture from their environment and their metabolism generally shuts down when they dry out. Bryophytes and lichens are also similar to each other in that they propagate by spores or small fragments that are capable of blowing long distances. Bryoids may form crusts on the soil, helping to protect it from erosion. Many small insects, mites, spiders, water-bears, and other invertebrates live in or take shelter in bryoid structures, and some animals feed on bryoids.

Threats

Habitat loss, air and soil pollution, and sea level rise are the principal threats to bryoids in New York City. Habitat loss includes removal of large live or dead trees or coarse woody debris (logs and branches on the ground). Well-meaning management and restoration can cause the loss of small inconspicuous species like bryoids. Even the creation or improvement of a footpath can damage or destroy bryoids or their substrates. Climbing and sitting on rocks or logs in parks can inhibit or kill bryoids.

Lichens are sensitive to air pollution, especially sulfur oxides, fluorine, ozone, and certain metals. The combination of air pollutants and urban dryness may have a synergistic effect on bryophytes. Many lichens and bryophytes are sensitive to salt and are potentially affected by deicing salts. Increasing salinity intrusion with rising sea levels (associated with global climate change) may threaten many bryoids.

Conservation and Management

Continued improvement in ambient air quality may allow greater diversity and abundance of bryoids in New York City. Rock outcrops with particular significance as bryoid habitat should be off-limits to recreational use, at least in larger parks. Not removing standing dead trees in parks (where they are not a threat to persons or structures) and downed logs will conserve much important microhabitat for bryoids as well as invertebrates and other organisms. Wheeled and tracked vehicles should be kept on roads or trails as much as possible to protect soil-inhabiting bryoids. Dumped logs and stumps, and occasionally demolition debris if sufficiently weathered, may be important for bryoids and can be left alone if out of public view (or buffered with plantings). If larger parks are surveyed for bryoids, then important areas can be protected from deicing salts and other locally generated pollutants, as well as the physical damage from tires and foot traffic.

Survey Techniques and Constraints

Bryoids may be collected by non-specialists and identified by specialists. However, persons not experienced in identifying bryoids are likely to miss many species, especially rare species that are more important to know about. When possible, expert surveys should be performed in larger parks and development sites. It may be possible to identify rare species and other high priority species, and tailor development plans or management activities to protect bryoid macrohabitats and microhabitats.

While we don't recommend that untrained persons attempt to perform bryoid surveys, we think it is important to be aware of bryoids and their diversity in the city. Expert surveys of bryoids will help guide planning for conservation and development. Bryoids are important elements of biodiversity that need more attention in urban areas, and some of New York City's greenspaces may contribute to the conservation of this diversity.

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Cliff Ferns

By Marielle Anzelone

Ebony spleenwort (*Asplenium platyneuron*)
Walking fern (*Asplenium rhizophyllum*)
Blunt-lobed cliff fern (*Woodsia obtusa*)
Upland brittle bladder-fern (*Cystopteris tenuis*)
Purple cliff brake (*Pellaea atropurpurea*)

Habitat

Cliff ferns are found throughout the eastern United States on limestone cliffs and other rocky habitats. They may form dense tufts, growing in water-holding cracks and crevices in the rock.

In New York City, these ferns may be found in relatively undisturbed, calcareous (calcium-rich) rocky sites or on circumneutral soils. Two examples are Pelham Bay Park in the Bronx and on sunny cliffs in Highbridge Park in Manhattan. Interestingly, they are also found in urban core sites.

Marielle Anzelone

Blunt-lobed cliff ferns on the Park Avenue train trestle.

Erik Kiviat

Ebony spleenwort on quarry rubble (New Jersey Meadowlands).

One of the best places to see these ferns in relative abundance is the Metro North Railroad viaduct, where the tracks run on an elevated, masonry trestle along Park Avenue in East Harlem from East 98th to 109th streets (NRG 2006). At approximately 30 feet high, this trestle acts as a Manhattan "cliff."

Such stone walls that date from the mid- to late 1800s are prime habitat for cliff ferns. Typically, mortar for these walls was created out of rock, soil, timbers, and various types of mining debris. Suitable fern habitat was created as these materials weathered and seeps were formed. Soil accumulated as a result of rock weathering and plant decay. The crumbling mortar serves as the calcareous substrate these ferns require. The dry rock surface is habitable due to the pockets and irregularities in the wall materials that retain and release rainwater.

Distribution in New York City

Ebony spleenwort (*Asplenium platyneuron*)

- Staten Island (Siebenheller 2003): Once common, rare by 1906. Found in Bloodroot Valley, Clove Lakes Park, Wolfe's Pond Park, Snug Harbor (locally abundant)

Walking fern (*Asplenium rhizophyllum*)

- Manhattan: Metro North Railroad trestle in East Harlem from E. 98th to 109th streets (only three plants found)

Blunt-lobed cliff fern (*Woodsia obtusa*) — Uncommon in New York City, but can be locally abundant.

- Bronx: Pelham Bay Park, Van Cortlandt Park (Vault Hill), Riverdale Park
- Brooklyn: Prospect Park
- Manhattan: Metro North Railroad trestle in East Harlem from E. 98th to 109th streets (locally abundant), Central Park, Inwood Hill Park, Highbridge Park
- Staten Island: Historically rare, currently thought to be extirpated (Siebenheller 2003)

Tim Howard

Walking fern (outside New York City).

Marielle Anzelone

Blunt-lobed cliff fern.

Jaknouse/Wiki Images

Upland brittle bladder-fern (*Cystopteris tenuis*).

Kim Smith

Purple cliff brake.

Upland brittle bladder-fern (*Cystopteris tenuis*)

- Staten Island: Once locally abundant at three locations, extant (still in existence) only at Bloodroot Valley (Siebenheller 2003)

Purple cliff brake (*Pellaea atropurpurea*)

- Manhattan: Metro North Railroad trestle in East Harlem from E. 98th to 109th streets (uncommon)

Description and Identification

Cliff ferns tend to be small, often with creeping rhizomes, although spleenworts have erect rhizomes (Montgomery and Fairbrothers 1992). Characteristics of frond shape and size, presence of hairs or scales on plant, growth form (creeping, erect, clumped, etc.) and sori (clusters of spore-producing structures) are useful diagnostic features. For species-specific identification features, see Cobb et al. (2005).

Ecology

Ferns, which evolved before the angiosperms (seed-producing flowering plants), reproduce by means of exceedingly tiny, dust-like spores that are capable of traveling long distances. Once settled in a suitable location, a spore germinates and grows into a small, heart-shaped plant called a gametophyte. The gametophyte produces both sperm and eggs. When conditions are right (usually after a rain), the sperm is released and travels through water in search of eggs. A fertilized egg develops into a sporophyte, a young plant form that is

recognizable as a fern. The mature fern with fronds, roots, and rhizomes produces spores on the underside of its leaves, starting the cycle over again (Mehltreter et al. 2010). Some ferns also spread locally by vegetative growth of rhizomes. The leaves of walking fern produce very long slender tips that can root if they reach suitable soil and then produce new fern clumps.

In urban stone wall habitats, wetland ferns, like sensitive fern (*Onoclea sensibilis*) and marsh fern (*Thelypteris palustris*), are often found with cliff ferns, able to survive due to water pooling in the masonry. Associated angiosperms (both native and nonnative) and mosses also grow on walls, although they are more commonly found in adjacent marginal sites like vacant lots and roadsides.

Herbivory has never been observed or recorded for these fern species in their New York City locations. One explanation may be that far fewer herbivorous insects feed on ferns than on flowering plants (Hendrix 1980, Mehltreter et al. 2010). It may also be that there are fewer herbivores (for example, slugs or white-tailed deer *[Odocoileus virginianus]*) in the city in general.

Threats

Due to the tendency of people to take the attractive fronds from the wild for dried decorations or gardens, in New York State, these wall fern species and most other ferns are designated "exploitably vulnerable" (likely to become threatened in the near future if causal factors continue unchecked) (NYS Department of Environmental Conservation 2011).

Ferns are well known colonizers of bare or disturbed habitats (Mehltreter et al. 2010). Generally, wall ferns compete poorly with angiosperms, but the ferns can tolerate xeric (dry), open sites to some extent. Moisture, nonetheless, can be a limiting factor as wall habitats have little water-holding capacity. The limited availability of suitable calcareous habitat is a concern. Since many of the stone walls are located within or around the perimeter of parks, development is not a threat. However, cliff ferns growing on old stone walls are threatened by wall restoration and the repointing of mortar, especially because most of the walls date from the late 1800s.

Conservation and Management

The portions of walls (built or natural) where ferns occur need protection from washing, painting, repointing, or removal of the ferns. Ferns usually occupy small parts of walls and maintenance can be conducted around them. Owners and managers should be vigilant for attempts to collect live ferns for transplanting. Structures that cast shade on walls (e.g., awnings, trees) should be maintained in their current condition if possible because the amounts of shade and sun on the ferns, and the moisture status of the rooting medium, are critical factors of the habitat. Vines or other large plants that are overgrowing wall ferns may need to be removed. Where derelict structures are to be razed or rebuilt, walls should be surveyed for ferns and other plants of conservation concern.

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Conifers

By Marielle Anzelone

Virginia pine (*Pinus virginiana*)
Shortleaf pine (*Pinus echinata*)
Pitch pine (*Pinus rigida*)

For information about additional conifer species, see end of Profile.

Habitat

Collectively known as scrub pines, pitch pine and occasionally Virginia pine and shortleaf pine grow in deep, well-drained, nutrient poor, sandy soil of coastal plains and back dunes (also called scrubby oak barrens). In the New York metropolitan region, these trees are often found in pine barrens (for example, the Long Island Pine Barrens and New Jersey Pine Barrens). However, there are no such pitch pine-dominated forests in the City. (Farther inland, pitch pine commonly grows on rocky sites with shallow, droughty, acidic soils.)

Distribution in New York City

These three pine trees are found predominantly in the southeastern United States, where they are a common component of Piedmont environments. They are less common in the northern portion of their ranges. In the Mid-Atlantic and Northeast, they favor coastal (sandy) and rocky habitats, perhaps reaching their greatest expression in the southern New Jersey Pine Barrens. Where present, if site conditions are favorable, they can form dense stands.

Stephen M. Young/NY Natural Heritage Program

Pitch pine (*Pinus rigida*) male flowers.

Stephen M. Young/NY Natural Heritage Program

Pitch pine cone.

Virginia pine and **shortleaf pine** have never been common in New York State, the northern limit of their range. Virginia pine's northern range limit is mainly on Staten Island, with an additional population in the Hudson Highlands (New York Natural Heritage Program 2011). Virginia pine is listed as S1 (endangered) in New York State, and shortleaf pine as S1 (undetermined). **Pitch pine** has a wide distribution in the state and is abundant in the Albany Pine Bush, Shawangunk Mountains, and the Long Island Pine Barrens.

The three pines are rare in New York City because they only grow in open, sunny woodlands on dry sandy soils, an uncommon urban habitat. On Staten Island, **Virginia** and **shortleaf pines** are limited to tiny populations within Clay Pit Ponds State Park Preserve. **Pitch pine** is found in Pelham Bay Park in the Bronx, Idlewild Park in Queens, and at four sites in Staten Island, including Clay Pit Ponds.

Description and Identification

Virginia pine is a medium-sized pine that reaches 15 to 40 feet (4.5 to 12 m) in height. The trunk is dark brown and usually contorted with spreading branches. Leaves (needles) of all eastern pines are grouped in clusters (fascicles) of two, three, or five. The needles of Virginia pine are short and in twisted bundles of two. Its seed-bearing cones are slender and curved when closed, egg-shaped when open. Each scale of the cone has a short, sharp prickle.

Shortleaf pine is a taller, thicker, straighter tree, growing to 90 feet (27 m) tall. Its needles, in twos or threes, are longer than those of Virginia pine. Its cone scales lack prickles.

Pitch pine grows to 60 feet (18 m) in height. Its trunk is nearly black and often crooked. Its stiff, slightly curved, and sharply-pointed needles occur in clusters of three. It can sprout new whorls of needles along the trunk, branches, and base after fire, an ability not shared by the other two scrub pines. The species name, *rigida*, refers to its rigid or stiff cones as well as needles.

Stephen M. Young/NY Natural Heritage Program

Virginia pine (*Pinus virginiana*) cone with prickles.

Ecology

The needle-like leaves of scrub pines remain green throughout the year and persist for three to four years. The trees have separate cones (strobili) for pollen and seeds, with both sexes occurring on the same plant (technically these are not flowers although they function similarly). Cones appear in May. Male cones fall off after pollen release, while female (seed) cones require two years to mature. The pines produce some seed every year, with mast crops (large seed production) at 3- to 10-year intervals. The seeds bear small papery wings to aid in wind dispersal, which occurs in October and November.

Scrub pines are often found growing together. Associated trees may include red maple (*Acer rubrum)*, sweetgum (*Liquidambar styraciflua)*, bigtooth aspen (*Populus grandidentata)*, sassafras (*Sassafras albidum)*, and oaks, especially northern red oak (*Quercus rubra)*, post oak (*Quercus stellata)*, and black oak (*Quercus velutina*). Over time, hardwoods such as the oaks may shade and replace the evergreen scrub pines.

Associates of these pines may include shrubs such as sweet fern (*Comptonia peregrina)*, early low blueberry (*Vaccinium pallidum)*, and highbush blueberry (*Vaccinium corymbosum)*, along with the woody vine roundleaf greenbrier (*Smilax rotundifolia)*.

Associated herbaceous species include flat-topped goldenrod (*Euthamia tenuifolia)*, hyssopleaf thoroughwort (*Eupatorium hyssopifolium)*, switchgrass (*Panicum virgatum)*, bracken fern (*Pteridium aquilinum)*, Virginia meadow beauty (*Rhexia virginica)*, and little bluestem (*Schizachyrium scoparium)*.

These pines are susceptible to fungal infestations that result in root rot and heart rot. Insect herbivores include sawflies, webworms, and needle miners. Young bark and leaves are eaten by rabbits, squirrels, and mice. The seeds are eaten by small mammals and birds, including wild turkeys (*Meleagris gallopavo)* and songbirds

Stephen M. Young/NY Natural Heritage Program

Virginia pine needles are in bundles of two.

(including the pine warbler *[Dendroica pinus]*, pine siskin *[Spinus pinus]* and pine grosbeak *[Pinicola enucleator]*). Caterpillars of Polyphemus (*Antheraea polyphemus)*, imperial (*Eacles imperialis)* and northern pine sphinx (*Lapara bombycoides)* moths feeds on pine needles as does the gray hairstreak butterfly (*Strymon melinus)*. The eastern pine elfin (*Callophrys niphon)* prefers *P. virginiana*, but will also feed on *P. rigida* and *P. echinata*. Pitch pine is often host to the wood-boring northeastern pine sawyer beetle (*Monochamus notatus)* and pine flower snout beetles (family Nemonychidae), which feed on the male cones. Scrub pine roots have symbiotic associations with mycorrhizal fungi, especially *Pisolithus tinctorius*. This fungus is found growing among conifers in areas that are very sandy or otherwise have very poor soil.

Conifers in general are sensitive to salt, air pollution, and over-fertilization from environmental pollution. The 2-needle pines are generally more tolerant of urban conditions than the 3-needle pines, which are more tolerant than 5-needle pines such as eastern white pine (*Pinus strobus)*.

Threats

The upland forest habitats of these scrub pines have no legal protection and are vulnerable to destruction. For example, populations of the three scrub pines were destroyed by construction of the retail center at Charleston on Staten Island's South Shore.

The existing populations of scrub pines are small and are being out-competed by oaks, maples, and sweetgum. Populations of Virginia and shortleaf pines in Clay Pit Ponds State Park Preserve bear few cones, and seedlings languish in the shade of the forest canopy.

Conservation and Management

Remnant stands of scrub pines in New York City are a valuable component of the City's natural heritage, genetic diversity, and resources for research and education. Competing vegetation may be manually removed to prevent pine trees from being overgrown by other encroaching trees and vines. Sufficient area may be manually or mechanically cleared to encourage natural population expansion, where such clearing does not threaten other species or habitats of conservation concern.

Other Conifers

Eastern hemlock (*Tsuga canadensis*): A notable stand of old growth hemlock is at the New York Botanical Garden (Bronx). This tree of cool moist environments is near the southern limit of its range. Hemlocks are killed by a nonnative insect, the hemlock woolly adelgid (*Adelges tsugae)*.

White pine (*Pinus strobus*): Planted widely in New York City and native to certain areas of Long Island (A. Greller, personal communication, 2011) it must once have been native to the city. Sensitive to salt and air quality.

Eastern red cedar (*Juniperus virginiana*): Infrequent in New York City (Gargiullo 2007). Somewhat more tolerant of salt and urban conditions than many conifers. The "berries" (cones) are important food for songbirds.

Atlantic white cedar (*Chamaecyparis thyoides*): Once a dominant tree of acidic freshwater swamps on Long Island and in the New Jersey Meadowlands, this species was probably native to New York City. Intolerant of salt and urban conditions.

Additional information on northeastern conifers is available in Fowells (1965), Highshoe (1988), Peattie (1991), Peterson (1980), Rhoads and Block (2005), and Weldy and Werier (2010).

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Seabeach amaranth (*Amaranthus pumilus*)

By Jay Kelly and Jennifer Stenzel

Habitat

Seabeach amaranth is native to Atlantic Coast beaches and barrier islands, growing on open sandy beaches, usually on pure mineral sand, sometimes on sand mixed with shell fragments. Its habitat is restricted to upper beach areas between the high tide line and the foot of dunes, boardwalks, or other structures lining the landward limits of the beach. It appears to be intolerant of other plants and is usually not found in densely vegetated sites (Weakley et al. 1996).

Distribution in New York City

Historically, seabeach amaranth was found on beaches from Massachusetts to South Carolina. It is believed to have been extirpated from New York as of 1955, and disappeared from all but North and South Carolina by the 1980s (Weakley et al. 1996). The plant mysteriously reappeared in New York in 1990, and in the following decade returned to New Jersey, Delaware, Maryland, and Virginia (Mangels 1991, Ramsey et al. 2000, Kelly 2002, Lea and King 2002, McAvoy 2002). Scientists speculate that Hurricane Hugo may have carried seeds north from the Carolina coast in 1989 or unearthed seeds lying dormant in the sediment seed bank. Today, seabeach amaranth is found on the barrier island ecosystem of Breezy Point in Jamaica Bay and elsewhere along Long Island's southern barrier beaches.

Description and Identification

Seabeach amaranth has reddish, succulent stems and small, rounded, glossy, spinach-green leaves that are notched at the tip and clustered at the tops of the stems. Plants typically grow into clumps a few inches wide by late summer, but can occasionally reach two to three feet in diameter, although remaining less than a foot in height. The small flowers and dark seeds are inconspicuous, located in small clusters along the stems (U.S. Fish and Wildlife Service, NYNHP 2012).

Stephen M. Young/NY Natural Heritage Program

Seabeach amaranth.

Ecology

The seabeach amaranth is an annual, "fugitive" plant—one that moves from place to place each year as its seeds are carried by the wind and waves. The seeds of the species are enclosed in a fleshy "utricle" that allows them to be more easily carried by wind or waves to other sites. The seeds are also covered with a waxy coating that enables them to float in salt water (Weakley et al. 1996). The plant itself does not tolerate inundation by salt water, however, which results in mortality or morbidity.

Germination begins in May and continues through the summer, and plants persist until the first hard frost, which may be as late as December (Kelly, personal observation) or January in some years (Weakley et al. 1996). Flowering begins as soon as plants reach sufficient size in June or July and continues until September or October. The species is capable of self-pollination, as seed production has been observed in isolated individuals more than 60 miles (100 km) from other seabeach amaranth plants (Weakley et al. 1996).

Larger individuals are capable of producing upwards of 20,000 seeds per plant (Lea and King 2002). Such prolific seed production allows populations to increase quickly following successful dispersal to other areas of suitable habitat. The species is also thought to be capable of extended periods of seed dormancy as an adaptation to burial by sediment in the dynamic shoreline environment; other species in the genus have demonstrated seed viability after more than 100 years of dormancy (Weakley et al. 1996).

Seabeach amaranth traps sand, beginning the initial stages of dune formation and creating suitable habitat for other shoreline plants. Although it prefers sparsely vegetated sites, seabeach amaranth may be associated with plants such as American sea rocket (*Cakile edentula*), Russian thistle (*Salsola kali*), and seaside spurge (*Chamaesyce polygonifolia*).

Amaranth seeds are very rich in protein. With the largest seeds of any species in its family, the seabeach amaranth has been under study for possible cultivation as a cereal (USDA 2002).

Stephen M. Young/NY Natural Heritage Program

Seabeach amaranth has reddish, succulent stems.

Threats

Seabeach amaranth was federally listed as a Threatened species in 1993 and is listed as Endangered in New York. While the species has reappeared through most of its historic range, questions remain about its long-term viability in many areas. Populations tend to be small, isolated, non-persistent and/or highly dynamic in their numbers, and monitoring has documented precipitous declines or disappearance of many populations in recent years (Kelly, unpublished data).

Threats to the plant include erosion or burial from storm surges, and predation by webworms and other herbivores (Weakley et al. 1996). Widespread alteration of beach habitat by human activities, however, represents the primary threat to the species' long-term survival. This includes intensive recreational use by pedestrians and off-road vehicles, mechanical beach raking or grooming, shoreline stabilization structures such as jetties and groins that prevent amaranth dispersal, and habitat fragmentation (suitable habitat patches tend to be too far apart for seed dispersal and colonization).

Conservation and Management

Seabeach amaranth is most often found on beaches managed for the protection of beach-nesting birds such as the piping plover (*Charadrius melodus*) and least tern (*Sterna antillarum*), where mechanical raking and off-road vehicles are restricted. Because of the dynamic nature of this species and its habitats, effective conservation requires the protection of large areas of contiguous shoreline habitat from incompatible land uses such as beach raking and off-road vehicles. This would allow populations to find refuge by dispersing to "safe sites" when local areas or populations are destroyed by storm surges, predators, or other factors.

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Seabeach amaranth at Atlantic Beach.

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Eastern Prickly-pear (*Opuntia humifusa*)

By Marielle Anzelone

Habitat

Prickly-pear cactus grows on coastal beaches in open, dry, sandy areas of back dunes (the second dune formation above the beach). Not far outside of New York City, it also grows on cliff faces or rocky sites (Gargiullo 2007). At Asharoken, on Long Island, prickly-pear was observed growing just above the beach (E. Kiviat, personal communication, 9 July 2012).

Distribution in New York City

This member of the cactus family (Cactaceae) is widespread in the eastern United States but often localized, listed as endangered in Massachusetts, special concern in Connecticut, and rare in Pennsylvania. It is, however, common on Sandy Hook, New Jersey. In New York State the species is considered "exploitably vulnerable," and is protected from collecting or harvesting without the landowner's permission, as it is likely to become threatened in the near future (USDA 2012).

In New York City, eastern prickly-pear is found occasionally in relatively undisturbed open sand of back dunes in areas with little competition from other plants. It can form colonies and may be locally abundant. It is not known to occur in Manhattan. Suitable habitat does exist in Brooklyn, but there are no known occurrences in the borough. The species is found at one locality in a Bronx park, one on the Rockaway Peninsula in Queens, and one in a Staten Island park. Eastern prickly-pear is also cultivated in gardens and may escape locally from plantings.

Erik Kiviat

Eastern prickly-pear (Kingston, N.Y.).

Description and Identification

Eastern prickly-pear is a perennial evergreen plant characterized by its low or prostrate, flat, leathery pads (actually jointed stems). These grayish-green succulent pads grow up to 8 inches long and have areas of small, bristly spines scattered over the surface. Large spines are infrequent, but the more common smaller bristles (glochids) release into skin upon contact and cause mild irritation. Large, showy yellow flowers with up to 12 petals appear in June, each blooming for only one day. If they are pollinated, fleshy red fruits develop by fall. The fruits are 1 to 2 inches long and one-half to four-fifths inch in diameter, and many hard, stony seeds are embedded in the pulp.

Ecology

Eastern prickly-pear is the only native cactus species found in the northeastern U.S. While tolerant of extreme conditions of heat and wind, including coastal salt spray, it is intolerant of shade (NYNHP 2011).

Associated herbaceous species include American beach grass (*Ammophila breviligulata*), American sea rocket (*Cakile edentula*), little bluestem (*Schizachyrium scoparium*), seaside goldenrod (*Solidago sempervirens*), and smooth aster (*Symphyotrichum laeve*).

Woody species associated with this cactus include common hackberry (*Celtis occidentalis*), eastern red cedar (*Juniperus virginiana*), northern bayberry (*Morella pensylvanica*), black cherry (*Prunus serotina*), post oak (*Quercus stellata*), black oak (*Q. velutina*), winged sumac (*Rhus copallina*), and Virginia rose (*Rosa virginiana*).

Eastern prickly-pear first flowers in its second year, as blossoms appear on the prior year's pads. Male anthers mature before the female pistil to deter self-pollination. Prickly-pear also reproduces vegetatively, creating large mats relatively quickly.

The chief pollinator of eastern prickly-pear is the spring rose beetle (*Strigoderma arboricola*). Bee visitors include plasterer bees, halictid bees, large leaf-cutting bees, miner bees, bumble bees (*Bombus*), and carpenter bees (*Xylocopa virginica*), with the larger species (e.g., bumble bees and carpenter bees) acting as pollinators (Hilty 2010).

Insects that eat eastern prickly-pear include pyralid moth caterpillars (*Melitara prodenialis* and *Dicymolomia*). The fruits are eaten by eastern cottontails (*Sylvilagus floridanus*) and raccoons (*Procyon lotor*), which disperse the seeds. Fruits are also eaten by coyotes (*Canis latrans*), foxes (*Vulpes vulpes*), skunks (*Mephitis mephitis*), squirrels (*Sciurus carolinensis*), and white-tailed deer (*Odocoileus virginianus*) (Eastman 1995, Hilty 2010).

The species is winter-hardy. In autumn the plant dehydrates and pads wrinkle and yellow as it concentrates its sap into an antifreeze-like solution that enables it to withstand cold temperatures (Eastman 1995). Older pads become brownish-gray and woody with age (Hilty 2010).

Threats

The few extant (still in existence) occurrences of eastern prickly-pear and its specialized habitat make the species' continued existence in the City precarious. Populations are threatened by human-related habitat loss, development of taller vegetation including invasive species, and the collection of wild plants by gardeners.

Conservation and Management

Active management, especially removal of taller, shade-producing plants, may be required to maintain the open, sunny habitats the eastern prickly-pear requires. To encourage the expansion of cactus populations, areas that support prickly-pear should be protected from mountain bikes, all-terrain vehicles, and pedestrians. In appropriate locations, access for educational purposes can be afforded by means of a boardwalk.

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Buttonbush dodder (*Cuscuta cephalanthi*)

By Marielle Anzelone

Habitat

Buttonbush dodder is a vine that parasitizes a variety of shrubs and herbaceous plants, so it is found in the habitats of its host plants. These are mostly freshwater wetlands, including swamps, marshes, stream banks, and moist thickets.

Distribution in New York City

This member of the dodder family (Cuscutaceae) is found through most of the United States. In New York State the species is listed as S1 (critically imperiled). It is likely more common than indicated by its status. Differentiating *Cuscuta* species can be very challenging. Because it is hard to identify, buttonbush dodder may be underreported.

Buttonbush dodder is known to occur in only one location on Staten Island.

Note: Other dodder species located in New York City include common dodder (*Cuscuta gronovii*), southern dodder (*C. obtusiflora var. glandulosa*), field dodder (*C. pentagona*), compact dodder (*C. compacta*), and smartweed dodder (*C. polygonorum*). All of these species are rare in both the City and State, except for common dodder (A. Greller, personal communication, 9 May 2011).

Description and Identification

Buttonbush dodder has yellow- or orange-tinged, filamentous stems. The vine grows around the host plant in a counterclockwise direction. Because this parasitic plant does not photosynthesize, its leaves are greatly

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Buttonbush dodder (herbarium specimen).

reduced. They appear as minute scales that are scattered in an alternate arrangement along the stem. Buttonbush dodder blooms from July through September, bearing tiny, white flowers in compact, crowded clusters. The flowers are 5-parted and pointed in outline, distinguishing this species from other dodders. In fact, flowers are necessary for species determination. The fruit is a many-seeded, rounded capsule crowned by older flower parts.

Ecology

Buttonbush dodder is an annual herbaceous vine. Like all dodders, it is parasitic. It contains no chlorophyll for photosynthesis and obtains its food from host plants. During seed germination in the spring, a pale yellowish stem emerges and wraps itself around the stem of another plant. Special structures called haustoria penetrate the host plant. These absorb sugars and other photosynthetic products as nutrition for the dodder (Rhoads and Block, no date). Some of these haustoria may survive the winter and start new plants already connected to the host in the spring. Once established, their spaghetti-like stems form a cobwebby network over neighboring plants.

The small, waxy white flowers of dodder are produced in late summer, followed by many spherical seed capsules. Although wasps and other Hymenoptera have been observed on other dodders, little is known about pollination of buttonbush dodder (Sopher, no date) and it may self-pollinate. A dodder seedling must find a host in 5 to 10 days or it will die. For this reason, seed germination, emergence, and attachment to a host occurs quickly, sometimes in as little as 24 hours (NYNHP 2011).

Host plants range from small herbs to woody shrubs. In addition to the common buttonbush (*Cephalanthus occidentalis*) for which this dodder is named, known host plants in New York State include willows (*Salix*), asters (*Aster s.l.*), goldenrods (*Solidago*), horsetails (*Equisetum*), mints (*Lamiaceae*), and American water-willow (*Justicia americana*). The ability of buttonbush dodder seeds to remain dormant for longer than one season, and the plant's host-seeking behavior, are poorly understood (NYNHP 2011).

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Common dodder (*Cuscuta gronovii*).

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Tendrils of southern dodder curl around other plant stems.

Threats

Threats to its host plants also endanger the parasitic buttonbush dodder. These may include wetland habitat degradation and development. Research is needed on other sensitivities of buttonbush dodder (e.g., to pollutants or herbivores).

Conservation and Management

Wetland buffers should be created and maintained to preserve the hydrologic regime and prevent habitat destruction.

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Ericaceous Shrubs

By Marielle Anzelone

Lowbush blueberry (*Vaccinium angustifolium*)
Early low blueberry (*Vaccinium pallidum*)
Deerberry (*Vaccinium stamineum*)
Black huckleberry (*Gaylussacia baccata*)
Tall huckleberry (*Gaylussacia frondosa*)

Habitat

Members of the Ericaceae (heath family), these shrubs grow in nutrient-poor, well-drained, acidic soils (mostly sandy, in some cases rocky) in open understories of undisturbed forests. Such "scrubby oak barrens" are found in natural areas on the outer coastal plains. In the region, ericaceous shrubs also are often associated with "pine barrens," forests dominated by pitch pine (*Pinus rigida*). However, there are no pitch pine forests in the five boroughs, and pitch pine is rarely found in the City.

Distribution in New York City

These ericaceous shrubs may be found in relatively undisturbed, acidic soils throughout New York City, although none is common. The highest concentrations are in Pelham Bay Park in the Bronx and in a number of parks on Staten Island. Inwood Hill Park in Manhattan has stands of early low blueberry on the ridges of its rocky crests. Where present, if site conditions are favorable, ericaceous shrubs can dominate the forest understory.

Lowbush blueberry (*Vaccinium angustifolium*).

Early low blueberry (*Vaccinium pallidum*).

Deerberry (*Vaccinium stamineum*).

Black huckleberry (*Gaylussacia baccata*).

Tall huckleberry (*Gaylussacia frondosa*).

Lowbush blueberry (*Vaccinium angustifolium*)

- Staten Island: Only borough where species is extant (still exists). Known to occur at six sites

Early low blueberry (*Vaccinium pallidum*)

- Bronx: Pelham Bay Park
- Manhattan: Fort Tryon Park and Inwood Hill Park
- Queens: Alley Pond Park; possibly extirpated from Cunningham Park (A. Greller, personal communication, 9 May 2011)
- Staten Island: Known from 13 sites

Deerberry (*Vaccinium stamineum*)

- Staten Island: Only borough where species is extant. Small populations known from three sites

Black huckleberry (*Gaylussacia baccata*)

- Bronx: Pelham Bay Park
- Queens: Possibly extirpated from Cunningham Park (A. Greller, personal communication, 9 May 2011)
- Staten Island: Known from seven sites

Tall huckleberry (*Gaylussacia frondosa*)

- Staten Island: Only borough where species is extant. Small populations known in four sites

Other ericaceous shrubs found in New York City include fetterbush (*Eubotrys racemosa* [synonym *Leucothoe racemosa*]), often common around kettle pond margins; pinkster azalea (*Rhododendron periclymenoides*), now rare in northern Queens; swamp azalea (*R. viscosum*), at edges of acid ponds in Queens, Bronx, Staten Island; and highbush blueberry (*Vaccinium corymbosum*) in wet woods and pond margins (A. Greller, personal communication, 9 May 2011).

Description and Identification

These deciduous upright shrubs reach various heights at maturity. They grow slowly and are long-lived, producing large colonies from underground stems. Their leaves are alternate and untoothed. *Gaylussacia* species have yellowish resin dots (visible with a 10x hand lens) on the undersides of the leaves; *Vaccinium* species do not. The leaves turn various shades of orange, red, and burgundy in fall. By late October, the plants are leafless and dormant in preparation for winter. Both genera have white, bell-shaped flowers in pendant clusters in May and June. Flowers develop on second-year growth. If the flowers are pollinated, fleshy, dark blue to black fruits appear in July through September. The fruits have a white bloom (white powder-waxy coating) early in the season. Young *Vaccinium* stems are smooth and green in winter, while older stems become fissured and gray. Information on identification is available in Petrides (1972) and Gleason and Cronquist (1991).

Ecology

Blueberry and huckleberry shrubs are typically found growing together and often with other members of the heath family, such as pinkster azalea, round-leaf pyrola (*Pyrola rotundifolia*), and spotted wintergreen (*Chimaphila maculata*). At shadier sites, mapleleaf viburnum (*Viburnum acerifolium*) and wild sarsaparilla (*Aralia nudicaulis*) are associated plants. At sunnier sites, common greenbrier (*Smilax rotundifolia*) and Canada mayflower (*Maianthemum canadense*) are found. The tree canopy is often dominated by oak (*Quercus*) species, including white oak (*Q. alba*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*), and blackjack oak (*Q. marilandica*). Sassafras (*Sassafras albidum*) may be codominant. Pine (*Pinus*) species, such as short-leaved pine (*P. echinata*) and pitch pine, and gray birch (*Betula populifolia*) may also be present.

Populations inhabiting rock outcrops, such as the early low blueberry shrubs in Inwood Hill Park, may grow with chestnut oak (*Quercus prinus*), shadbush (*Amelanchier*), and various grasses (Poaceae).

Gaylussacia and *Vaccinium* leaves are eaten by many species of caterpillars, including sulfurs and fritillaries. Flowers of these shrubs are insect-pollinated, mainly by native bees that emerge early in the growing season,

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Highbush blueberry (*Vaccinium corymbosum*).

such as certain bumble bees and smaller bees. The early spring blooms are an important source of nectar for native pollinators. It is common to find punctures at the bases of flowers made by "nectar-robbing" bees looking for a shortcut to their nectar reward. Fruits are eaten by songbirds and mammals, which subsequently disperse the seeds. The plants have symbiotic relationships with fungi, which increase the nutrient uptake of their roots.

Threats

In the New York City region, the ranges of blueberries, huckleberries, and other members of the heath family are contracting. These species appear to be sensitive to urbanization. A number of causal factors may be at play (Clemants and Moore 2005).

Blueberries and huckleberries prefer acidic soils, and urban soils tend to be more basic. The symbiotic mycorrhizae ("fungal roots") necessary for the shrubs' survival are very fragile. Their fungal filaments, which lie just below the soil surface, are easily destroyed. For this reason, ericaceous shrubs are threatened by improper uses of natural areas that damage the organic soil layer. Active recreational pursuits involving mountain bikes and off-road motorized vehicles (which are illegal) are largely responsible for this destruction. Vegetation development (the growth of taller, shade-producing plants) may also threaten some populations that grow in open habitats and require abundant sunlight. (See DeCandido et al. 2004 for discussion of general threats.)

It should be noted that there are additional threats to other Ericaceae species not examined here. For example, a good number of these species are hydrophytes (wetland or aquatic plants), and the majority of New York City's wetland habitats have been destroyed by development. Among the affected species are cranberry (*Vaccinium macrocarpon*) and leatherleaf (*Chamaedaphne calyculata*).

Much ecological information may be found in Tirmenstein (1991) for *Vaccinium pallidum* and Gucker (2006) for *Gaylussacia baccata.*

Conservation and Management

Staten Island, the least urbanized borough, has significant areas of unprotected greenspace. Much of this open space is undergoing rapid development. Over the last 70 years, the island has lost over 40 percent of its native plant species (Robinson et al. 1994), including 10 of 26 species in the heath family. For example, trailing arbutus (*Epigaea repens*) is extinct in New York City. It had been known from a number of sites in Staten Island, where its abundance warranted several eponymously named local roads and woodlands (Arbutus Woods, Arbutus Avenue, Arbutus Way, etc.).

Loss of plant species in the City is due primarily to loss of habitat, and unlike wetlands, upland forests have no legal protection and are most vulnerable to destruction. Therefore, it is essential to protect the upland sites where these plants occur. The installation of perimeter barriers to prevent entry by illegal off-road vehicles and the removal of unsanctioned mountain bike trails, along with increased enforcement patrols in parks (via bicycle, not car) would help minimize improper recreational use. Policies that value these areas in their natural, "undeveloped" state and keep park improvements such as ball fields and parking lots to a minimum in sensitive areas should be promoted (DeCandido et al. 2004).

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Spring Beauty (*Claytonia virginica*)

By Marielle Anzelone

Habitat

The spring beauty is found in shady, moist understories of rich woods and floodplain forests, usually in somewhat drier sites, in well-drained, slightly acidic to neutral soils. This wildflower occasionally grows in lawns.

Distribution in New York City

A member of the purslane family (Portulacaceae), the spring beauty is found in woodland habitats throughout the eastern United States and Canada from Quebec and Ontario south to Georgia. It grows in weedier sites in the more southern portion of its range.

In New York City, the spring beauty is occasionally found in relatively undisturbed woodlands on slightly acidic soils. It can be locally abundant, often forming a carpet of flowering plants. The spring beauty occurrences in Queens may be the only populations on Long Island. Spring beauties grow in lawns in Bronx River and Pelham Bay Parks. The plant is also found in rock crevices in Corson's Brook Woods on Staten Island. It can survive more environmental degradation than most spring-blooming woodland species, so remains relatively common in the urban setting.

- Bronx: Bronx River Park, Pelham Bay Park, Van Cortlandt Park
- Manhattan: Fort Tryon Park, Inwood Hill Park
- Queens: Alley Pond Park
- Staten Island: Six known sites, including Corson's Brook Woods

Marielle Anzelone

Spring beauty flowers open on warm sunny days.

Description and Identification

The spring beauty is a perennial herbaceous wildflower that grows up to six inches tall. A reddish-brown pea- to marble-sized corm (fleshy underground stem base) bears several flowering stems, each with a single stem leaf and two basal leaves. The leaves are linear, sessile, and fleshy. The small flowers with five petals are white to pale pink with darker pink veins. They bloom from March to May. The fruit is an ovoid capsule with several shiny black seeds that have an ant-attracting elaiosome (oily appendage). The capsule explosively ejects the seeds, often as far as two feet (Eastman 1992). (See Gleason and Cronquist [1991] for identification characteristics.)

Ecology

The spring beauty overwinters as a corm. It reproduces readily from both seed and corm, forming large carpets relatively quickly. Its leaves usually emerge in mid-April. The blooming period in mid- to late spring lasts about a month. Individual flowers open sequentially (with male reproductive parts maturing first) and last about three days. Blooming ends before overhead trees are fully leafed out in May. The flowers open on warm sunny days and close during cloudy weather and at night (Eastman 1992).

The capsular fruits containing several seeds mature within 10 days of pollination. The seeds are initially dispersed by explosive dehiscence of capsules and secondarily dispersed by ants, which take the seeds back to their burrows for food. Foliage turns yellow and dies back in early summer. Corms can withstand summer drought, but need some moisture in fall for root growth. Roots and shoots begin to develop after 90 to 120 days of dormancy. Cold temperatures stop further growth until spring.

This species is a spring ephemeral, a species that can thrive beneath the closed canopy of a mature forest. Spring ephemerals require high sunlight levels in early spring before the trees fully leaf out. They can take up large quantities of nutrients during their short growing season, but also return a large quantity of nutrients to the soil from their senescent leaves (Gilliam 2007).

Mariélle Anzelone

A carpet of spring ephemerals, spring beauty and trout lily.

The spring beauty is typically found growing with trout lily (*Erythronium americanum*), another spring ephemeral. Other associated herbaceous species include white wood aster (*Eurybia divaricata*), wood-rush (*Luzula multiflora*), false Solomon's seal (*Maianthemum racemosum*), Canada mayflower (*Maianthemum canadense*), mayapple (*Podophyllum peltatum*), skunk cabbage (*Symplocarpus foetidus*), and sessile-leaved bellwort (*Uvularia sessilifolia*). Shrubs associated with spring beauty may include spicebush (*Lindera benzoin*), mapleleaf viburnum (*Viburnum acerifolium*), and arrowwood (*V. dentatum*). The tree canopy usually consists of American beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), and oaks (*Quercus species*), especially red oak (*Quercus rubra*).

The chief pollinators of spring beauties are the solitary bee *Andrena eriginiae* and bumble bees (*Bombus* species). The flowers are also visited by halictid bees (including *Agapostemon* species) and honey bees (*Apis mellifera*), as well as bee flies, muscid flies, and syrphid flies. Butterflies and skippers are less frequent visitors. These insects usually seek nectar; some of the bees also collect pollen (Hilty 2010). Spring beauty seeds are eaten by mice.

Threats

Despite being secure throughout most of their range, spring beauties and other spring ephemerals have become less frequent within the City's boundaries. This is due in part to their ecological sensitivity to urbanization. Because they are associated with mature forests, it can take as long as 20 years after a disturbance for them to reappear. Their upland forest habitats have no legal protection and are vulnerable to destruction.

The species' own biology offers challenges as well. Spring beauty requires minimum temperatures for the activity of pollinating insects, yet must photosynthesize before the tree canopy closes in May. Its reproductive period therefore is restricted to the short period between the lowest temperatures at which pollinators can be active and tree canopy closure that restricts photosynthesis. Shade-tolerant perennials may rarely flower in consecutive years. Pollination of herbs of wooded landscapes is relatively infrequent. Seed dispersal of forest herbs is localized (Jolls 2003). (See Bierzychudek [1982] for further discussion.)

A more immediate threat is posed by invasive nonnative plants. Lesser celandine (*Ranunculus ficaria*), also a spring ephemeral, emerges earlier than spring beauty and may compete for resources (Invasive Plant Atlas, no date). Norway maple (*Acer platanoides*) inhibits the growth of nearby understory plants. Its earlier leaf emergence and resulting shade from the tree canopy shortens the time that the spring beauty can complete its aboveground life cycle (The Pennsylvania Flora Project, no date).

Conservation and Management

Existing spring beauty populations will benefit most from the protection of their habitat. Woodland sites need to be protected from disturbances caused by improper recreation, including mountain bikes and all-terrain vehicles. Invasive species should be removed or reduced in abundance.

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Forest Lilies

By Marielle Anzelone

Canada mayflower (*Maianthemum canadense*)
False Solomon's seal (*Maianthemum racemosum or Smilacina racemosa*)
Smooth Solomon's seal (*Polygonatum biflorum*)
Sessile-leaved bellwort (*Uvularia sessilifolia*)

Habitat

These plants in the lily family (Liliaceae) grow in well-drained, slightly acidic soils in the shady, moist understories of relatively undisturbed forests. They have a high tolerance for shade and can grow even under the deep shade of beech trees.

Distribution in New York City

These herbaceous plants are found throughout the eastern United States and Canada in various woodland habitats. They tolerate a range of ecological conditions.

In New York City, forest lilies may be found in relatively undisturbed woodlands on slightly acidic soils. All of these species are relatively common. If site conditions are favorable, they can be locally dominant, often forming extensive, long-lived colonies. (Note that "frequent" means a species is found at a large proportion of localities.)

Canada mayflower (*Maianthemum canadense*) — frequent

- Bronx: Pelham Bay Park
- Manhattan: Fort Tryon Park, Inwood Hill Park
- Queens: Cunningham Park
- Staten Island: 13 known sites

Marielle Anzelone

Canada mayflower.

Marielle Anzelone

False Solomon's seal.

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Smooth Solomon's seal.

Sessile-leaved bellwort.

False Solomon's seal (***Maianthemum racemosum***) — common; often persists in somewhat disturbed forests

- Bronx: five known sites
- Brooklyn: Prospect Park
- Manhattan: Fort Tryon Park, Highbridge Park, Inwood Hill Park
- Queens: Alley Pond Park, Forest Park
- Staten Island: 18 known sites

Smooth Solomon's seal (***Polygonatum biflorum***) — frequent

- Bronx: Pelham Bay Park, Seton Falls Park, Van Cortlandt Park
- Manhattan: Fort Tryon Park, Highbridge Park, Inwood Hill Park
- Queens: Alley Pond Park
- Staten Island: 12 known sites

Sessile-leaved bellwort (***Uvularia sessilifolia***) — frequent

- Bronx: Pelham Bay Park
- Queens: Cunningham Park
- Staten Island: 16 known sites

Description and Identification

Forest lilies are perennial monocots that overwinter as short, underground rhizomes. They have an unbranched, single stem bearing alternate, ovate leaves in a 2-ranked arrangement. Most stems do not flower unless there is sufficient light, as in a forest gap. Six-petaled, bisexual flowers bloom in May to June. In *Maianthemum* species, the inflorescence is a spire of tiny white blossoms in a terminal raceme or panicle. Pale, pendant, bell-shaped flowers are suspended along the stem in smooth Solomon's seals and bellworts. If the flowers are pollinated, few-seeded fleshy berries, either red or blue, appear in June to July. Most reproduction is vegetative, with one to two new segments of rhizome detaching from a parent plant at the end of the growing season, thus increasing colony size. An individual colony may live dozens of years. (See Gleason and Cronquist [1991] for identification characteristics.)

Ecology

These forest lilies are typically found growing together. Other associated herbaceous species include wood anemone (*Anemone quinquefolia*), wild sarsaparilla (*Aralia nudicaulis*), spring beauty (*Claytonia virginica*), trout lily (*Erythronium americanum*), white wood aster (*Eurybia divaricata*), wild geranium (*Geranium maculatum*), cinnamon fern (*Osmunda cinnamomea*), mayapple (*Podophyllum peltatum*), and white rattlesnakeroot (*Prenanthes alba*).

Associated shrubs may include spotted wintergreen (*Chimaphila maculata*), witch-hazel (*Hamamelis virginiana*), pinkster azalea (*Rhododendron periclymenoides*), early low blueberry (*Vaccinium pallidum*), mapleleaf viburnum (*Viburnum acerifolium*), and arrowwood (*Viburnum dentatum*).

The tree canopy typically consists of red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), and oaks, especially red oak *(Quercus rubra*) and white oak (*Quercus alba*).

The chief pollinators of forest lilies are bumble bees (*Bombus* species), along with other solitary bees, bee flies, and hover flies. Short-tongued halictid bees may visit the flowers to collect pollen, but they are not effective pollinators. Bellwort seeds have fatty appendages (elaiosomes) that attract ants, which disperse the seeds by carrying them to their nests. Other forest lily fruits are consumed and dispersed by a few birds and small mammals. (However, the fruits may be unpalatable as they often remain on plants well into fall.) Foliage of these plants is eaten by white-tailed deer (*Odocoileus virginianus*). Their roots have symbiotic associations with mycorrhizal fungi, which benefit the plants by increasing nutrient uptake.

The herb layer of the forest, including forest lilies, typically contains a large portion of forest biodiversity and plays important roles in the transformations of nutrients and energy in the forest (Gilliam 2007).

Threats

Herbaceous vegetation is particularly sensitive to natural and human disturbances, and so serves as an indicator of site quality and ecological integrity. For example, since Canada mayflower responds negatively to disturbance, its presence may be an indicator of a thriving mesic hardwood forest.

Although still common and secure through most of their ranges, these liliaceous plants have become less frequent within the City's boundaries. This is due in part to their ecological sensitivity to urbanization and to habitat destruction. They disperse slowly and require well-developed soils and a sheltered microclimate. It may take as many as 20 years, or longer, after a disturbance for forest lilies to reappear.

Disturbances can include arson and off-road vehicles. Repeated burning opens the tree canopy and encourages shade-intolerant and often more aggressive species to take hold. (Fire may help to maintain a natural biological community in dry habitats such as serpentine barrens, but can be destructive to mesic [middle moisture] forests.) Motorcycles and other all-terrain vehicles are a major concern since their wheels tear out sensitive herbaceous vegetation. The bare mineral soils left in their wake may have insufficient organic matter and mycorrhizal fungi to support sensitive forest plants.

The upland forest habitats of these plants have no legal protection and are most vulnerable to destruction. Pollination of herbaceous plants in the City's wooded landscapes is relatively scarce. When they do produce fruit, seed dispersal is localized (Jolls 2003).

Conservation and Management

Existing forest lily populations will benefit most from the protection of their habitat. Limiting improper recreational uses, for example, could allow populations to expand.

Additional information on natural history and conservation of these forest lilies is available in Gargiullo (2007) and Gracie (2012).

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Pink Lady's Slipper (*Cypripedium acaule*) and Other Orchids

By Marielle Anzelone

Habitat

This orchid species has an affinity for partial shade and well-drained, acidic soils in mature forests with intact understories. It is known to grow on decaying wood (Sanders 2003). For successful germination, pink lady's slipper seed requires a particular microclimate and an associated mycorrhizal fungus.

Distribution in New York City

Pink lady's slipper is found throughout the eastern United States and Canada in various woodland habitats, but occurs in only one borough of New York City (Robinson et al. 1994), although found in nearby Long Island (Lamont 1996).

- Staten Island: Three known sites, including Evergreen Park and private lands

Description and Identification

The pink lady's slipper is a perennial monocot with a single unbranched flower stalk and two large, basal, elliptic leaves. The leaves are untoothed and lightly hairy. The solitary flower is uniquely shaped, with a large, pink, pouch-like lower petal that houses the male and female floral parts (Gleason and Cronquist 1991).

Erik Kiviat

Pink lady's slipper (in the Catskill Mountains).

Pink lady's slipper blooms in May and June. The fruit is a cylindrical pod that contains many tiny, dust-like seeds. The roots are fleshy and fibrous. When several plants occur together, they are often vegetative offsets of a mother plant.

Ecology

In the wild, pink lady's slipper begins flowering more than 10 years following germination. If pollination occurs, thousands of the dust-like wind-borne seeds are produced in mid-summer. Producing blooms is so taxing that in subsequent years the plants are typically dormant (Sanders 2003). Individual plants can live for decades.

In New York City, pink lady's slipper is usually found growing in association with ericaceous shrubs. These may include spotted wintergreen (*Chimaphila maculata*), pinkster azalea (*Rhododendron periclymenoides*), and early low blueberry (*Vaccinium pallidum*). Associated herbaceous species include wild sarsaparilla (*Aralia nudicaulis*), white wood aster (*Eurybia divaricata*), Indian pipe (*Monotropa uniflora*), and Canada mayflower (*Maianthemum canadense*).

Erik Kiviat

Pink lady's slipper (in the Catskill Mountains).

The orchid's complex floral anatomy lures insect pollinators. The inflated pouch-like petal enclosing the flower's sexual parts has a slit opening for insects to enter, but they must exit through a smaller opening at the top and thus collect pollen in passing (Davis 1986). Larger visitors may be caught at this exit and have to chew their way out (Sanders 2003). The main pollinators of pink lady's slipper are ground-nesting andrenid and halictid bees, honey bees (*Apis mellifera*), and smaller bumble bees (*Bombus*) (Eastman 1992).

Pink lady's slipper and other forest orchids rely on symbiotic fungi that help the plant roots take up vital nutrients and water. In turn, the orchid provides sugars and starches to the fungus. Unlike those of other plants, orchid seeds lack an attached food source. The fungal symbionts help supply nutrients and energy and are critical to seed germination.

Threats

Forest orchids such as pink lady's slipper are very sensitive to habitat changes, making them especially vulnerable to urbanization. Outside of New York City, this species often grows in coniferous forests (Sanders 2003), but such woodlands are on the decline in the five boroughs.

Pollination rates are low, limiting seed set. Pink lady's slipper seeds are extremely vulnerable to changes in their environment. They have a high mortality rate, and few find the optimum conditions necessary for germination. Soil disturbance from mountain bikes and all-terrain vehicles adversely affects the habitat of native forest herbs, especially orchids.

Because people often collect the flowers from the wild, in New York State, pink lady's slipper is designated "exploitably vulnerable" (i.e., likely to become threatened in the near future throughout all or a significant portion of their ranges within the State if causal factors continue unchecked).

Conservation and Management

Pink lady's slipper and other forest orchids are difficult to propagate and transplant. The best means for supporting their continued existence in the City is protection of their habitats from development and human disturbances, including active recreation.

The scarcity of extant (still in existence) populations and their small population sizes leave pink lady's slipper exceedingly vulnerable to local extirpation (Robinson et al. 1994). To discourage the collection of these forest orchids, it is essential to educate the public about the importance of leaving plants in the wild.

Other Orchid Species

(From information provided by Andrew Greller and David Taft)

New York City historically had 30 known species of native orchids, but only seven species remain in addition to pink lady's slipper (DeCandido et al. 2004). These seven species are listed below, along with the number of known occurrences. All native orchids are of great conservation concern in New York City and should be protected if at all possible. Native orchids are currently known in four of the five boroughs of New York City, with the exception of Manhattan.

Yellow lady's slipper (*Cypripedium parviflorum*): Apparently extirpated a century ago.

Large coralroot (*Corallorhiza maculata*): One population limited to a handful of individuals.

Downy rattlesnake-plantain (*Goodyera pubescens*): One population of three individuals.

Large whorled pogonia (*Isotria verticillata*): Two localities.

Bog twayblade (*Liparis loeselii*): One locality with few individuals.

Nodding ladies' tresses (*Spiranthes cernua*): Four populations with a handful of individuals each.

Green fringed orchid (*Platanthera lacera*): Three populations.

There is also one nonnative orchid, **broad-leaved helleborine (*Epipactis helleborine*)**. This species is increasing in New York City parks.

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Animal Profiles

As with plants, animals depend on certain environmental factors for survival, such as food quality and abundance, shelter, water, and the presence of mates. Because animals in general are more mobile than plants, animals may use combinations of different macro- or microhabitats for different life history functions (e.g., winter dormancy, reproduction, foraging), at different times of the day or year, or in different years. Many animals spend much time hidden from sight and human awareness in the soil, in dense vegetation, high in trees, or otherwise inconspicuous sites. Thus it may be difficult to know what kinds of animals are in a habitat without resorting to special survey techniques and expertise.

The animal species or groups of species profiled here are only a few of the noteworthy or rare species in New York City. These species may be rare or common outside of the City, but are of conservation concern here.

Details of identification are beyond the scope of the Handbook, and readers will want to refer to the many good standard field guides and taxonomic manuals that are available, only a few of which are cited here.

Wood Frog, James Gibbs

Spatterdock darner (*Rhionaeschna mutata*), Allen Barlow

Don Riepe

American Horseshoe Crab (*Limulus polyphemus*)

By Jennifer H. Mattei

Habitat

Horseshoe crabs are found on the continental shelf of eastern North America from Maine to Florida and parts of the Yucatan Peninsula in Mexico. Juveniles and adults often feed just offshore in intertidal flats, in the shallow areas of bays, harbors, and in marshes. They prefer sandy or muddy bottoms protected from strong wave action and consume a variety of invertebrates including marine worms (polychaetes) and small shellfish. In the winter, they tend to go into deeper water and/or bury themselves for several months in the sand and mud.

Jennifer H. Mattei

Juvenile horseshoe crabs feeding in a mudflat alongside mud snails.

Jennifer H. Mattei

Adult horseshoe crab feeding along the shores of Long Island Sound.

Distribution in New York City

- Brooklyn: Manhattan Beach, Plumb Beach, Marine Park, Gowanus Canal, Brighton Beach, Dead Horse Bay, Coney Island Beach, Dyker Beach Park
- Bronx: Orchard Beach
- Manhattan: Stuyvesant Cove Park, East 23rd and 18th Streets
- Queens: Rockaway Beach, Jamaica Bay Wildlife Refuge within the Gateway National Recreation Area, Jamaica Bay Park, Alley Pond Park, shoreline along North Channel Beach
- Staten Island: Mt. Loretto State Preserve, South Beach, Crescent Beach, Buono Beach near Alice Austen Park, Lemon Creek Park, Wolfe's Pond Park, Midland Beach, Conference House Park

Description and Identification

Horseshoe crabs have a hard exoskeleton (outer shell) divided into three parts: the head (prosoma), abdomen (opisthosoma) and tail (telson). Two large compound eyes are found on either side of the prosoma with eight simple eyes (for light detection) found scattered across the prosoma, down the telson, and two on the underside, near the mouth. The spiny mouth is surrounded by seven pairs of legs; some used for feeding, locomotion—pushing along through sand and mud, defense, although they cannot pinch very hard, and the males' front legs are used to clasp females during mating (they look like little boxing gloves). The telson is not a stinger or a sword but is used by the horseshoe crab to right itself when it has been flipped upside down by a wave. Females are between 20 and 30 percent larger than males. On average, horseshoe crabs are 2 feet (60 cm) long and 1 foot (30 cm) wide. The life span is approximately 18 to 25 years based on tag return data.

D. Briggs/Yale Peabody Museum

Fossil horseshoe crab (Xiphosurid) from the Ordovician Period. Found in Morocco.

D. Briggs/Yale Peabody Museum

A *Mesolimulus* fossil from the Jurassic Period. Found in Morocco.

Despite their name, horseshoe crabs are not true crabs, but are grouped in their own class (Merostomata), which is more closely related to arachnids (a group that includes spiders and scorpions). Horseshoe crabs are also called "living fossils" as they are the closest living relatives of the now-extinct trilobites. Close relatives of the modern-day *Limulus* have existed on Earth since the Ordovician Period (about 400 million years ago). Their general appearance has remained relatively unchanged over the millennia.

Four species of horseshoe crab exist today. Only one species (*Limulus polyphemus*) is found in North America along the Atlantic and Gulf coasts; the other three are found in Southeast Asia and are suffering from severe population declines.

Ecology

Horseshoe crabs are well known for their large nesting congregations on beaches. However, on many beaches in New York and Connecticut, there are fewer adults spawning and usually only mated pairs are observed (Mattei et al. 2011). The spawning season occurs during May and June when large numbers of horseshoe crabs move onto sandy beaches to mate and lay eggs. To avoid predators and the heat of the sun, horseshoe crab spawning activity more frequently occurs at night. Some will miss the outgoing tide and bury themselves in the sand until the next high tide. Male and female horseshoe crabs are coupled during mating and egg-laying. While covered with water, a female digs down 4 to 10 inches (10 to 25 cm) and deposits between 4,000 and 10,000 eggs in one nest. She may return on several nights and lay up to 20,000 eggs during the spawning season. Often, more than one male will contribute to the fertilization of the eggs as the female buries them.

Horseshoe crab larvae emerge from their nests several weeks after the eggs are laid. Juvenile horseshoe crabs resemble adults, except that when they hatch they do not have a telson until after their first molt (shedding of the exoskeleton, or outer shell). In order to grow, a juvenile horseshoe crab must molt several times a year during the first two to three years. (The presence of the shed exoskeletons, or casts, on beaches indicates nearby nursery habitat.) It takes anywhere from 9 to 12 years for horseshoe crabs to mature, and they usually do not molt again after they start spawning.

Jeff Simon

Tagged mated pair of adult horseshoe crabs.

Mark A. Beekey

Newly hatched crab larva.

Horseshoe crabs are an important part of the ecology of coastal ecosystems. During the nesting season, the eggs are a major food source for migrating shorebirds, and it has been observed that red knots and ruddy turnstones time their migrations to coincide with the horseshoe crab spawning period, mid-May, in Delaware Bay. Many fish species also rely on horseshoe crab eggs and newly hatched larvae for food. In addition, the horseshoe crab's carapace is habitat for many organisms, including algae, flatworms, mollusks, barnacles, and bryozoans.

The horseshoe crab is also important in medical science. Its blood contains Limulus Amebocyte Lysate (LAL), used by pharmaceutical companies for the detection of bacterial toxins during vaccine production. The federally mandated LAL test informs physicians and veterinarians that the vaccines they use are not contaminated and will not make their patients ill. Scientists have also learned much about the human eye by studying the horseshoe crab's large optic nerves.

Threats

In the 1990s, American horseshoe crab numbers declined greatly through much of its range. Scientists believe that a combination of factors contributed to the decline, including degradation and loss of habitat for juvenile horseshoe crabs and overfishing. Horseshoe crabs are used extensively as bait in the American eel and conch fisheries along many parts of the Atlantic coast. Thousands of horseshoe crabs are caught and transported to pharmaceutical companies to extract LAL from their blood, after which they are released to the sea alive. Recent studies have indicated that approximately 15 to 30 percent of the crabs harvested for this purpose may die from handling (Leschen and Correia 2010). In addition, human disturbance can adversely affect spawning activities. Beach development and shoreline modifications can prevent horseshoe crabs from reaching sandy areas or can strand them once they reach spawning areas. Recreational vehicle traffic on beaches and large beach combing tractors can crush the crabs and destroy their nesting habitat.

Conservation and Management

The conservation and management of this species are controversial, given that horseshoe crabs are important to a variety of stakeholders including commercial bait fishermen, the biomedical industry, and Atlantic states that receive substantial revenue related to ecotourism.

In 1998, the Atlantic States Marine Fisheries Commission (ASMFC) approved the Interstate Fishery Management Plan for Horseshoe Crabs (FMP). The goals of the FMP included "…management of horseshoe crab populations for continued use by current and future generations of the fishing and non-fishing public" (e.g., biomedical industry; scientific and educational research; migratory shorebirds; and other dependent fish and wildlife). The ASMFC developed stock assessment and management guidelines for the horseshoe crab that prompted many state and federal agencies to assess their management policies, initiate the collection of baseline data, and develop long-term monitoring programs for horseshoe crabs within their jurisdictions (ASMFC 1998). ASMFC recommendations and state harvest regulations are updated annually based on new knowledge of the species' biology and conservation needs (ASMFC 2011).

As part of their new management strategies for stabilizing the horseshoe crab population in Long Island Sound, both New York and Connecticut state wildlife managers have set up no-harvest zones on a few spawning beaches. They have also changed the harvest regulations and established harvest limits. In New York and Connecticut, researchers are looking for volunteers to help monitor horseshoe crab spawning activities on local beaches. There are three levels of volunteerism:

1) Beach Walkers:
   a. Search for tagged horseshoe crabs that come up on beaches. Each tagged crab has a unique number on it.
   b. Report tag numbers that are found: email: info@projectlimulus.org; phone: 203-365-7577, or 1-888-LIMULUS.
   c. Time: year round.

2) Beach Taggers:
   a. Trained to tag and measure horseshoe crabs (both night and day tagging).
   b. Responsible for returning data sheets and unused tags.
   c. Any day, any time during the spawning season.

3) Beach Counters:
   a. Teams of trained volunteers who count male and female horseshoe crabs in a defined area.
   b. Dates: during full and new moons in May and June.
   c. Times: both high tides (night and day). It takes about two hours to walk the beach at high tide and volunteers get wet!
   d. Any time a crab is turned over and cannot right itself, it is vulnerable to predators. To give an overturned crab a helping hand, pick it up by its shell and set it down on its legs. Never lift the horseshoe crab by its telson (tail) because you might injure it. To volunteer on Long Island and New York City, see the New York Horseshoe Crab Monitoring Network website (http://www.nyhorseshoecrab.org/).

To volunteer in Westchester County or Connecticut, see the Project Limulus website (www.projectlimulus.org).

Jennifer H. Mattei

Tag for individual identification on a horseshoe crab.

Jennifer H. Mattei

Volunteers from Bridgeport, CT.

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Feminine Clam Shrimp, *Cyzicus* (*Caenestheriella*) *gynecia*

By Erik Kiviat

The clam shrimps are an obscure group of crustaceans. Clam shrimps have bivalve shells and look superficially like fingernail clams (Mollusca: Bivalvia: Sphaeriidae); when their shells are open, the crustacean appendages are visible. Most clam shrimps live in small temporary ponds, and a few species live in large lakes; vernal pools, seasonal wetlands, alpine tundra pools, salt lakes, and playas are inhabited by various species. *Cyzicus gynecia* is the only North American clam shrimp from which males have not been recorded (all individuals are hermaphroditic) and is called the feminine clam shrimp (Cordeiro 2008). Recently the scientific name was changed from *Caenestheriella gynecia* to *Cyzicus gynecia.*

Habitat

Feminine clam shrimp live in long-lasting intermittent rain pools on dirt roads or ATV (all-terrain vehicle) trails. Pools in New York and New Jersey were about 1-10 square meters in surface area and 10-15 cm deep when full (Schmidt and Kiviat 2007). These pools occurred in groups and contained little or no refuse and few vascular plants. Bottom sediments were silty or clayey and were soft to a depth of about 2-5 cm. Pools evidently were created and maintained by ATVs and cars or light trucks. Roads and trails supporting pool habitats were bordered by woodlands or in one case common reed (*Phragmites australis*) mingled with woody plants. Pools subject to more-than-occasional tidal flooding may not be suitable habitat.

Erik Kiviat

Two feminine clam shrimps on a fingertip above the rain pool habitat.

Erik Kiviat

Rain pool habitats of the feminine clam shrimp on a dirt pipeline service road in the New Jersey Meadowlands.

Distribution in New York City

Occurrences have not yet been reported in New York City. Populations have been documented in the New Jersey Meadowlands and the Hudson Valley. Potential habitat in New York City should be surveyed for this species. The feminine clam shrimp is known from very few sites and only in New York State, New Jersey, Massachusetts, Pennsylvania, and Ohio (Schmidt and Kiviat 2007, Cordeiro 2008). Although this species might be expected to occur more widely in rain pools on dirt roads, many such habitats both near and distant from known populations have been surveyed with negative results.

Description and Identification

As its name implies, a clam shrimp superficially resembles a miniature clam. From a distance, clam shrimps moving slowly along the underside of the surface film may appear to be mosquito larvae, although they are actually quite different. The adult shell is about 4-10 mm in size, light brown or gray, and marked by ring-like growth increments. In turbid drying pools, the margins of an open shell may be faintly visible beneath the surface with two pairs of appendages at one end. A closed shell out of water, or an empty clam shrimp shell, might be mistaken for a fingernail clam. An animal believed to be a clam shrimp should be identified to species by an expert.

Ecology

Adults have been found active during a long period of spring, summer, and early fall. They may be seen in clear pools swimming slowly along the bottom or in turbid pools moving slowly along the underside of the surface

film. This species persists in a "resting egg" stage in the bottom mud when a pool dries. Clam shrimps generally feed on algae, bacteria, protozoans, rotifers, and detritus (dead plant material), and are subject to predation by larger animals such as birds, amphibians, and larger insects (Pennak 1978).

Threats

Drainage or filling of pool habitat for road maintenance is probably the greatest threat. Managers often do not take this species seriously because it is not officially listed, it occurs in an artificial (inadvertently human-made) habitat, and the ATVs that are responsible for maintaining the habitat and probably dispersing the animals from pool to pool are widely disliked by land managers.

Estuarine salinity intrusion, deicing salts, pesticides, petroleum, and other pollutants are likely toxic to clam shrimp. Methoprene, a juvenile growth hormone analog used to control mosquito larvae, is toxic to aquatic crustacea (D. Molloy, personal communication, 2000) and a potential threat to clam shrimp.

The sole known New Jersey clam shrimp population, on a gas pipeline road in the Meadowlands (Schmidt and Kiviat 2007, Orridge et al. 2009), had its habitat destroyed during construction for wetland mitigation in 2010. One Hudson Valley population, in the Town of Hyde Park, had half its habitat destroyed during a residential development project (E. Kiviat, personal observation); the other half is on an adjoining site also proposed for development (J.G. Barbour, personal communication, no date). A nearby population in the Town of Rhinebeck has been inaccessible for survey work due to an ownership change. A third Hudson Valley population is in a state park in Ulster County; the parks agency is sympathetic to conservation but there is no explicit management plan. Potential threats to a reported fourth Hudson Valley population (J. Westerveld, personal communication, 2009), in Orange County, are unclear, although it is in an area of development activity.

Conservation and Management

Clam shrimp pools should be identified and then protected from filling, draining, pollution, and other threats. Eventually, some form of disturbance may be necessary to keep the pools from silting in. Infrequent passage of wheeled vehicles may be necessary for this purpose as well as effecting gene flow among the pools. The ecological tolerances and requirements of the feminine clam shrimp are poorly known and management may require experiment and adaptation. It should be possible to create habitat for this species given the correct geochemical conditions, but this has not been tried.

Survey Techniques and Constraints

Habitat complexes—groups of large, near-permanent rain pools on dirt roads or trails—should be surveyed for clam shrimp during summer. Pools may be surveyed for clam shrimp by sweeping a fine-mesh aquatic dip net through the water and carefully examining the muddy slurry brought up in the net. Clam shrimp densities vary, and at low density numerous sweeps may be necessary to detect adults in a pool. During cold weather, or soon after reflooding of dried pools, adult clam shrimp may not be detectable. It is possible that adults would not be found at all in some years. Visual observation of pools with clear water (i.e., those pools that have not recently been disturbed by vehicles or animals) may reveal clam shrimp moving along the bottom.

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Odonates (Dragonflies and Damselflies)

By Ellen Pehek

Comet darner (*Anax longipes*)
Spatterdock darner (*Rhionaeschna mutata*)
Southern pygmy clubtail (*Lanthus vernalis*)
Yellow-sided skimmer (*Libellula flavida*)
Needham's skimmer (*Libellula needhami*)
Mocha emerald (*Somatochlora linearis*)
Little bluet (*Enallagma minisculum*)
Rambur's forktail (*Ischnura ramburii*)

Habitat

The **comet darner** is found in many types of lakes and ponds with abundant emergent vegetation, especially sandy-bottomed coastal ponds and fishless ponds.

The **spatterdock darner** breeds in fishless ponds and lakes with abundant emergent vegetation, primarily spatterdock (*Nuphar lutea*).

The **southern pygmy clubtail** breeds in spring-fed streams and seeps with sandy and muddy bottoms. It is often found in areas where skunk cabbage (*Symplocarpus foetidus*) grows.

The **yellow-sided skimmer** is found in coastal plain seepage streams or bogs.

Allen Barlow

Southern pygmy clubtail (*Lanthus vernalis*).

Allen Barlow

Needham's skimmer (*Libellula needhami*).

Allen Barlow

Yellow-sided skimmer (Libellula flavida).

Allen Barlow

Rambur's Forktail (*Ischnura ramburii*).

Allen Barlow

Spadderdock darner (*Rhionaeschna mutata*).

Needham's skimmer is restricted to the coastal plain, in freshwater marshes, tidal streams, and estuaries.

The **mocha emerald** inhabits small, often intermittent, mucky or boggy forest streams.

The **little bluet** is restricted to Coastal Plain ponds and similar shallow water habitats.

The **Rambur's forktail** is found in Coastal Plain ponds, marshes and slow-flowing streams with abundant emergent vegetation.

Distribution in New York City

In recent years, the **comet darner** has been observed on Staten Island and in Queens.

The **spatterdock darner** has been observed in Queens and on Staten Island.

The **southern pygmy clubtail** was first found in New York City in 2000, in a park on Staten Island.

Present on Staten Island, the **yellow-sided skimmer** is not known to occur in other boroughs. It was once found outside the City on Long Island.

The **Needham's skimmer** is present on Staten Island and in Brooklyn and Queens.

Although present on Staten Island in one site first reported by William T. Davis in 1898, the **mocha emerald** has not been reported in the other boroughs.

The **little bluet** was reported in Queens for the first time in 2008. Only two other sites are known in New York State, both on Long Island.

The **Rambur's forktail** is present on Staten Island and in Queens.

Ellen Pehek

Comet darner (*Anax longipes*) larva, well-camouflaged.

Description and Identification

Dragonflies and damselflies belong to the order of insects called Odonata. As insects, they have six legs and two pairs of wings. Although there are many differences between them, dragonflies are generally larger, with strong wings that are held at 180 degrees from the body when the insect is at rest, whereas damselflies are smaller, and most fold their wings back along the body.

The **comet darner** is a very large dragonfly, up to 3.5 inches (8.9 cm) long, with a green thorax and red abdomen that is bright red in males and brick red in females. Unlike the similar common green darner (*Anax junius*), it lacks a bulls-eye marking on the forehead.

The **spatterdock darner** is a large black dragonfly, nearly 3 inches (7.6 cm) long, with blue markings and blue eyes. The female is usually black with green spots on the abdomen and yellow stripes on the thorax, but can occasionally be black and blue like the male.

The **southern pygmy clubtail** is a small dragonfly, 1.4 inches (3.6 cm) long, with a black abdomen and pale yellow thorax with one black shoulder stripe. The similar northern pygmy clubtail (*Lanthus parvulus*) has two black stripes on its thorax.

The **yellow-sided skimmer** male has a pruinose (waxy) blue thorax and abdomen. Unlike similar skimmer dragonflies, it has no dark markings other than the stigma on its forewings, and its wings have an amber tint. The female has a yellow abdomen and paler yellow thorax with a brown stripe and black wingtips.

The **Needham's skimmer** is a medium-sized dragonfly. The male is bright orange-red with orange wings. It can be distinguished from the golden-winged skimmer (*Libellula auripennis*) by a redder body color and more dark veins on its wings. The female is golden with a black line down the back of the abdomen.

The **mocha emerald** is an unmarked brown dragonfly with brown-tinted wings. It can be distinguished from other emerald dragonflies (genus *Somatochlora*) by its large size—up to 2.6 in (6.6 cm) long—and the shape of the appendages at the end of the abdomen, which differ among species.

As its name suggests, the **little bluet** is one of the smaller damselflies, about 1 inch (2.5 cm) long. The male is blue with black markings; when mature, its thorax becomes lavender. The female is tan underneath and black above.

The **Rambur's forktail** is a damselfly about 1 to 1.5 inches (2.5 to 3.8 cm) long. The male is black on the top of its abdomen and yellow underneath, with a blue band around abdominal segment 8 and blue beneath segments 9 and 10. Its thorax is green with black shoulder stripes. The female's coloration varies: it can be male-like, orange and black, or olive and black.

Ecology

Comet darners are active from June to mid-September, peaking in July. These strong fliers may forage far from their breeding habitat. Males patrol ponds from about 9 am until noon. Pairs mate while hanging in a tree, and eggs are laid in plant stems or algae beneath the water (Dunkle 1989).

Spatterdock darners fly in New York from early June to mid-July. Females lay eggs on the underside of floating and emergent vegetation. Like other large darners, they rest high in trees, but can be seen when patrolling for mates or foraging along paths, roads, and forest edges.

Southern pygmy clubtail adults can be seen from May through early July, peaking in June. They forage in clearings in the woods. Males perch high in trees and sometimes on rocks in a stream. Females perch on the ground (Dunkle 2000).

Yellow-sided skimmers have been seen in New York City from June to July, but their flight season elsewhere is from March to September. They can often be found perched on a stem over a boggy pool (Dunkle 2000).

Needham's skimmers are seen from May or June through September. Males may defend a perch on a plant stem, foraging for mates or food from there and returning frequently, or make long, uninterrupted flights (Dunkle 2000).

Mocha emeralds have been observed from mid-June to mid-September, peaking in August. They are most active for a few hours after dawn, and again from late afternoon until dusk. The rest of the time mocha emeralds will hang from a twig or tree trunk in forest shade. Females lay eggs in the mud near a stream, from the waterline to several feet upslope (Dunkle 2000).

Little bluet adults can be seen flying from June through mid-July.

Rambur's forktails have been observed from May to November, but the best time to find them is late June through early August.

Threats

Filling or changes in hydrology and water quality at their breeding sites, and loss or degradation of surrounding upland (foraging) habitat are the most important threats to these odonates. The **little bluet** is listed as Threatened in New York State, and all are monitored by the New York Natural Heritage Program and considered Species of Greatest Conservation Need by the New York State Department of Environmental Conservation (see Appendix B).

Conservation and Management

Care should be taken to protect headwaters of streams from soil disturbance or stormwater runoff. The acidic coastal ponds used by many of these species should be protected from stormwater runoff, which contains fertilizer or other pollutants. Open fields or forest clearings are necessary for most of these species to forage. The **mocha emerald** and **southern pygmy emerald** require a mature forest buffer, but the necessary width is unknown.

Survey Techniques and Constraints

Odonate adults are easy to survey, and counts at one locality for 15 minutes can give a relative index of abundance and diversity. Adults that cannot be identified on the wing can be captured with an aerial insect net for observation and released. Documenting breeding requires observation of the aquatic larvae or exuvia (the shed skins of larvae after they transform to adults). Larvae can be difficult to identify, often requiring a hand lens or microscope. For keys to identifying larvae, see Needham et al. (2000). For additional information, see the references.

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Native Bees and Honey Bees (*Apis mellifera*)

By Elizabeth Johnson

Habitat

Bees can be found in a variety of habitats, both large and small patches. Of particular importance are unmanicured greenspaces that provide nesting habitat in close proximity to sources of flower nectar and pollen.

Bees can do especially well in many urban habitats, depending on how they are managed, such as abandoned railway corridors and other rights-of-way, empty lots, and old scrubby fields. New research expanding the suite of plant species that are used on green roofs may also benefit bees (see Gardens, Green Roofs, and Green Walls profile).

Distribution in New York City

Native bees and honey bees are found throughout the City wherever there is sufficient nesting and foraging habitat. As of this publication date, Dr. John Ascher and other scientists at the American Museum of Natural History have documented more than 230 species from the five boroughs. The most diverse populations are found in the less developed areas of the City, especially where there is undisturbed, loose (friable) soil, as in coastal areas.

A new species, the Gotham bee, *Lasioglossum gotham* Gibbs, was recently described based in part on specimens from Brooklyn Botanic Garden and the New York Botanical Garden (AMNH 2012). A few bee species found in the City remain undescribed.

Description and Identification

Like most other flying insects, bees have two pairs of wings and three pairs of legs. They generally can be distinguished from wasps by the fact that their bodies are hairier, and even the less hairy bee species possess branched hairs visible under the microscope. Female bees gather nectar and pollen for their young and can be

John S. Ascher

Claytonia bee (*Andrena eriginiae*).

John S. Ascher

Male *Agapostemon splendens* visiting aster.

John S. Ascher

Common eastern bumble bee (*Bombus impatiens*).

seen carrying pollen either on special parts of their hind legs, which are broader and flatter than in wasps, or under their abdomens (O'Toole and Raw 1999).

Species identification generally requires close inspection with a microscope to discern the various features such as tongue length, eye characteristics, wing venation, etc. Good keys and species pages with maps for all New York bee species are available online at Discover Life. Images can also be submitted to BugGuide for identification.

Ecology

Bees, like other animals, require food, shelter, and water to survive. For bees, this means abundant and diverse sources of nectar and pollen available through the season from late March until October, and adjacent nesting sites (either areas of undisturbed, loose soil or pithy twigs or cavities in wood). Approximately 70 percent of bees native to New York City are solitary ground-nesting species. Twenty-four percent are solitary twig and cavity nesters, and the remainder (native bumble bees and nonnative honey bees) nest in colonies.

The typical life cycle of a solitary bee involves the emergence first of males, then females in the spring or summer, followed by mating. Once mated, the female prepares a nesting site (either in the ground or in a pithy twig such as sumac, hydrangea, or elderberry), gathers pollen and nectar to provision nest cells, and lays eggs. Although there are exceptions, typically after hatching each larva consumes its pollen ball (provisions) and then pupates, remaining in the relative safety of the nest until the following year when it emerges as an adult and the cycle begins again. Primitively eusocial species (those that exhibit complex social behavior but whose colonies are not perennial, with all individuals except queens dying at the end of the season) such as bumble bees and many sweat bees mate at the end of the season in the fall, and the fertilized queens overwinter. Different species are active at different times of the year (O'Toole and Raw 1999).

More than 85 percent of flowering plants require animal pollinators to "move" pollen from male plant parts to female plant parts (Winfree et al. 2011). (The remainder, including grasses, some trees like oaks and pines, and herbs such as ragweed, are pollinated by wind or other means.) Good pollination, in turn, leads to good fruit and seed production. In New York City, bees are the most important pollinators, although other animal pollinators such as butterflies and moths, beetles, flies, wasps, and ruby-throated hummingbirds (*Archilochus*

colubris) also play a part.

Bees visit flowers to collect both pollen and nectar to provision nest cells for their young. Most bees are generalists, visiting a wide array of flowering plants. Some bees are oligolectic, preferring to visit plants from a single plant family, but only a very few are monolectic (species-specific) (O'Toole and Raw 1999). Among many oligolectic species found in New York City, *Macropis* oil bees formerly visited yellow loosestrife (*Lysimachia*), for which there are no recent records from the City, and the claytonia bee (*Andrena erigeniae*) only visits spring beauty (*Claytonia*) (See Spring Beauty profile). Safeguarding populations of host plant species is essential for the survival of these specialist bee species (Matheson et al. 1996).

Threats

Lack of sufficient habitat is an important threat. Although gardens in urban and suburban areas may be plentiful and most flowering garden plants are beneficial for many bees, the plants may not provide the right nectar or pollen for certain specialist bee species. Nesting habitat may not be sufficient or close enough to foraging sites. In addition, many of the relatively open habitats on which bees depend, such as old fields or abandoned lots, are being developed or replanted with trees, which do not support bee populations. Parks and garden areas that do exist are often highly groomed, and while they may be used by common urban-tolerant bee species, they may lack the nesting resources or undisturbed areas necessary to support uncommon species (K. Matteson, personal communication, 17 January 2013).

Pesticides are a major threat, whether applied at a larger scale as part of urban agricultural or other pest control operations or by homeowners in their backyards. Insecticides kill insects directly or can have sublethal effects that alter their capacity to navigate or carry out their daily activities. Insecticides can also poison pollen grains on which adult bees and their young feed. (See, for example, the report on neonicotinoids by Hopwood et al. [2012.]) Herbicides remove "weeds," which are typically good nectar sources for bees. Additional stresses include air pollution, which has been shown to affect bees' ability to detect floral scents (McFrederick et al. 2008).

Introduced diseases are an additional threat to bee diversity. Over the past 10 years multiple bumble bee species have declined dramatically in the eastern United States. As of this writing, the main culprit seems to be a disease introduced via the commercial greenhouse industry, where European strains of *Nosema* parasites may

Elizabeth Johnson

Cellophane bee (*Colletes* sp.) nest in early spring

have been inadvertently brought here and later spread to the wild. Prior to development of the commercial bumble bee industry, the American bumble bee, *Bombus pensylvanicus*, had already disappeared from the New York City area, likely due to loss of its habitat, including meadows with clovers, although it persists in southern New Jersey (J. Ascher, personal communication, 7 June 2012).

Conservation and Management

There are many management actions that community gardeners, homeowners, park managers, and others can take to benefit native bees. In fact, some neighborhood backyard and community gardens, especially in low-density residential areas of the city, provide more floral resources and support more insects than nearby greenspaces (Matteson et al. in press).

These conservation actions include minimizing soil cultivation to avoid disturbing ground nests; leaving hedgerows of natural habitat adjacent to farm fields or between greenspaces and developed areas; allowing some garden planting beds to remain mulch-free for ground-nesting species, and protecting bare soil in other areas; embracing a more natural landscape by not manicuring parks and gardens (for example, by minimizing pruning and allowing fallen logs to remain in place to decompose); avoiding the use of pesticides; using native plants where possible (many bees and plants have evolved close relationships and native species may provide more nectar and/or pollen); adding nest boxes to attract cavity-nesting bees; and restoring native bee habitat (Mader et al. 2011).

The Great Pollinator Project and the Butterfly Project both have developed management and training guidelines and also curricula to enhance understanding of these pollinators and how best to care for them.

Survey Techniques and Constraints

Bees are best surveyed during their active season, between March and October, on warm, calm, sunny days. For detailed protocols for a variety of survey techniques, see Droege et al. (2010). Consulting other invertebrate survey methodology books can also be helpful. Bees are challenging to identify, so consultation with experts is best.

Honey Bees

Contrary to what many people think, the European honey bee (*Apis mellifera*) is not a native bee species; rather, it was brought to the New World in 1622 by early colonists, and possibly even earlier to the West Indies or South America. This is one of the few bee species that nests in large colonies (others include tropical stingless bees) and is readily managed by humans. For these reasons, they have become indispensable pollinators of large-scale crops such as almonds and strawberries in California and beneficial to smaller agricultural efforts such as orchard crops in the New York region. In addition, honey bees produce large stores of honey and wax, both important to humans. Honey bees seem to do well in certain urban areas, due perhaps in part to the abundance of gardens and water in close proximity to their hives. In New York City, it is now legal to keep honey bee hives. For information on honey bee keeping, see New York City Beekeepers Association or New York City Beekeeping. For information on colony collapse syndrome, a mysterious ailment that has caused the loss of over 50 percent of managed hives in the U.S. over the past few years, see the U.S. Department of Agriculture's website Honey Bees Colony and Collapse Disorder.

John S. Ascher

European honey bee (*Apis mellifera*).

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Stream Salamanders

By Ellen Pehek

Northern red salamander (*Pseudotriton ruber*)
Northern dusky salamander (*Desmognathus fuscus*)
Northern two-lined salamander (*Eurycea bislineata*)

Habitat

Northern red salamanders are found near streams, springs, and ponds surrounded with deciduous or mixed woodlands. They spend time in both aquatic and terrestrial habitats throughout the year (Petranka 2010).

Northern dusky salamanders prefer faster flowing streams with seeps and springs and can be found under rocks and logs near the water's edge (Klemens 1993, Gibbs et al. 2007). They prefer smaller tributaries and seeps as compared with two-lined salamanders that will use larger rivers.

Northern two-lined salamanders are typically found in small streams in deciduous forests but will use a variety of wet habitats including floodplain rivers, springs, and seepage areas. They can sometimes be found several hundred feet from the nearest stream (Klemens 1993).

Distribution in New York City

The **northern red salamander** is only present in New York City on Staten Island in three or four parks. The Hudson River Valley is the species' northern limit. In New York State it is also found on the Pennsylvania border (Gibbs et al. 2007). The species ranges south to northern Florida and west to Kentucky. During summer

Brian Zarate

Northern red salamander *(Pseudotriton ruber)*.

John F. Bunnell

Northern red salamander larva. Note external gills.

and early fall, the northern red may be found under objects or leaf litter in the forest. In the autumn, females travel to a stream to lay their eggs and may be found under cover objects such as rocks or logs. Larvae spend several years in the stream, where they may be found under rocks and logs year-round. Adults join them in the stream during the winter months.

The **northern dusky salamander** is present on Staten Island and Manhattan; previously, it occurred in the Bronx. Northern duskies are found in most of New York State, except for Long Island and the State's extreme northern edge (Gibbs et al. 2007). The species' overall range extends from Maine and the Canadian Maritime Provinces south to South Carolina, Georgia, and Tennessee, where it intergrades with the southern dusky, and west to Indiana. Northern dusky salamanders are most active from early spring to autumn, when they may be found by lifting cover objects along stream and seep habitat. Some populations living along seeps that do not freeze may be found year-round.

Northern two-lined salamanders are present in the Bronx, Queens, and Staten Island. Adults are most reliably found near streams during the mating and egg-laying seasons, from fall through mid-summer. At other times they may be far (330 ft/100 m or more) from water (Gibbs et al. 2007), burrowed into forest substrate. Larvae may be found year-round in their aquatic habitat. The northern two-lined salamander is found throughout New York State, except for most of Long Island (Gibbs et al. 2007). Its overall range extends from Quebec and New Brunswick in the north, south to northern Virginia and west to Ohio (Lannoo 2005).

Description and Identification

The **northern red salamander** is a medium to large salamander that is bright coral-red with black spots as a young adult. As individuals mature, the black spots merge and the ground color often darkens to a purplish-brown. Larvae are mottled brown and black with gills branched like a feather.

The **northern dusky salamander** is a medium-sized gray, brown, or black salamander, sometimes with a wavy-edged rusty stripe down the back. It is stout, with rear legs noticeably larger than the front, and a keel on the upper tail. A light line runs from the rear of the eye to the rear of the jaw, which distinguishes it from

James P. Gibbs

Northern dusky salamander *(Desmognathus fuscus)*.

any salamanders of the genus *Plethodon*, such as the red-backed salamander (*Plethodon cinereus*) (Conant and Collins 1998). Aquatic larvae are tan or brown with light spots on the back. They have simple gills that branch like a tree, as opposed to the feather-like gills of the northern two-lined salamander.

The **northern two-lined salamander** is a small- to medium-sized, very slender, yellow salamander with two dark stripes down the back and a clear yellow belly. Recently-transformed larvae and old adults may be brownish and the lines may not be distinct. The tail is laterally compressed (flattened from side-to-side). Larvae are brown with light spots on the back and gills that are branched like a feather.

For more information, see also Behler and King (1979).

Ecology

Stream salamanders are important components of the riverine ecosystem. They are the top predators in headwater streams and seeps, contributing to the structure of the invertebrate community. A recent study of the blackbelly salamander (*Desmognathus quadramaculatus*) in Nantahala National Forest in North Carolina found that salamander biomass in headwaters far exceeded that of other vertebrates in downstream waters (Peterman et al. 2008). Studies to measure salamander biomass in headwaters in the New York metropolitan region are needed, as well as comparisons between urban and rural headwaters.

Northern red salamanders feed on terrestrial and aquatic invertebrates such as worms, fingernail clams, and insects, as well as smaller salamanders. Petranka (2010) noted that eastern red-backed salamanders are their primary salamander prey. Males and females mate while in the forest during summer through early fall. The females then migrate to the water and lay eggs under rocks within the stream, or occasionally a pond. The predators of northern red salamanders are not well known — their bright coloration may provide them some protection in areas where the toxic red eft (juvenile red-spotted newt) is also found.

Ellen Pehek

Northern dusky salamander with young.

Northern dusky salamander larvae feed on small invertebrates such as stonefly nymphs and fingernail clams. Adults feed on a wide range of terrestrial and aquatic invertebrates, including insects, centipedes, snails, and smaller salamanders. Adults mate in spring or fall on the edge of the stream or seep. Females lay eggs under logs, rocks, or other objects near the water and remain with them until hatching 50 to 80 days later. The larvae then crawl into the water where they live for up to 11 months before transforming into adults. Dusky salamanders are preyed on by other salamanders, snakes, birds, and mammals.

Northern two-lined salamanders feed on terrestrial and aquatic invertebrates as well as fish eggs and fry. They mate from fall to spring at the edge of the water. Females lay eggs on the undersides of rocks in flowing water. Fish, larger salamanders, snakes, birds, and small mammals all prey on northern two-lined salamanders.

Threats

Stream salamanders are the only group of salamanders that has not lost diversity in New York City. All species historically found in the City (Bishop 1941) are present today. The northern red and northern dusky, however, have fragmented distributions and have disappeared from some of their previous localities. Although two-lined and northern red salamanders appear secure in the region, northern duskies are disappearing from Westchester County, NY, and Fairfield County, CT (Klemens 1993). Loss and degradation of habitat are the most serious threats to these salamanders. None of the three species found in New York City is listed at the state or federal level, or monitored by the New York Natural Heritage Program. The northern red salamander is listed by the New York Department of Environmental Conservation as a Species of Greatest Conservation Need (see Appendix B).

Conservation and Management

Recommended actions include avoiding road crossings of streams; mapping and assessing headwater streams and seeps; protecting forested buffer around seeps and streams; protecting forested buffer around stream

Ellen Pehek

Northern two-lined salamander *(Eurycea bislineata)*.

headwaters; using safe alternatives to sodium chloride for road de-icing; reducing impervious surfaces, which lead to erosion and sedimentation in the watershed; and protecting habitats from foot and off-road vehicle traffic.

Survey Techniques and Constraints

An index of population density is easily created by sampling in belt transects across or along a stream or seep. Using a strainer or aquarium net held on the substrate below a rock or other object, turn over the rock and salamanders (as well as insect larvae, crayfish, and occasionally dace or eels) will wash into the strainer. In areas of low current velocity you may need to prod the salamanders into the net. Because a portion of the population may be in crevices well below the surface, this is only a relative measure of density. Surveys for adult two-lined and northern red salamanders should be timed to the season(s) when they are present in the water, because in the forest they will be dispersed and difficult to find. Dusky salamanders do not wander far from the stream or seep, so may be surveyed at any time the water is not frozen (Bishop 1941).

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Leopard Frog (*Lithobates [Rana]* species)

By Erik Kiviat and Kristen Bell Travis

Until recently, leopard frogs in the New York City region were believed to be southern leopard frogs (*Lithobates sphenocephalus utricularius*, synonym *Rana sphenocephala utricularia*). A new genetic analysis (Newman et al. 2012) found this entity to be a new, as yet undescribed, species. Leopard frogs in the Great Swamp of northeastern New Jersey (Townsend 2012), the New Jersey Meadowlands (Kiviat, unpublished data), a site on Staten Island, a Putnam County, NY site, and an Orange County, NY site belong to this undescribed species (Foderaro 2012). It is likely that other populations in this general area will be discovered. More information will become available on this entity in the near future (J. Feinberg, personal communication, 23 February 2012).

Habitat

Breeding habitats probably include a variety of freshwater ponds, marshes, and shrub swamps that are flooded throughout the spring season. Northern leopard frogs (*Rana pipiens*) and southern leopard frogs tend to wander into a variety of wetland and upland habitats outside the breeding season, and the undescribed species probably does so as well. Slightly brackish water (possibly up to 1 part-per-thousand salinity) may be tolerated in the breeding pools.

Distribution in New York City

In the first half of the 1900s, this frog was common on Long Island and Staten Island (Mathewson 1955), but by the 1970s the species was uncommon in Nassau and Suffolk counties (Schlauch 1978). Leopard frogs have not been confirmed on Long Island recently, and possibly a single population survives on Staten Island. There are no definite recent records from the other boroughs.

Erik Kiviat

Undescribed leopard frog in the New Jersey Meadowlands.

Description and Identification

A leopard frog found in New York City would be the undescribed species or possibly a released northern leopard frog or southern leopard frog. The undescribed species is a medium-sized, spotted true frog resembling the pickerel frog (*Lithobates palustris*). The adult leopard frog is distinguished from the pickerel frog by round rather than (usually) squarish dorsal spots, light borders around the dorsal spots, and lack of a yellow wash on the concealed surface of the hind leg. Lack of yellow on the leg is diagnostic for leopard frog. Larvae (tadpoles) or juveniles should be identified by an expert.

Calling males of the undescribed leopard frog make two notes: a "snore" or "growl" and a "cluck," whereas the pickerel frog only makes a "snore" or "growl" note. A chorus of leopard frogs may sound like a chorus of wood frogs (*Lithobates sylvaticus*) if individual calls cannot be distinguished.

Ecology

These frogs breed in March and April. In intermittent waters, larvae must transform into adults before the breeding pool dries. One leopard frog breeding site just outside New York City is a stormwater pond that dries up during some summers; it is bordered on three sides by hardwood swamp that presumably functions as summer foraging habitat. Two other sites outside New York City constitute extensive flooded freshwater common reed (*Phragmites australis*) marshes that probably always contain some standing water. Another site is a flooded shrub swamp on a small stream.

Threats

Leopard frog populations in the New York metropolitan area presumably have suffered from loss and degradation of habitat. Leopard frogs may be more sensitive than other frogs and toads to acidification of habitats from acidic precipitation (Schlichter 1981). Southern leopard frog is sensitive to the interactive toxicity of ultraviolet radiation and agrochemicals or petroleum hydrocarbons (Butterfield et al. 2005). Methoprene, a mosquito control agent commonly used in New York City and elsewhere, can cause malformations in developing frogs (Butterfield et al. 2005). Leopard frogs may be susceptible to many other pollutants including other pesticides, heavy metals, PCBs, deicing salts, and excessive nitrogen.

In New York State, "southern" leopard frog is listed as Special Concern, which means that it warrants attention but is not protected under state law. In fact, as a game animal in New York these frogs can be hunted legally at certain times of year. New York Natural Heritage Program ranks this species as G5 S1S2, which means that it is common rangewide but imperiled or critically imperiled in New York; the ranked entity is almost certainly the undescribed species and therefore the "G" (global) ranking is probably incorrect.

Conservation and Management

Habitat conservation for leopard frogs includes protection of suitable wetlands from filling, draining, and pollution (including all the pollutants mentioned above); protection of substantial, undisturbed buffer zones surrounding those wetlands; and reduction of acidic precipitation. Coastal wetlands in New York City are often prime targets for mosquito control efforts. In addition to posing dangers to frog development, mosquito control chemicals may disrupt or limit prey availability for leopard frogs. Known leopard frog wetlands should not be treated, and safer treatments for other wetlands need to be developed (the bacterial larvicides Bti and

Bs, or a fungal larvicide, may be safer alternatives for mosquito control). Safe migration corridors between breeding pools and nonbreeding habitats, such as special culverts under highways, may be needed.

Survey Techniques and Constraints

Calling males should be sought in March and April (between dusk and midnight) in pool-like freshwater and slightly brackish wetlands. Tape-recorded calls can be used to elicit calling from wild males. Because leopard frog calls closely resemble calls of wood frogs in the New York City area, expert identification is necessary. Nonbreeding adults and juveniles should be sought in wetlands and adjacent vegetated uplands; however, it may be difficult to detect a small population using this technique. Walking slowly through vegetation and turning cover objects (such as boards) are good ways to look for leopard frogs. Disturbed adults flee with great agility into dense vegetation, such as sedge thatch, and conceal themselves. Larvae may be found by dipnetting or minnow-trapping in breeding pools, but are difficult to distinguish from pickerel frog larvae. This species should be documented by color photographs of live adults or tape recordings of calls.

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Diamondback Terrapin (*Malaclemys terrapin*)

By Terry Dickert

Habitat

The diamondback terrapin is the only North American turtle known to live exclusively in brackish water. Its coastal habitats include salt marshes, bays, estuaries, tidal creeks, and lagoons. Nesting occurs on upland habitats such as sandy beaches, dunes, sand and gravel trails (including railroad berms), grasslands, and shrublands (Feinberg and Burke 2003).

Distribution in New York City

- Bronx: near City Island, Pelham Bay Park
  (There is also a very small population in the Hudson River between the George Washington Bridge in NYC and the Tappan Zee Bridge in Westchester.)
- Brooklyn: Floyd Bennett Field, Jamaica Bay Wildlife Refuge, Four Sparrow Preserve, Marine Park
- Queens: Jamaica Bay Wildlife Refuge (with a "Terrapin Trail"), Alley Pond Park, JFK Airport (occasionally found on runways during nesting season), Public Place Park, The Rockaways
- Staten Island: Saw Mill Creek, Old Place Creek, Lemon Creek, Neck Creek, Bridge Creek, Prall's Creek, Richmond Creek, Main Creek

Description and Identification

The diamondback terrapin is named for the diamond pattern on its sculpted carapace (upper shell), which has large scutes (scales or plates) marked with concentric rings. Its shell coloration is extremely variable; the carapace ranges from gray to brown to black, while the unhinged plastron (lower shell) is usually yellow or olive green. A terrapin's typically light-colored skin often has a unique pattern of black spots, flecks, or squiggly markings. Many older individuals sport a dark mustache-like facial mark. Terrapins are medium-sized turtles and sexually dimorphic, with much larger females (6 to 9 inch shell length) than males (4 to 5.5 inch shell length) (Brennessel 2006, Gibbs et al. 2007).

Russell Burke

Diamondback terrapin adult; the white beak is often visible from a distance through binoculars.

Russell Burke

Close-up of beak.

Ecology

Diamondback terrapins reside year-round in the New York City area. During May and June, groups of terrapins congregate in offshore waters for the mating season. Female terrapins come on shore to nest in June and July. Females lay clutches of 3 to 18 eggs, with an average of 13 per nest, and can dig one, two, or three nests per year. After nesting, the females rejoin male terrapins in deeper waters to feed until winter hibernation (Day 2007). Terrapin eggs take 70 or more days to hatch. Some hatchlings emerge in late summer or early fall, while others overwinter in the nest and emerge the next spring. Slow-growing like many turtles, terrapins mature in three to eight years, with males maturing earlier than females (Burke 2007).

As broad-spectrum carnivores, terrapins are at the top of the coastal salt marsh food chain. They dine mainly on mollusks and crustaceans such as mussels, snails, clams, and crabs, crushing their prey with their powerful jaws. They may also eat minnows, some marsh plants, and algae.

Threats

With succulent flesh prized for turtle soup, diamondback terrapins were nearly extirpated from the region by intense harvesting from the mid-1880s until the 1930s. Their populations recovered somewhat after the Great Depression when turtle soup declined in popularity. The large-scale efforts from the 1850s to the 1960s to convert New York City shoreline marshes into uplands destroyed the vast majority of terrapin habitat in the region.

Current threats to terrapins include continued habitat loss and degradation; coastal development, dredging, filling, and marshland and beach alterations reduce both aquatic and nesting habitats for terrapins. Nitrogen pollution from sewage overflow and storm runoff affects bay and marsh vegetation. Nest predation by raccoons and other wildlife can destroy over 95 percent of terrapin nests, posing a serious threat to turtle eggs, hatchlings, and even some adults. "Root predation" may occur when beach plant roots penetrate eggs and absorb their nutrients (Lazell and Auger 1981). Terrapins face perils from boat propellers, automobiles and road construction,

Russell Burke

Female diamondback terrapin digging nest in sparsely vegetated, loose soil.

tide-borne debris, and drowning in crab traps, particularly lost or abandoned commercial "ghost traps." Even planes may be a threat when terrapins move across airport runways to reach nesting grounds (Newman 2011). Although harvesting levels have been greatly reduced since the 1930s, terrapins have been collected and sold as pets or food in some urban specialty markets. Climate change can be a long-term threat to diamondback terrapins because it may skew the sex ratio due to temperature-dependent sex regulation, and sea level rise may eliminate or alter critical habitat.

Conservation and Management

Because human disturbance can prevent nesting by female terrapins, beach visitors should keep a respectful distance from the turtles and not trespass on closed trails during the critical nesting season. Terrapins often cross roads in search of nesting sites, and while roadkill is not a major contributor to mortality in New York City, careful driving in nesting areas throughout their range is important, particularly in June and July. Implementation of fisheries laws requiring an excluder device, or "bycatch reduction" apparatus, on commercial crab traps can prevent many accidental turtle drowning deaths. Collection of terrapins is illegal in wildlife refuges and requires a license elsewhere in New York. Releasing terrapins "rescued" from pet stores or food markets into the wild is also illegal and can introduce new diseases into native populations.

Survey Techniques and Constraints

Terrapins are best surveyed during the nesting season as adult females move to and from upland nesting locations. Researchers are also developing a methodology for assessing population status using head count surveys (Harden et al. 2009).

Russell Burke

Hatching diamondback terrapin marked for individual identification in a research project.

Russell Burke

Diamondback terrapin adult and researcher.

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Freshwater and Land Turtles

By Kristen Bell Travis

Spotted turtle (*Clemmys guttata*)
Eastern box turtle (*Terrapene carolina*)
Eastern mud turtle (*Kinosternon subrubrum*)

Habitat

Spotted turtles are found in a wide range of wetland and pond habitats in the metropolitan region including nontidal marshes, fens, non-calcareous wet meadows, nontidal hardwood swamps, intermittent woodland pools, kettle shrub pools, ponds (natural and artificial), and probably supratidal pools and tidal marshes. Spotted turtles move readily among habitats, potentially covering large areas of the landscape. They spend periods of estivation (summer dormancy) in shallow wetlands (Ward et al. 1976) or upland habitats such as forests (John Behler, unpublished data).

Eastern box turtles inhabit a mosaic of upland hardwood and mixed forest, hardwood swamp, upland meadow, upland shrubland, and wet meadow habitats, and particularly favor the transition zones between habitats. They can occasionally be found in gardens and other open areas adjacent to woodlands. These turtles like to spend time in and near streams, ponds, and wetlands, but they are also found far from water in upland habitats. Box turtles spend dry periods estivating, buried partially to completely in leaf litter, and they overwinter buried shallowly in leaf litter and soil (they can survive freezing). They may travel over 2,360 feet (750 m) to nest, and seem to prefer to nest in open sites with sandy, well-drained soils (Ernst et al. 1994, Dodd 2001, Gibbs et al. 2007).

James P. Gibbs

Spotted turtle (*Clemmys guttata*).

John F. Bunnell

Eastern box turtle (*Terrapene carolina*).

Eastern mud turtles inhabit both freshwater and brackish wetlands, including marshes, small ponds, swamps, creeks, and water-filled ditches. This species prefers shallow, slow-moving waters with a soft bottom and aquatic vegetation. On Long Island, they may be found in brackish marshes and ponds dominated by common reed (*Phragmites australis*). Mud turtles nest in sandy soil or plant debris, and occasionally in rotting logs, muskrat lodges, or beaver lodges. They also frequently shelter in muskrat lodges. Mud turtles may stay on land (primarily estivating) for most of the year. They hibernate in sandy hillsides or litter at the edges of wetlands or underwater in soft mud (Ernst et al. 1994, Gibbs et al. 2007).

Distribution in New York City

One population of the **spotted turtle** may remain on Staten Island, but no individuals have been observed since 1998 (E. Pehek, personal communication, 2 October 2012). The species was reintroduced at Jamaica Bay; but whether it re-established there is unknown (Cook 2002). It is dormant from October to February, most active and visible in April, and nests in June.

Eastern box turtles are potentially present in all boroughs except Manhattan, although the last record for the Bronx was in 1997. Most viable populations are probably on Staten Island (E. Pehek, personal communication, 2 October 2012). The species has successfully re-established at sites in Queens and Brooklyn (Cook 2002). It is dormant in winter and is active only from May to October (nesting in June).

The **eastern mud turtle** is potentially present on Staten Island, but none has been observed since 1995 (E. Pehek, personal communication, 2 October 2012). The species was reintroduced at Jamaica Bay in Queens but whether it re-established there is unknown (Cook 2002). It is active only from April to October (nesting in June).

Robert T. Zappalorti/Nature's Film and Photo Images

Eastern mud turtle (*Kinosternon subrubrum*).

Description and Identification

The **spotted turtle** is a small turtle with a carapace (upper shell) to 4.7 inches (12 cm) in length. It is blackish above with discrete yellow "polka dots" on the head, neck, and carapace (2 to 3 spots per large scale on an adult carapace, but only one per scale on a hatchling). Its plastron (undershell) is yellow, with or without black blotches, and unhinged.

The **eastern box turtle** is a terrestrial turtle with a high, domed carapace up to 6 inches (15 cm) in length, usually with a low central keel. It is brownish above with extremely variable markings in yellow or orange. Its plastron and head may also have variable orange or yellow markings. The plastron has a single, strong hinge. Box turtles can completely withdraw all limbs and head inside their shell, which closes like a box, hence the common name. Males usually have red eyes and a concave plastron. Females have brown eyes and a flat plastron.

The **eastern mud turtle** is small, with a carapace to 4 inches (10 cm) in length. The smooth, unkeeled, oval carapace is usually a solid color brown, olive, or black. The plastron is yellow to brown, with two hinges. The head is dark brown with yellow mottling. The tail has a hard, horny "scale" over the tip. The common musk turtle or stinkpot (*Sternotherus odoratus*), found in similar habitats, has a plastron with only one hinge, in the front.

See Behler and King (1979), Conant and Collins (1998), and Klemens (1993) for more information.

Ecology

The **spotted turtle** feeds in the water, on aquatic plants, algae, insect larvae, small crustaceans, snails, tadpoles, and small fish. When disturbed it tries to burrow into the muddy bottom. Its predators include raptors, skunks,

and raccoons. In New York, females typically lay one clutch of one to eight eggs each year. Sex determination is temperature-dependent, with males produced at cooler temperatures. Eggs hatch in September to October, and hatchlings bury themselves soon after emerging, or else overwinter in the nest.

Eastern box turtles tend to have discrete home ranges that can be fairly small— less than 2.5 acres (1 ha) to 12 acres (5 ha), with a diameter of less than 984 feet (300 m) —but may move outside of these areas for nesting or overwintering. Some individuals ("transients") appear not to have a home range but instead keep traversing new ground, which could be a mechanism for genetic exchange. Invertebrates (especially insects, snails, slugs, and earthworms) make up the largest part of the box turtle's diet, but fungi and fleshy fruits and other plant parts are important food sources as well. At a Long Island study site, box turtles were found seasonally where specific foods such as berries and fungi were available (E. Kiviat, unpublished data). The turtles can be important agents of seed dispersal. They are also reported to eat carrion. Predators such as raccoons, skunks, dogs, rodents, crows, and various snakes will readily eat eggs and young turtles. Although larger adult turtles are better protected by their hard shell, they can also fall prey to raccoons and other larger mammalian predators (Dodd 2001). Clutches usually contain four to five eggs, and one mating can fertilize eggs for up to four years. Sex determination is temperature-dependent; hatchlings emerge in September to October.

Eastern mud turtles feed on crustaceans, aquatic insects, algae, and snails on the soft mud bottom. (This could make them particularly susceptible to accumulating contaminants from sediment.) Predators of mud turtles include weasels, foxes, crabs, fish, and snakes. Typical clutches are small (two to four eggs), and eggs hatch in August or September. Hatchlings may overwinter in the nest.

Threats

These three turtle species face similar threats in the urban environment of New York City. Because they move among different habitats for hibernation, foraging, nesting, and estivation, they are especially susceptible to highway mortality; fences and other barriers that block access to necessary habitats; and danger from "traps" (such as steep-sided pits) around buildings, roads, and construction sites. Since female turtles often travel longer distances than males (for nesting), they may experience higher mortality in urban areas, leading to a male-biased population (Marchand and Litvaitis 2004). Proximity to large human populations increases the likelihood of illegal turtle collecting. Fragmentation of suitable habitat leads to small, isolated turtle populations that are more vulnerable to inbreeding and extirpation. In many cases, remaining habitats have been substantially altered (with changed wetland hydrology or cleared forest understory), which may make them unsuitable for turtles. Predators associated with human habitats such as raccoons and skunks are major predators of turtle eggs, hatchlings, and adults, and turtles may be unable to reproduce successfully in areas where these animals occur at high densities. In urban areas, contaminants from industry, treated sewage, garbage disposal, and traffic end up in streams, soil, and wetlands, with largely unknown but potentially deadly effects on turtles. Climate change may be a long-term threat to all turtles with temperature-dependent sex determination.

In New York State, **spotted** and **eastern box turtles** are listed as Special Concern; they warrant attention but are not actively monitored by the New York Natural Heritage Program. Natural Heritage ranks **spotted turtle** as G5 S4: secure rangewide, and apparently secure in New York State. **Eastern box turtle** is G5 S3: secure rangewide but uncommon in New York State. **Eastern mud turtle** is listed as Endangered, with a ranking of

G5 S1: secure rangewide but critically imperiled in New York State. It is illegal to kill or possess any of these turtles in New York State.

Conservation and Management

Rigorous studies of the remaining populations of **spotted** and **mud turtles** on Staten Island are needed to determine population size, reproduction, and recruitment (the numbers of hatchlings that survive to adulthood). The same studies are needed for populations of box turtles wherever they occur, but especially on Staten Island where there is the best chance of maintaining self-sustaining populations. Such information will help inform future management.

Where turtle populations are known to occur or suitable habitat exists, wetlands should be protected from further eutrophication and pollution, and natural hydrologic regimes of flooding and drying should be maintained. Because turtles are vulnerable to illegal collecting, known locations of populations should not be published. Suitable fences and culverts installed where turtles need to cross roads could help reduce road mortality. Connected habitat for all essential life activities (nesting, overwintering, foraging, estivating, basking) needs to be preserved. In some cases, reintroduction of a species to an area of suitable habitat or introduction of individuals to an existing population (to increase genetic diversity) may be advisable; this should be done by experts and only after careful analysis, and after potential source populations have been quarantined in sterile conditions and tested for pathogens.

Survey Techniques and Constraints

Spotted turtles may be surveyed with baited aquatic hoop traps and eastern mud turtles with modified minnow traps or submerged box traps (E. Pehek, personal communication, 16 July 2012) when these animals become active in the spring (April to May). Trapping requires a scientific collector's license from the State Department of Environmental Conservation. All three species are most active terrestrially during the nesting season (May to June) as females travel to nesting sites. This is a good time for visual encounter surveys in appropriate habitats, and roadside surveys for living or dead turtles. All species tend to estivate (remain dormant) during dry periods in the summer and fall, partially or completely buried in uplands or wetlands. Therefore, visual encounter surveys in these seasons are best conducted during or after a rain, when turtles tend to move about. Dogs have been successfully trained to locate **box turtles** by scent. Drift fence arrays with pitfall traps have also been used to survey turtles moving in and out of different habitats. Radiotelemetry has been used successfully with many turtle species to track movements and habitat use through the seasons.

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Snakes

By Kristen Bell Travis

Eastern ribbon snake (*Thamnophis sauritus*)
Northern black racer (*Coluber constrictor*)
Northern ringneck snake (*Diadophis punctatus*)
Northern water snake (*Nerodia sipedon sipedon*)

Habitat

Eastern ribbon snakes are usually found near water, in vegetation bordering streams, ponds, swamps, or marshes. These snakes are primarily associated with calcareous wetlands including fens, circumneutral bog lakes, and some kettle shrub pools. In New York City there are no true calcareous wetlands or bogs, but eastern ribbon snakes have been observed in or near vernal pools and may be found at kettle shrub pools (E. Pehek, personal communication, 2010). They shelter in animal burrows and lodges, and may climb into vegetation.

Northern black racers prefer open habitats, such as shrubby old fields, pastures, open woodlands, forests, and sometimes areas near wetlands. The few sandy pitch pine forests in the five boroughs may provide the best habitats. Racers can be found basking in the open or in low shrubs, or resting under rocks or boards. They hibernate in burrows, rock outcrops, or rotted stumps. They may hibernate communally with other snake species, and sometimes travel great distances to dens.

Robert T. Zappalorti/Nature's Film and Photo Images

Eastern ribbon snake *(Thamnophis sauritus)*.

Robert T. Zappalorti/Nature's Film and Photo Images

Northern black racer *(Coluber constrictor)*.

John F. Bunnell

Juvenile northern black racer. Note different color patterns from adult.

Northern ringneck snakes inhabit forests where there are patches of moist soil, sunny areas (such as forest edges, clearings, or gaps from fallen trees), and abundant cover objects (such as logs, rocks, and debris). These snakes are often found under cover objects, and are most active at night. They hibernate in brush or rock piles, rotting logs, burrows, or rock outcrops.

Northern water snakes are indeed aquatic and are rarely found far from their permanent freshwater habitats. These include streams, rivers, ponds, lakes, swamps, marshes, wet meadows, and roadside ditches. Water snakes use dams, dikes, muskrat and beaver lodges, and stream banks for basking, shelter, and overwintering sites.

Distribution in New York City

The **eastern ribbon snake** is present on Staten Island; whether it occurs in the other boroughs is unknown (E. Pehek, personal communication, 2010). The snakes are present all year but dormant from approximately October to March.

The **northern black racer** is present on Staten Island and has become re-established at Jamaica Bay Refuge in Queens and probably at Floyd Bennett Field in Brooklyn after reintroduction (Cook 2002). It is present all year but in hibernation from October to April.

The **northern ringneck snake** is present in Staten Island's serpentine barrens but its status in the other boroughs is unknown (Pehek 2002). It is present all year but dormant from October to March.

The **northern water snake** is present on Staten Island. It has been recorded at Alley Pond Park in Queens (NYS DOS Division of Coastal Resources, no date). The species was reintroduced at Jamaica Bay, but whether it has become re-established there is unknown (Cook 2002). Present all year, it is active from April to October.

Ellen Pehek

Northern ringneck snake *(Diadophis punctatus).*

Robert T. Zappalorti/Nature's Film and Photo Images

Northern water snake (*Nerodia sipedon*).

Description and Identification

The **eastern ribbon snake**, a medium-sized, slender snake, is longitudinally striped with brown and yellow. Its maximum total length is about 29.5 inches (75 cm). Its very long tail is about one-fourth to one-third of the total length. It has keeled scales with a single anal scale. A lateral yellow stripe on scale rows three and four distinguishes the eastern ribbon snake from the similar eastern garter snake (*Thamnophis sirtalis*) with a yellow stripe on rows two and three; this characteristic can be seen through binoculars at a range of a few meters. Ribbon snakes are "skittish," appear to flee quickly, and are harder to catch than garter snakes.

The **northern black racer** is a large, slender, glossy black snake up to 75 inches (190 cm) long. Its belly is gray to black; some white scales are scattered on its chin and throat. Young racers have a strong pattern of red or brown blotches on a gray background. Black racer body scales are smooth. The similar-looking eastern rat snake (*Pantherophis alleghaniensis*) has keeled scales and is thicker in proportion to its length.

The **northern ringneck snake** is a small, slender bluish-gray snake with a bright yellow or orange ring behind the head. Its belly is yellow to reddish-orange. Its body length is up to 15 inches (38 cm).

The **northern water snake** is a large, heavy-bodied snake up to 42 inches (107 cm) long. Its back is patterned with brown or reddish cross bands or blotches on a gray or brown background, although older individuals may be so dark that the pattern is not apparent. Its belly is white to yellow, usually with crescent-shaped reddish spots.

For more information, see Behler and King (1979) and Conant and Collins (1998).

Ecology

Snakes are carnivores (secondary consumers); as such, they are important in maintaining ecological balance in urban as well as rural environments. Some species eat a variety of prey; others have a specialized diet. Snakes

tend to be very secretive, spending most of their time under cover objects, underground, or well-camouflaged and nearly invisible in plain view. Nonetheless, many routinely travel long distances to meet their requirements for food, shelter, and reproduction.

Eastern ribbon snakes feed mostly on amphibians. They forage actively in the morning and evening. The species is ovoviviparous, giving birth to 10 to 12 live young in July or August.

Northern black racers are active, diurnal hunters, often foraging with neck and head elevated. They eat a varied diet of arthropods, lizards, frogs, bird eggs and nestlings, snakes, and small mammals. Clutches of usually 9 to 12 eggs are laid in June or July and hatch from July to September.

Northern ringneck snakes feed mainly on earthworms, salamanders, and small insects. They forage at night, and during the day often aggregate (up to 10 individuals) under cover objects. They commonly lay 3 to 4 eggs in rotting logs, organic debris, or under rocks in June or July, and hatchlings emerge from August to September.

Northern water snakes feed primarily on fish, frogs, salamanders, and tadpoles. They forage actively along the water edges and are excellent swimmers. They tend to be diurnal in spring and fall, and nocturnal in summer. When startled, water snakes escape by diving to deeper water and remaining submerged. They are ovoviviparous, giving birth to 20 to 50 live young in August or September. In a partially urbanized area, they were found to have home ranges of approximately 1.24 acres (0.5 ha), to be relatively sedentary when not foraging, and to exhibit high site fidelity, returning to the same locations again and again (Pattishall and Cundall 2008).

Threats

Loss and degradation of habitat are the most serious threats to these snakes. Motor vehicles also pose a threat, and road mortality may have a significant impact on small snake populations. Negative public perception of snakes is also a problem, since people often kill snakes when they encounter them. None of these species is listed as endangered at the state or federal level, or monitored by the New York Natural Heritage Program. However, they are of conservation concern in the City because their populations are very local and widely separated. With only one population, the **northern ring-necked snake** may be the rarest (E. Pehek, personal communication, 2010). The **northern black racer** and **eastern ribbon snake** are listed by the Department of Environmental Conservation as Species of Greatest Conservation Need in New York State (see Appendix B).

Conservation and Management

For snakes associated with aquatic habitats or wetlands (such as eastern ribbon and northern water snakes), Semlitsch & Bodie (2003) recommended leaving a buffer of 551 to 997 feet (168 to 304 m) around the wetland to protect core terrestrial habitat. It is also important to promote connectivity among appropriate habitats, including safe routes under highways. Snakes often have large home ranges and need to travel long distances between foraging, basking, hibernating, and nesting areas. Educating the public about the ecological importance and harmlessness of snakes is sorely needed to help turn popular misconceptions into appreciation.

Survey Techniques and Constraints

Snakes are notoriously difficult to survey. They spend much of their time concealed and quiescent, and when encountered often escape too quickly for definite identification or capture. Surveying requires long periods of

time in suitable habitats during ideal weather conditions. Even then, not observing a species should never be interpreted as its absence. Searching under cover objects may increase the likelihood of finding **ringneck snakes.**

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Long-legged Wading Birds

By Jennifer Stenzel and Susan Elbin

Great blue heron (*Ardea herodias*)
Great egret (*Ardea alba*)
Snowy egret (*Egretta thula*)
Tricolored heron (formerly Louisiana heron) (*Egretta tricolor*)
Little blue heron (*Egretta caerulea*)
Cattle egret *(Bubulcus ibis*)
Green heron (*Butorides virescens*)
Black-crowned night-heron (*Nycticorax nycticorax*)
Yellow-crowned night-heron (*Nyctanassa violacea*)
Glossy ibis (*Plegadis falcinellus*)

Habitat

Long-legged wading birds can be found in a wide variety of aquatic habitats. They are a part of a larger group of birds called colonial waterbirds, which also includes gulls, terns, and cormorants. As the name implies, hundreds to thousands of pairs from one or several of these species nest together in large congregations called rookeries or breeding colonies. Among the benefits of nesting in colonies are increased predator detection,

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Great egret (left), snowy egret (right), and glossy ibis in flight.

increased predator avoidance, increased food-finding ability, and increased opportunity to find mates. In general, colonies are located on islands, which provide additional protection from predators, freedom from human disturbance, adequate supporting structures, material for nest-building, and nearby foraging areas. Some species (such as great blue herons) form colonies on mainland sites, including edges of ponds or wetlands, and others (such as yellow-crowned night-herons) in housing developments (Bernick 2005, Bernick 2007, Craig 2011).

Most long-legged wading birds in New York City build their nests in small- to medium-size trees and tall shrubs, and a few build on the ground. In other areas, some build nests in dense, tall patches of common reed (*Phragmites australis*), but this has not yet occurred in New York City. Based on a single study in Delaware Bay, it appears that common reed is as good for nest support as woody plants, or nearly so, and reedbeds can also provide a buffer against human intrusion (Parsons 2003).

Distribution in New York City

Colonial waterbirds can be found throughout the five boroughs, foraging in freshwater and tidal ponds, marshes, creeks, and mud flats. Even though it is located along one of the most heavily developed corridors in the northeastern United States, New York Harbor supports the largest breeding population of colonial water birds in the region. The harbor-wide breeding population of long-legged wading birds has remained constant since the mid 1990s even as numbers of breeding pairs on individual islands have changed. In the late 1980s, colonies first appeared in the "Harbor Heron Complex" located along the Arthur Kill and Kill van Kull along the western shore of Staten Island. This complex consists of 2,196 acres of undeveloped land, including tidal and freshwater marshes, a pond, creeks, and several islands. By 2005, nesting activity had shifted and mixed-species colonies began to grow in lower New York Bay on Hoffman Island; in Jamaica Bay on Canarsie Pol; and in the East River on South Brother Island. Shifting concentrations of breeding colonies is characteristic of long-legged wading birds, and colonies may return to the Arthur Kill/Kill van Kull islands in the future (Craig 2011).

Description and Identification

Colonial wading birds are medium to large birds that have long legs, necks, and bills, features that help them to capture prey while wading in shallow water.

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Black-crowned night-heron.

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Snowy egret.

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Glossy ibis.

The **great, cattle,** and **snowy** egrets have white plumage and range in size from the **cattle egret** (~ 20 inches in length) to the **great egret** (~ 3.5 feet tall). Adult cattle egrets have a yellow-orange bill and legs, with buffy orange plumage during the breeding season; **snowy egrets** have black legs, bright yellow feet, and a black bill; and the **great egret** has black feet and legs and a yellow bill.

Great blue herons are the largest of the herons (almost four feet tall) with blue-gray plumage and a thick yellow bill. **Tricolored herons** have purple to gray-blue feathers with a white chest and belly and a rust-colored neck. **Little blue herons** stand about two feet tall and have dark slate blue feathers, a reddish head and neck, and a dark bill. In contrast to most other herons whose young more closely resemble adults in coloration, immature little blue herons are white. **Green herons** are small herons about the size of a large crow with a greenish-black head, chestnut neck, dark body, and yellow legs.

Night-herons are stocky, short-legged birds with thick bills. Adult **black-crowned night-herons** have a white belly, gray wings, and a black back and cap, while **yellow-crowned night-herons** are gray with a black head with a white crown and head stripe. Both are about two feet tall.

Glossy ibis stand about 20 inches tall and have dark purple to black plumage with an iridescent blue-green gloss.

The NY/NJ Harbor Estuary Program and NYC Audubon have produced a good Guide to Harbor Herons.

Ecology

Wading birds are sometimes called "indicator species," because they are top predators in estuarine and aquatic food webs (Kushlan 1993). By monitoring the effect of their diet (fish, frogs, crustaceans, and even small mammals) on their survival and ability to reproduce, scientists gain valuable information about the condition of the entire ecosystem. For example, toxicology studies from 2003 found high levels of heavy metals and DDT metabolites in double-crested cormorant (*Phalacrocorax auritus*) eggs. Recent (2009) unpublished studies on herring gull (*Larus argentatus*) eggs show high concentrations of organochlorine pesticide derivatives as well as legacy contaminants (S. Elbin, personal observation). Because of the industrial setting of many of the harbor islands, oil spills from refineries and oil leaks from ships and barges can degrade habitats and contaminate fish and other aquatic prey (Burger 1994, Maccarone and Parsons 1994). Colonial wading birds create unusual habitats in their nesting colonies. The soil is fertilized with the nitrogen and other nutrients in the birds' excrement, and the bodies of dead or ill nestlings that fall to the ground attract predators. Nitrogen-associated plants and lichens, and dung-feeding invertebrates are important features of these colonies. Songbirds and other small animals may nest or live within the large stick nests of the wading birds.

Threats

In the 1800s, the feathers of wading birds, especially egrets, were very popular in the millinery trade and were used in ladies' hats. Wading birds were hunted so extensively that, partly out of concern for their continued survival, the U.S. Lacey Act of 1900 was passed to regulate interstate and international trade of animal parts. The passage of the Federal Clean Water Act in 1972 also benefited wading birds in New York City, as it resulted in significant improvements in water quality.

At present, the most serious threats to wading birds include loss of feeding and breeding habitat (particularly

related to loss of freshwater wetlands); oil pollution associated with tanker traffic and spills; residual contamination by metals, PCBs, and other toxicants in estuarine food webs; entanglement in fishing gear; predation at breeding colonies by native and introduced species (hawks, raccoons, and rats); and human disturbance at the breeding colonies (Burger 1986; Elbin and Tsipoura 2010).

Recent threats also include management practices to address nonnative invasive species such as the Asian long-horned beetle (ALB) (*Anoplophora glabripennis*) (Bernick 2007). ALB is a recently-spreading nonnative insect that can kill many species of trees, and it is likely that it will affect New York City woodlands and the organisms that depend on those trees. Accepted containment practices recommended by the USDA to halt the spread of this beetle require the removal of trees within a prescribed distance from an infested tree. In 2007, evidence of ALB prompted removal of about 3,500 gray birch and red maple trees from Prall's Island, an uninhabited island off Staten Island in the Arthur Kill. These trees were important nesting and roosting habitat for wading birds. Closer coordination among land managers is key to balance the needs of all species in conservation action.

Conservation and Management

In November 2001, the New York State Department of Environmental Conservation (DEC) designated the state-owned portion of the Harbor Herons Complex as a "Bird Conservation Area." It covers 111 acres (Goethals Bridge Pond, adjoining wetlands, and property along Old Place Creek) and includes much of the important foraging habitat that lies within New York City (Blanchard et al. 2001). The Bird Conservation Area program was established by the DEC in 1997, and was modeled after the National Audubon Society's Important Bird Areas (IBA) program. Its goal is to safeguard and enhance bird populations and their habitats on State lands and waters (see Management Guidance Summary for the Harbor Herons Complex). In 2010 the Harbor Herons subcommittee of the Harbor Estuary Program completed the Harbor Herons Conservation Plan for the New York/New Jersey Harbor.

In addition, North and South Brother Islands in the East River and Shooters Island, Isle of Meadows, and Prall's Island in the Arthur Kill/Kill van Kull are designated IBAs for New York State. These islands are owned by the New York City Department of Parks and Recreation.

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Great egret.

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Nesting colony of egrets and herons.

Success of the colonies requires ample foraging areas (Brzorad et al. 2004), many of which remain unprotected. Protection of these wetland foraging sites and clean-up of contaminants in other foraging areas should be a high priority.

Survey Techniques and Constraints

New York City Audubon surveys the Staten Island sites as part of their annual Harbor Herons surveys. The New York Harbor Surveys are conducted during the same time of year (mid- to late May) and coordinate well with the New York State Department of Environmental Conservation's Long Island Piping Plover and Waterbirds Surveys. All surveys are conducted in a way that minimizes human disturbance to the birds and time spent on the colony.

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Secretive Marsh Birds: American and Least Bitterns

By Nancy Slowik

Habitat

The **American Bittern** (*Botaurus lentiginosus*) and **Least Bittern** (*Ixobrychus exilis*) are closely related and sometimes found breeding and foraging in the same habitat. Their cryptic color, secretive nature, and inaccessible habitats make these two species difficult to find and study.

American bitterns nest in nontidal freshwater marshes with tall emergent vegetation, but can also be observed in tidal marshes during migration and in winter. Platform nests are typically built on tussocks of emergent vegetation located in dense stands of cattails (*Typha*) or reeds (*Phragmites australis*) and surrounded by shallow water. Nests are occasionally built on drier ground, in upland fields surrounded by dense, tall grasses. The nests are constructed of plant material consisting of reeds, sedges (*Carex*), or other vegetation (Lowther et al. 2009). Evidence suggests that American bitterns prefer to nest in large wetlands of at least 25 acres; however, breeding birds have been found in wetlands as small as 3 acres (Gibbs and Melvin 1998).

Least bitterns can be found in both freshwater and brackish marshes with tall emergent vegetation. Bulrushes and cattails are preferred nesting vegetation in northern areas, but least bitterns may also nest along the edges of lakes and rivers in marshes with some woody vegetation (Poole et al. 2009). Common reed is sometimes suitable nesting habitat. Ground nests are placed on an elevated platform of plants with a protective canopy of tall grasses pulled over the nest and attached to surrounding vegetation (Poole et al. 2009).

Barbara Saunders

American bittern (*Botaurus lentiginosus*) in Central Park.

Barbara Saunders

Fledgling least bittern (*Ixobrychus exilis*) with vestiges of nestling down.

Both species can occupy the same habitat since they have different feeding habits and breeding cycles. They both require extensive marshes for breeding. Spring floods may destroy initial nest sites, but both species can rebuild.

Distribution in New York City

The decline of the **American bittern** can be linked to the expansion of landfill practices encroaching on their breeding habitat, especially in the New York City area. American bitterns were confirmed to breed in a cattail swamp on Staten Island in 1948, and an immature bird was reported at Goethals Bridge Pond on Staten Island in 1980 (Siebenheller 1981). This species was listed in the 1980-1985 New York State Breeding Bird Atlas as a possible breeder on the north shore of Staten Island and on the south shore of Queens. None was reported in the New York City area in the 2000-2005 State Breeding Bird Atlas (McGowan and Corwin 2008). They were reported in the 1993-1996 New Jersey Breeding Bird Atlas as locally common in appropriate habitat, but listed overall to be declining as a breeder (Walsh et al. 1999).

Least bitterns were discovered breeding at the former Clay Pit Pond on Staten Island in 1948, but the area was subsequently destroyed by landfill (Siebenheller 1981). This species was listed as a probable breeder on the north shore of Staten Island and confirmed on the south shore of the Brooklyn-Queens border in the 1980-1985 New York State Breeding Bird Atlas. The most recent (2000-2005) Atlas lists the species as probable in the same locations (McGowan and Corwin 2008). The 1992-1996 New Jersey Breeding Bird Atlas lists the species as an uncommon, local summer resident in that state, noting that bittern numbers may be underestimated due to difficulties in confirming their status (Walsh et al. 1999).

Description and Identification

The **American bittern** is a medium-sized, stout-bodied heron. Adult plumage is brown and heavily streaked with a rusty crown and white throat. The distinguishing field mark is a long, black neck patch. Sexes are similar in color and pattern but not size, with females being slightly larger (Lowther et al. 2009). This species can be confused with immature night-herons, but the loud and distinctive booming call of the American bittern is diagnostic.

The **least bittern** is one of the smallest herons in the world. The sharp contrast in plumage colors is the distinguishing field mark for this species: Its dark crown, back, and tail set off the rich brown and white of the neck, side, and breast. The sexes are dimorphic in plumage, but similar in size (Poole et al. 2009).

Ecology

American bitterns utilize stealth techniques to locate food, remaining motionless in tall vegetation along the shoreline until they strike their prey. Their diet includes insects, amphibians, small fish, and small mammals. They are most active at dawn and dusk (Lowther et al. 2009).

Least bitterns are able to feed near open water by perching on and grasping plants with their feet and snatching insects and small fish. This technique enables them to exploit deeper water, a niche that precludes other herons. They can also construct small feeding platforms to capture prey, or may stand at the edge of a tidal creek to catch fish at low tide. Their diet includes frogs, tadpoles, snakes, crayfish, and small mammals. Least bitterns seem to be more tolerant of human presence than American bitterns (Poole et al. 2009). Their ability to remain attached to a reed swaying in the wind enhances their camouflage, making them very difficult to locate.

Both bittern species will freeze and stand erect, with their head and bill held upright.

Threats

The continued loss of wetland habitat remains the greatest threat to these species. Fragmentation and degradation may also contribute to the species' decline, particularly for American bitterns. Polluted runoff may adversely affect their food sources (Gibbs and Melvin 1998). Common reed is often considered an invasive plant and its presence used to designate a wetland as degraded habitat. However, Rich Kane of New Jersey Audubon found that common reed can support a wide variety of nesting bird species, including both bitterns (Kane 2001). **American bittern** is listed by the New York Department of Environmental Conservation as a Species of Greatest Conservation Need and a Species of Special Concern in the State. The Natural Heritage Program rank is S4, indicating that it is currently relatively secure in New York State (New York Natural Heritage Program 2005). **Least bittern** is listed as threatened in New York State and is a Species of High Concern in the Mid-Atlantic/New England/Maritimes Regional Waterbird plan. The Natural Heritage Program rank is S3 (see Appendix B).

Conservation and Management

The secretive nature and cryptic color of these two species may limit reporting on their abundance in the New York City area. Identification of appropriate habitat would be the first step in locating breeding sites since they are selective about habitat and vegetation. Studies should be conducted to determine if either species has adapted to using habitat dominated by nonnative plants in either tidal or nontidal marshland. Conservation of both species is linked to the preservation of freshwater and brackish wetlands, and their protection from polluted runoff, siltation, fragmentation, and possibly nonnative plants. In addition, stable water levels must be maintained during the April to August breeding season (Gibbs and Melvin 1998).

Survey Techniques and Constraints

Surveys should be conducted at dawn or dusk since both species are crepuscular. Both birds, American bitterns in particular, are best detected by their calls. At low population densities, least bitterns may not sing much or even respond to call playback, so may be difficult to detect. Freshwater wetlands with tall emergent vegetation are preferred, but drier upland grasslands should not be overlooked for American bittern. Cattails, bulrushes, and sedges are the preferred emergent vegetation, but common reed should also be investigated. Least bitterns may be able to nest in more urbanized settings because of their tolerance of human presence (New York Natural Heritage Program 2011). Nighttime surveys may be necssary to detect least bittern breeding calls.

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American Kestrel (*Falco sparverius*)

By Robert DeCandido

Habitat

In the northeastern United States, American kestrels can be found in two distinct environments: rural areas, particularly agricultural land, and urban areas. In rural areas, these small falcons hunt in crop fields, grasslands, and open shrublands. Rural kestrels nest in tree cavities and nest boxes placed on barns and utility poles. In urban areas such as New York City and Paterson, NJ, kestrels commonly perch above city streets watching congregations of house sparrows (Passer *domesticus*), their major prey. Kestrels can be found hunting from along Broadway in Manhattan to abandoned landfills in the outer boroughs. In cities, kestrels prefer to nest in holes in the cornices of late 19th Century buildings, approximately 40 to 120 feet above street level.

Distribution in New York City

American kestrels nest in all five boroughs. They are most common in areas that have large numbers of late 19th Century buildings with metal (or wooden) cornices containing holes. Here, kestrels nest in proximity to European starlings (*Sturnus vulgaris*) and rock pigeons (*Columba livia*). The largest concentration of nesting

Melanie Mason/NJ Division of Fish and Wildlife

Male American kestrel (*Falco sparverius*).

Charles Barreca

Female American kestrel in nest box.

kestrels in the City is on the Upper West Side of Manhattan, where an estimated 8 to 12 pairs nest from 59th to 125th streets (DeCandido and Allen, personal observation, 2010). In winter, several of these pairs can be found hunting house sparrows in Riverside Park. Overall, between 50 and 75 pairs of kestrels nest in New York City, probably the largest number of nesting pairs in the State (DeCandido and Allen 2010). American kestrels are also common breeders in older sections of Brooklyn, Queens, and the Bronx. However, they are very rare breeders on Staten Island, where most buildings were constructed after World War II and lack cornices (DeCandido and Allen, personal observation, 2010).

The first published account of nesting kestrels in New York City was in 1915, but these falcons were likely common nesters by the mid- to late 19th century with the introduction of the house sparrow. The number of nesting pairs peaked in the 1960s to 1970s when there were numerous abandoned and declining buildings throughout the City. In the South Bronx and Brownsville, Brooklyn, for example, kestrels were reported to nest inside abandoned buildings. Since then, and especially since 1995, buildings throughout the City have been repaired, with holes in cornices filled in and cornices removed or replaced, so fewer kestrel pairs nest here today. Only a small number of kestrel pairs are known to nest in New York City parks (DeCandido and Allen, personal observation, 2010).

Description and Identification

Kestrels are about the size of a blue jay (*Cyanocitta cristata*) or American robin (*Turdus migratorius*). Like all falcons, they have long, slender wings that cross their tails when perched. Females have brown wings and streaking on the breast and abdomen, whereas males have blue wings and a light-orange breast with spots. Both sexes have a distinctive call: "killy-killy-killy."

Ecology

In New York City, American kestrels may begin visiting previous years' nest sites on the warmer days of February; most begin in early March. Pairs usually sit outside the future nest cavity (and may explore additional ones in

the neighborhood) for a few days. During this time they begin copulating, and by mid-March, most kestrel females are sitting on eggs. In approximately 30 days (mid-April), the eggs hatch. Broods in the City average 3 to 4 young, with 5 being the highest number seen here. Young kestrels are fed a diet of mainly house sparrows with an occasional American goldfinch (*Spinus tristis*) or house finch (*Carpodacus mexicanus*). Kestrels are great nest raiders and often seize young birds from other species' nests. The larger female kestrels may occasionally even catch European starlings. In some parts of the City (Queens, Brooklyn, the Bronx, and the Upper East Side and Upper West Side of Manhattan), kestrels have been observed bringing Italian wall lizards (*Podarcis siculus*) to their nests (Burke et al. 2010). New York City kestrels also catch house mice (*Mus musculus*), dragonflies, bees, an occasional day-flying little brown bat (*Myotis lucifugus*), and, during the spring and autumn migrations, small passerine birds in City parks (DeCandido and Allen, personal observation, 2010).

By late May, young kestrels begin to leave the nest (fledge). Fledging peaks in mid-June. Each year, about 30 to 75 young kestrels end up on the ground before they can fly, and are brought to raptor rehabilitators in New York City and New Jersey. Researchers have not found kestrels raising second broods in the City during a breeding season (as they sometimes do in the Midwest at this latitude). By early August, young kestrels fly well and wander widely. Some migrate south—in fact, one banded New York City kestrel was found dead in Florida in 2005. It is believed that most adult pairs stay on or near their breeding territories in winter in the City since they have been observed here from December to February. However, the degree to which young and adult kestrels in the City shift their winter ranges (and/or migrate south) needs further investigation.

More than 99 percent of the kestrel nests found in the City have been in building cornices. Occasionally a pair will use a nest box on an abandoned landfill (as in Pelham Bay Park in the Bronx), but otherwise cornices on late 19th Century buildings are a keystone resource for New York City kestrels. Since both adult and nestling kestrels feed primarily upon house sparrows, this nonnative bird should also be considered a keystone resource (DeCandido and Allen, personal observation, 2010).

Threats

Along with the eastern screech-owl (*Megascops asio*, formerly *Otus asio*), another cavity-nesting raptor in decline in New York City, kestrels seem to be vulnerable to animals that use tree cavities, such as eastern gray squirrels (*Sciurus carolinensis*), raccoons (*Procyon lotor*), and sometimes European starlings. Kestrels are occasionally preyed upon by other raptors when they hunt in more open areas like parks. Such predators include red-tailed hawks (*Buteo jamaicensis*), Cooper's hawks (*Accipiter cooperii*), and peregrine falcons (*Falco peregrinus*). Young kestrels, especially those still in the nest, sometimes contract frounce (*Trichomonas*), a protozoan disease commonly seen in urban areas that constricts the esophageal region, leading to starvation. Early studies of lead and mercury levels in nestling kestrels show no significant (harmful) amounts of these toxins in New York City birds (C. Seewagen, personal communication, no year).

Conservation and Management

In 2011, researchers (Art Gingert and Robert DeCandido) began placing nest boxes for kestrels in Manhattan and the Bronx. Although as of 7 June 2012 boxes had not been used, the hope is that kestrel pairs will adopt them eventually instead of nesting in building cornices, which are being repaired or removed.

Survey Techniques and Constraints

Researchers in the City have formed a network of kestrel "spies" to report sightings of the birds in each of the five boroughs. (See http://www.battaly.com/nehw/AmericanKestrel/ for how to report a kestrel sighting and what to look for.) To find kestrels, observers walk along City streets looking for any perched atop buildings, on antennas, and on railings of balconies. Although there is no citywide banding program as yet for kestrels (2012), some young kestrels are occasionally banded each year when brought to raptor rehabilitators, who often have U.S. Fish and Wildlife Service bands.

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Owls

By Kristen Bell Travis

Barn owl (*Tyto alba*)
Eastern screech-owl (*Megascops asio*)
Great horned owl (*Bubo virginianus*)
Snowy owl (*Bubo scandiacus*)
Barred owl (*Strix varia*)
Long-eared owl (*Asio otis*)
Short-eared owl (*Asio flammeus*)
Northern saw-whet owl (*Aegolius acadicus*)

This profile covers the owl species that regularly occur in New York City. Other owl species recorded from the City, such as the burrowing owl (*Athene cunicularia*) and boreal owl (*Aegolius funereus*), for example, are accidental species (J. DiCostanzo, personal communication, 30 September 2012) and their occurrence cannot be predicted or managed. Some owls nest in the City (B) while others are only winter residents or migrants (W). Some species may be attracted to urban environments because of plentiful prey, low risk of predation, or available nest sites.

Habitat

The **barn owl (B)** is near its northern range limit in New York City, although the recent New York State Breeding Bird Atlas shows them as confirmed breeders in Ulster County and they have been known to nest as far north as Lake Erie and the Canadian border (J. DiCostanzo, personal communication, 30 September 2012). These owls prefer open habitats, including meadows, marshes, and agricultural fields. They can coexist with humans and occur in cities, towns, and farms around the world. Their distribution appears to be limited by suitable

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Adult barn owl (*Tyto alba*).

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Barn owl nestlings.

nest (and roost) sites: tree holes, cliff or bank cavities, nest boxes, rock ledges, or buildings. They will also roost in trees with dense canopies. Barn owls generally use the same territory year-round.

Eastern screech-owls (B) usually inhabit open woods at forest edges. They use tree cavities and dense vegetation for roosting (Gehlbach 1995). They nest in hollow trees or nest boxes, and may be limited by available nest sites (Smith et al. 1987). In Manitoba, eastern screech-owls were found to be closely tied to riparian habitat and to occur at higher densities and produce larger broods with earlier fledging dates in moderate- and high-density suburban areas than in low-density suburban and rural areas (Artuso 2009). Screech-owls in a rural-to-urban gradient just north of New York City were found to occur at increasing densities in more urban conditions (those with less forest cover and more impervious surface; Nagy et al. 2012). They may have higher survival rates in suburban and urban settings due to fewer predators, more prey, and the ease of hunting in lawn areas.

Great horned owls (B) are habitat generalists, and can be found in almost every climate zone in North America. Favored habitats include young or open forests, swamps, agricultural areas, and orchards. These owls prefer a mosaic of wooded, edge, and open habitats, and seem to benefit from habitat fragmentation and human use (Smith et al. 1999). They roost in trees (particularly conifers), thick brush, or human structures. They nest in trees near forest edges or in urban parks, using the old nests of crows, squirrels, or other raptors; they will also lay eggs on platforms, in old structures, or on the ground. Wooded parks in the City often provide an open understory—good for hunting—and large trees for roosting and nesting. Breeding and winter habitats are similar, as most great horned owls maintain the same territory year-round.

The **snowy owl (W)** breeds in high, rolling tundra, and its preferred winter habitat resembles those open spaces—meadows, marshes, dunes, low shrublands, airports. Snowy owls also frequent towns and cities. They choose habitats where prey and hunting perches (slight rise in a meadow, fence post, telephone pole, human structure) are most available.

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Eastern screech-owl.

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Great horned owl.

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Snowy owl.

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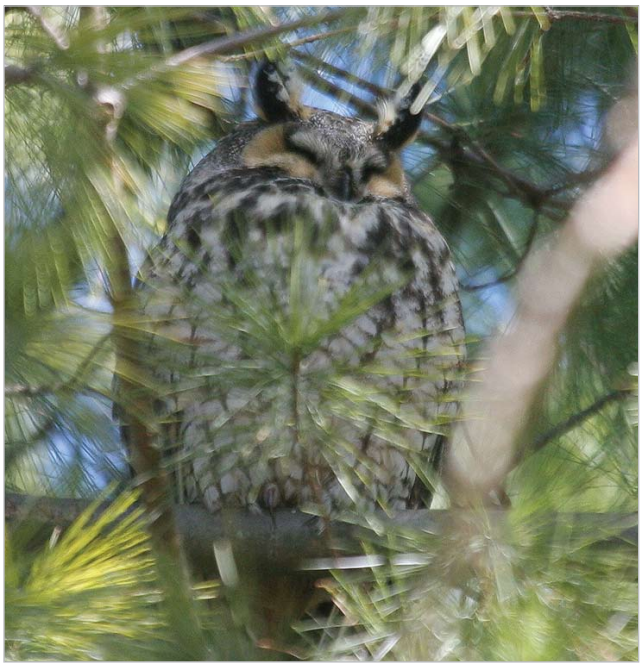
Barred owl.



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Long-eared owl.

Barred owls (**W**) depend on mature and old-growth forests (upland forests as well as swamps), typically of mixed hardwoods and conifers. They roost in tree branches or cavities (hardwood or conifer). They prefer large, unfragmented forests and tend to avoid agricultural areas and young forest. However, some populations do well in suburban areas with only moderate forest cover (about 41 percent, Dykstra et al. 2012). Their home range is usually the same year-round; the rare individuals seen in the city may be transients displaced by winter food shortages, or dispersing juveniles.

Long-eared owls (**W**) use open habitats such as grasslands and shrublands for hunting, and adjacent dense vegetation (brush, tree groves, forest edges) for nesting and roosting. In winter, they roost in particularly dense vegetation, often conifer stands. They may roost communally in trees in winter, and sometimes share roosts with short-eared owls.

S**hort-eared owls** (**W**) occur in open habitats, including meadows, shrublands, marshes, coastal grasslands, and agricultural areas. These owls may roost in trees, but generally roost on or near the ground, concealed in tall grass or shrubs. They may roost communally in winter, and winter roosts are often occupied in successive years.

The **northern saw-whet owl** (**W**) is found in forests and woodlands, especially conifer forests. These owls need dense vegetation for roosting and perches for foraging. Their winter habitat in coastal Maryland was found to usually be pine forest or shrub swamp (Churchill et al. 2002).

Distribution in New York City

Barn owls are found throughout the City, including Jamaica Bay Wildlife Refuge and Pelham Bay Park, Floyd Bennett Field, Forest Park, Mariner's Marsh Preserve, and Saw Mill Creek Park (Day 2007). They have been reintroduced in several parks. These owls are common all year, including breeding season. They nest at any time of year, often using buildings or nest boxes (DeCandido and Allen 2010). Large numbers also migrate through the area (Duffy and Kerlinger 1992).

The **eastern screech-owl** is present, although uncommon, throughout the City all year, and apparently is nesting in Inwood Hill Park in Manhattan, several parks in the Bronx, and many locations on Staten Island. The species has bred in Central Park. It may nest earlier in the year in New York City than elsewhere in the State (DeCandido 2005).

The **great horned owl** occurs in wooded parks throughout the City, including Pelham Bay, Van Cortlandt, Inwood Hill, Prospect, and Alley Pond Parks, the New York Botanical Garden, and many locations on Staten Island. It is common all year, including during the breeding season, and its population in the City is slowly expanding (Greenspan 2012).

The **snowy owl** is a rare winter resident that has been documented at Pelham Bay Park, Breezy Point, and Jamaica Bay. Most years, between one and six owls spend the winter at Kennedy Airport (Chevalier 1988). Year-to-year differences in numbers of snowy owls moving from their Arctic breeding grounds to the northern United States in winter may be related to prey availability but are not well understood (Parmelee 1992).

The **barred owl** is a rare winter resident and no longer nests in the City.

The **long-eared owl** is a common winter resident, and has been observed, for example, in Pelham Bay Park and occasionally Central Park. Large numbers also migrate through the City (Duffy and Kerlinger 1992). The species no longer nests in the City.

The **short-eared ow**l is a winter resident, perhaps most likely to be encountered at Jamaica Bay Wildlife Refuge or Floyd Bennett Field.

The **northern saw-whet owl** is a regular winter resident, especially in Pelham Bay Park. Large numbers pass through the City during fall migration (Duffy and Kerlinger 1992). Also, after irruption years they have been known to breed where they wintered. There are proven nesting records for Long Island and even a suspected

Steve Garvie/wiki Images

Short-eared owl.

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Northern saw-whet owl.

breeding in Queens (see Bull 1974 and Andrle and Carroll 1988) (J. DiCostanzo, personal communication, 30 September 2012).

Description and Identification

Barn owls are medium-sized owls with a pale, heart-shaped face, dark eyes, and no ear tufts.

Eastern screech-owls are small owls, either grayish or reddish, with large ear tufts and yellow eyes.

Great horned owls are large owls with ear tufts, a white throat, and yellow eyes. Body color ranges from pale grey to dark brown.

Snowy owls are large and white, with dark barring on their wings, body, and tail, yellow eyes, and no ear tufts. Juveniles, which are the birds normally seen in our area, have the dark barring; adults, particularly males, can be almost or totally pure white (J. DiCostanzo, personal communication, 30 September 2012).

Barred owls are large owls with a light-colored body streaked with dark brown, dark eyes, and no ear tufts.

Long-eared owls are medium-sized, with long ear tufts, a rusty facial disk, and yellow eyes. They are distinguished from great horned owls by their lack of a white throat and their more closely spaced ear tufts.

Short-eared owls are medium-sized, pale, and streaked, with inconspicuous ear tufts and yellow eyes.

Northern saw-whet owls are small owls with a whitish facial disk, no ear tufts, and yellow eyes.

Ecology

Most owls are monogamous, either for one breeding season or for life. The female incubates the eggs and broods the chicks while the male brings food; once the chicks are larger, the female hunts as well. They usually raise a single brood per year. Most of these owls are primarily nocturnal. Exceptions are the **short-eared owl**, which hunts at dusk and dawn in winter and is sometimes active in daylight, and the snowy owl, which primarily hunts in daylight.

Barn owls usually hunt by flying low over open areas; their diet is largely meadow voles (*Microtus pennsylvanicus*), Norway rats (*Rattus norvegicus*), and other small mammals, and sometimes birds. They commonly lay a clutch of 2 to 10 eggs; only about 50 to 80 percent of the eggs hatch, and only about 25 percent of those chicks survive their first year. Immatures disperse long distances from the nest.

Eastern screech-owls consume small mammals, invertebrates, and small birds.

Great horned owls generally hunt from a perch overlooking an open area (including highway verges). They have an extremely varied diet that includes squirrels, rabbits, and ducks. Nesting begins in winter; clutch size is one to four eggs.

Snowy owls most often hunt from a perch. They are opportunistic feeders, eating mainly lemmings in their arctic breeding grounds but a wide variety of other prey when available. They have been documented eating western black-tailed jackrabbits (*Lepus californicus*) (a population of which was established at John F. Kennedy Airport about 60 years ago when they "escaped" from a shipment), eastern cottontail rabbits (*Sylvilagus*

floridanus), rats, mice, ducks, and small birds, as well as feral cats at JFK Airport (Chevalier 1988) and introduced ring-necked pheasants (*Phasianus colchicus*) in Pelham Bay Park (DeCandido and Allen 2010).

Barred owls hunt from a perch and eat a diversity of prey, including mammals, invertebrates, birds, fish, reptiles, and amphibians.

Long-eared owls usually specialize in rodents but may switch to birds in urban areas. They hunt most often by flying low in open habitat. Long-eared and short-eared owls may take advantage of artificial lighting at night during songbird migrations to hunt birds (Canário et al. 2012).

Short-eared owls consume mostly small mammals (especially meadow voles [*Microtus pennsylvanicus*]), and also birds. These owls hunt on the wing, coursing over open habitat low to the ground.

Northern saw-whet owls eat small rodents (mice, voles, shrews, young rats) and some small birds (especially during their night migrations). They hunt from perches along edges, in forest openings, or where perches exist in open habitats; they sometimes cache prey in a roost branch for consumption the next day.

Threats

Owls in New York City are threatened by the loss and degradation of critical habitat, primarily forests, open fields, and wetlands. In particular, the loss of nesting habitat affects the ability of owls to successfully breed in the City. Cavity-nesting owls need large trees with cavities, or well-designed nest boxes.

Owls are sensitive to some insecticides, rodenticides, and chemical pollutants, which may cause problems with eggs, small clutches, or poor fledging success. Use of rodenticides can decrease prey availability for owls. Anticoagulant rodenticides can cause prolonged blood clotting time or death (Rattner et al. 2012), and organophosphate rodenticides can cause paralysis or death in owls.

Owls in urban environments are also killed by electrocution, and collision with windows, fences, power lines, and especially vehicles (Hager 2009). Road mortality is particularly dangerous for northern saw-whet owls (Hager 2009), as well as owls that feed or nest near roads. After fledging, young owls disperse from their parents' territory, up to many miles away, and are vulnerable to predation and road mortality during this time.

Competition with other owls may be a problem for some species. There is some evidence that the great horned owl may outcompete the barred owl, and the barn owl may outcompete the short-eared owl when nest boxes are provided. Predation by domestic cats may be a problem for smaller species. Short-eared owl roosts on the ground and so is vulnerable to predation by striped skunks, cats, and dogs. A uniquely urban problem for owls, enthusiastic birders have been known to mob owl roosts and nests, with detrimental effects on the owls.

The short-eared owl is listed as Endangered by New York State and S2 by the New York Natural Heritage Program, and barn owl, long-eared owl, and northern saw-whet owl are listed S3. Barn owl, long-eared owl, and short-eared owl are also listed by the New York State Department of Environmental Conservation as Species of Greatest Conservation Need in the State (see Appendix B).

Conservation and Management

Nest boxes can be an effective way to increase populations of cavity-nesting owls currently in the City (barn

owl, eastern screech-owl) or to try to encourage wintering owls to nest (northern saw-whet, barred owl). However, care must be taken in their construction and placement in order for nest boxes to truly help owl populations. A study in Europe found that barn owls had better nesting success in open church towers than in nest boxes placed on closed church towers (Klein et al. 2007). Size of nest boxes and their openings, height, surrounding structures or vegetation, etc., can have effects on clutch size, parasite load, fledging success, and competition with other species for the nest box (Lambrechts et al. 2012).

Similarly, artificial perches may help attract some owls to open areas for hunting (northern saw-whet, snowy owl). Short-eared owls (and presumably other open-habitat owls) benefit from grassland management such as burning or clearing woody vegetation. Barred owls, on the other hand, need mature forest structure. Leaving large, old trees (even if damaged) and dead trees in wooded parks is helpful for forest owls. Although difficult, keeping known roost and nest locations secret from the public would be beneficial.

Survey Techniques and Constraints

Piles of owl pellets or "whitewashed" tree trunks can indicate a regular roost site. Mist-netting is effective for some species (federal permit needed), call playback for others. Unnecessary disturbance should be avoided.

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Salt Marsh Birds

By Nancy Slowik

Seaside sparrow (*Ammodramus maritimus*)
Saltmarsh sparrow (*Ammodramus caudacutus*)
Willet (*Tringa semipalmata*)

Habitat

All three birds are habitat specialists that breed in the high salt marsh, the area above the mean high tide line, although willets are not exclusive salt marsh nesters. Salt marshes are transitional areas between the sea and land, along the intertidal shore of estuaries and sounds, where fresh and salt water mix (see Salt Marsh habitat profile). While the seaward low marsh zone is usually flooded during each high tide and exposed during low tide, the high marsh is flooded with salt water only during exceptionally high tides.

Seaside sparrow nests are found in expanses of medium-sized smooth cordgrass (*Spartina alterniflora*) with a mixture of salt meadow cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*), and blackgrass (*Juncus gerardii*). The nests ideally are located near creek edges or pools in which the birds can forage, although in less desirable nesting locations, seaside sparrows can travel away from the nest to forage (Post and Greenlaw 2009).

Saltmarsh sparrows are limited to breeding in the high tidal salt marsh (Greenlaw and Rising 1994) where they nest in the upper reaches of cordgrass-dominated wet grasslands and in drier saltmeadow habitats.

Willets nest on the ground, within the vegetation preferably in open high salt marshes. However, they may also nest on adjacent sandy beaches with vegetation or on upland sites with short native grass cover (Lowther et al. 2001).

Distribution in New York City

All three species have declined due to the alteration of salt marsh habitats for mosquito control and by landfill

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Seaside sparrow (*Ammodramus maritimus*).

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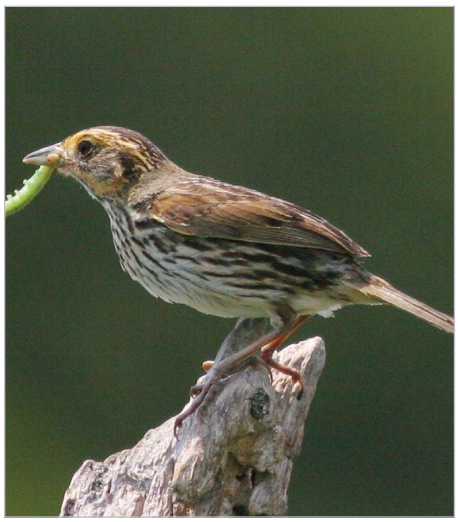

Saltmarsh sparrow (*Ammodramus caudacutus*).

Barbara Saunders

Willet (*Tringa semipalmata*).

practices in the 1940s and 1950s. However, all three species were reported nesting in Jamaica Bay and on Staten Island according to records submitted to the Second Atlas of Breeding Birds in New York State (2008).

The **seaside sparrow** is considered a rare and local breeder in New York State and was found breeding in Saw Mill Creek marsh on the western side of Staten Island along the Arthur Kill (McVay 2011), as well as along barrier islands on the south shore of Long Island (NYSDEC 2011).

The **saltmarsh sparrow** was confirmed in the 2004 State Breeding Bird Atlas to breed in Four Sparrow Marsh in Brooklyn on the north shore of Jamaica Bay (Greenlaw 2008) and can be seen at Dubos Point, Spring Creek Park, and other locations in Jamaica Bay (Riepe 2010). The species was also found to breed in Saw Mill Creek Marsh in Staten Island (McVay 2011).

Willets breed in salt marshes often just above the high tide line along the shores of southern Queens and Long Island. They occasionally will nest in dunes and on sparsely vegetated dredge spoil islands (Wasilco 2008).

Description and Identification

There are seven recognized subspecies of **seaside sparrow** along the East and Gulf Coasts, one of which is extinct. The New York subspecies, *A. m. maritimus*, is distinguished from the others by its size and long, conical bill. Sexes are similar, with a distinct yellow marking above the eye on the supercilium (eyebrow) and on the edge of the wing. Although similar to the saltmarsh sparrow, the seaside sparrow is larger and grayer (Post and Greenlaw 2009).

The **saltmarsh sparrow** is monomorphic, meaning that the sexes are similar in appearance, with a conspicuous orange-buffy eyebrow and a broad malar (cheek bone) stripe that curves around the face to create a yellow triangle. The bill is short and conical. The species can be distinguished from the seaside sparrow by its brighter and strongly patterned face, smaller size, and browner body (Greenlaw and Rising 1994).

The **willet** is a large, gray to brown shorebird with a white lower rump and distinctive black and white wing pattern. The distinctive white wing stripe is obvious in flight. The sexes are similar, but females are slightly larger. Willets can be confused with other large shorebirds such as whimbrels (*Numenius phaeopus*) or greater

Barbara Saunders

Seaside sparrow.

Barbara Saunders

Willets.

yellowlegs (*Tringa melanoleuca*) but a whimbrel is distinguished by its curved bill and a greater yellowlegs by its thinner bill, lack of the black and white wing pattern, and its bright yellow legs (Lowther et al. 2001).

Ecology

Seaside sparrow males arrive at their breeding grounds in New York in mid- to late April and defend their territory throughout the season. Females arrive a week later and build an open cup nest. Nests destroyed by flooding are rebuilt, so nesting can be observed as late as July (NYSDEC 2011). Pairs prefer to forage in open areas that can be well outside their breeding territory. They feed on a limited variety of arthropods found in open mud flats or at the bases of plants. These may include fly larvae, moth larvae and adults, spiders, short-horned grasshoppers, and crickets. The sparrow's bill is adapted to probing mud, but a common foraging behavior is walking and gleaning arthropods from plant stems (Post and Greenlaw 2009).

Saltmarsh sparrow males also arrive on their breeding grounds in mid to late April. However, they are promiscuous and do not defend a territory or help raise young. The females build a nest between grass stems. The relatively short incubation and nestling period ensures that some birds will successfully fledge young despite occasional flooding from spring high tides (Greenlaw and Rising 1994). Foraging techniques and diet are similar to the seaside sparrow. In one study, both sparrows showed a preference for adult noctuid moths and larvae and pupae of tabanid flies, which were larger but less abundant than other arthropods (Post and Greenlaw 2009).

Willets arrive in late March to early April, and individual pairs have been found to synchronize their nesting to minimize losses (Smith 2009). Willets defend their territories and nests with a loud, distinctive vocalization, *pill-will-willet* (Lowther et al. 2001), the last note giving rise to the name "willet." Little is known about their nesting behavior because the young are precocial (able to move around soon after hatching) (Smith 2009). Willets are generalist feeders that use sight and touch to find their prey. They forage on mudflats in sparsely vegetated habitats utilizing a variety of search and capture techniques. The most common method of locating food is visual, where the willet captures prey with its bill from the surface of the mud; prey includes crabs, gastropods, worms, amphipods, and insects. Tapping techniques are also used with the bill submerged to capture small fish and worms (Lowther et al. 2001).

Threats

Seaside sparrow and s**altmarsh sparrow** are threatened most by habitat loss from coastal development and degradation of their habitat by pollution. Seaside sparrow is listed as a Species of Special Concern in New York State, and the National Audubon Society included both sparrows on its 2007 Watch List (NYSDEC 2011) (see Appendix B). Dominance of the high salt marsh by the nonnative common reed (*Phragmites*) was considered a threat to all three species on the Connecticut coast (Benoit and Askins 1999), although in Rhode Island DiQuinzio et al. (2002) found saltmarsh sparrow nesting in short common reed as well as in the native short grass community of the high salt marsh.

Willets are currently listed as a species of high concern by the North Atlantic Regional Shorebird Plan. Although protected today, they were once hunted and extirpated by 1910 from much of their East Coast range by humans. Willets made a slow recovery after the Migratory Bird Treaty Act of 1918 (Smith 2009), and did not reappear as a nesting bird in New York State (Long Island) until 1966 (Wilcox 1980).

Willets and both sparrows face the threat of rising sea levels from climate change (Smith 2009).

Conservation and Management

Preservation of coastal wetlands and salt marshes, along with creative management in light of future sea level rise, as well as ongoing protection from pollution and common reed dominance are priorities for all three species.

Survey Techniques and Constraints

The specific habitat requirements for both sparrows and the willet will dictate where to search for them. While both sparrow species are secretive and difficult to spot, the **saltmarsh sparrow** is difficult to observe even by the most experienced bird watcher. The best time for locating nesting sites is between spring tides, especially when the birds are engaging in early courtship displays. **Willets** may be easier to locate on nesting sites because of their loud vocalizations and distraction displays when threatened (Lowther et al. 2001).

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APPENDIX A.
LAND USE, ZONING, AND OTHER REGULATORY PROGRAMS AFFECTING BIODIVERSITY PLANNING IN NEW YORK CITY

Molly Williams

Zoning and land use planning are tools that can be used to enhance and conserve New York City's biodiversity. This section provides a brief overview of the land use process, zoning laws, and other plans and regulations that affect the City's rich biodiversity resources.

Due to the myriad of regulations and jurisdictions that affect New York City's natural areas, protection and enhancement of the City's biodiversity requires stakeholders from federal, state, and city governments; private land owners; parks; and conservation organizations to work together. Collaboration will help ensure that New York City's flora and fauna and the habitats on which they depend are preserved and managed.

In recent years, the Mayor's Office of Long-Term Planning and Sustainability, the City Council, the NYC Department of Parks and Recreation, and the NYC Department of Environmental Protection, among others, have made great strides towards providing more planning and protection for the City's natural areas. These coordinated efforts have helped create short- and long-term goals and outcomes, which are also highlighted here.

1. LAND USE AND ZONING

Land use and zoning are two regulatory processes that directly impact the landscape and can threaten biodiversity through habitat destruction, modification, and fragmentation. Below is a brief summary of how land use and zoning occur in New York City. More information on land use and zoning in NYC can be found on the NYC Department of City Planning's website (http://www.nyc.gov/html/dcp/).

Zoning laws dictate which land use and development projects may or may not take place, and in New York City these laws are laid out in the Zoning Resolution, described below. Development that complies with the Zoning Resolution may be commenced without city or public review. Land use actions and development that do not comply with these regulations require discretionary action by the City Planning Commission and/or the Board of Standards and Appeals and must undergo the land use review process described below.

a. Land Use

Discretionary land use actions go through a process called **ULURP, the Uniform Land Use Review Procedure**, set forth in section 197-c of the City Charter. This procedure is to ensure that land use applications follow a standard format with public review within a mandated time frame. The Department of City Planning administers it, but ultimate approval is by the City Planning Commission, the City Council, and the Mayor. Most land use actions trigger ULURP, including, but not limited to, acquisition or disposition of property by the City, zoning map changes, siting of capital projects, and changes to the City map. Zoning text amendments do not require ULURP, but undergo a similar process, which is set forth in sections 200 and 201 of the City Charter.

A complete list of land use actions that require ULURP and a discussion of how the ULURP process works[1] can be found at New York City's Department of City Planning (DCP) website. New York City's DCP website also contains a schedule of ULURP fees.[2]

Community Boards and Borough Boards are involved in the ULURP process and play an advisory role on all ULURP applications affecting their districts. (A map of community districts and their profiles can be found on DCP's website.[3]) These advisory bodies may initiate their own land use action by applying for rezoning in coordination with the Department of City Planning. They may apply for zoning text amendments, initiate community 197-a plans, or establish/become involved in a task force. More information about community-based planning in New York City can be found at New York City's DCP website.[4]

Community Boards, organizations, and individual citizens have an important role to play in land use decisions affecting their neighborhoods and districts. Whenever a ULURP application is conducted within a community district, Community Boards can weigh in on the outcome by providing specific recommendations on the proposed action or decision. Although their role is advisory, it is nonetheless important. They are the voice at the local level and can bring up issues on the neighborhood level according to their needs and values. If scientists, experts, and interested citizens attend Community Board meetings, they can bring much needed expertise in issues of biodiversity conservation to the land use decisions facing the community.

b. Zoning

The City of New York establishes the zoning regulations in the **Zoning Resolution**. The Zoning Resolution is administered and enforced by the Commissioner of the Department of Buildings, except where otherwise stated in the City Charter and the Resolution. A good reference for zoning vocabulary and definitions can be found in the zoning glossary on DCP's website.[5]

The Zoning Resolution contains two parts – a map and text. The map displays the locations and boundaries of the zoning districts, and the text establishes the zoning districts along with the regulations that govern their land use and development. The zoning text sets forth regulations on the use and bulk of buildings, yard, street tree and open space requirements, and much more.[6] The purpose of the Zoning Resolution is to "promote and protect public health, safety and general welfare."[7] There are three main ways to alter or modify zoning regulations.

1. The Board of Standards and Appeals (BSA) may issue *variances* to the provisions in the Resolution if in so doing "the spirit of the law shall be observed, public safety secured, and substantial justice done."[8]
2. Both the Board of Standards and Appeals and the City Planning Commission (CPC) may authorize *special permits*. In other words, they may permit specific uses in specific districts not otherwise permitted by the zoning requirements that apply. CPC special permits must undergo the ULURP process whereas a BSA special permit does not.

1 Uniform Land Use Review Procedure – Department of City Planning http://www.nyc.gov/html/dcp/html/luproc/ulpro.shtml#actions (5/28/2012)
2 ULURP & CEQR Fees – Department of City Planning http://www.nyc.gov/html/dcp/html/luproc/ulurpfee.shtml (5/28/2012)
3 District Profiles – New York City Department of City Planning http://www.nyc.gov/html/dcp/html/lucds/cdstart.shtml (7/4/12)
4 Community-Based Planning – Department of City Planning http://www.nyc.gov/html/dcp/html/community_planning/index.shtml (5/28/2012)
5 NYC Zoning – Glossary - Department of City Planning http://www.nyc.gov/html/dcp/html/zone/glossary.shtml (5/28/2012)
6 Zoning – Department of City Planning http://www.nyc.gov/html/dcp/html/subcats/zoning.shtml (5/28/2012)
7 The Zoning Resolution – The City of New York. 2012. Department of City Planning. Preamble - updated 12/15/61.
8 The Zoning Resolution – The City of New York. 2012. Department of City Planning. Art. VII Ch. 2. Section 72-21 - updated 2/2/11.

3. The City Planning Commission, citizen, Community Board, Borough Board, Borough President, the Mayor, or the Land Use Committee of the City Council (with two-thirds approval) may apply for a zoning text amendment. Resolutions to amend the text of the Zoning Resolution shall be adopted by the City Planning Commission and acted on by the City Council pursuant to the City Charter Sections 200 and 201.

c. Zoning and Biodiversity

As stated above, development that complies with the Zoning Resolution, which is termed "as-of-right" development, may occur without being reviewed by the City or the public. Because the Zoning Resolution as a whole does not actively seek to conserve or enhance biodiversity, as-of-right development can pose a significant threat to the biodiversity that exists at a site.

The Zoning Resolution does contain certain provisions and amendments that are relevant to protection and management of biodiversity. Special Purpose Districts can apply zoning restrictions and additional requirements to certain areas to protect or maintain their environmental or scenic significance. Waterfront Zoning applies to all development and land use on the waterfront. Local governments or state governments may designate areas as Critical Environmental Areas if they own, manage or regulate these areas.

Special Purpose Districts apply to specific areas and the Zoning Resolution lays out the use and bulk regulations that apply to these districts. The special purpose district may have additional restrictions or allowances on land use and development due to the unique character or needs of that area. Special purpose districts modify or supplement the district regulations on which they are superimposed. They may be location specific or topic specific. Below are select examples of special purpose districts that relate to biodiversity.

The **Special Natural Area District**[9] is a Special Purpose District that is so far the most environmentally proactive—it addresses natural features such as aquatic, biological, botanical, geologic and topographic components that have "ecological and conservation values and functions…" Its purpose is to "preserve land having qualities of exceptional recreational or educational value… to reduce hillside erosion, landslides and excessive storm water runoff associated with development by conserving vegetation and protecting natural terrain…" and to promote use of the land in a way that is "in accordance with a well-considered plan." The regulations include "areas of no disturbance," where no site alteration may occur, including, but not limited to walkways, removal of topsoil or vegetation, and construction of roads. The Zoning Resolution lays out the actions that do not require special review and those that do.

The **Hillsides Preservation District** is another important Special Purpose District, created to reduce hillside erosion, landslides, and excessive stormwater runoff by conserving vegetation and protecting natural terrain, both for aesthetic values and the protection of natural features.

Designation (E) (Section 11-15) sets forth overall "Environmental Requirements," which apply restrictions to development in certain designated areas pertaining to hazardous materials, air quality, or noise, and must be addressed in the City Environmental Quality Review (CEQR) process.[10]

9 The Zoning Resolution – The City of New York. 2012. Department of City Planning. Art. X Ch 5. Updated 2/02/11

10 Zoning Resolution for the City of New York – Section 11-15 (3/28/12)

The City has made many recent efforts to improve zoning to consider the environment, including street tree requirements, streetscape preservation, yard and open space requirements, green parking lots, and green building. A more thorough list of these zoning text amendments can be found on the DCP website (http://www.nyc.gov/html/dcp/html/green_initiatives/index.shtml).

Text Amendments

The Street Tree Planting Text Amendment adopted in April 2008 by the City Council requires street trees to be planted every 25 feet for all new development and major enlargements in all zoning districts (with exceptions for some industrial zones) to be maintained thereafter by the New York City Department of Parks and Recreation (DPR).

The Yards Text Amendment of 2008 makes it illegal for people living in lower-density neighborhoods (such as in the outer boroughs) to completely pave over their front yards. They must maintain between 30-50% of green space. This amendment has the dual benefit of maintaining small patches of green space for smaller species that provide habitat (such as insects), while also helping to prevent water pollution by reducing stormwater runoff.

The Residential Streetscape Preservation Text Amendment was adopted in 2010 to preserve and enhance the streetscape character of residential neighborhoods. The amendment requires more street plantings and permeable land cover, thereby helping to reduce runoff and the urban heat island effect, increase vegetation, and improve air quality.

The Green Standards for Parking Lots Text Amendment was adopted in 2007 and requires commercial and community facility parking lots to include planting of shrubs and street trees, bioswales, and other features to achieve aesthetic value and sustainability goals.

Besides the ULURP, there are two other major procedures relevant to biodiversity in the City: environmental review and waterfront revitalization plan consistency review.

2. ENVIRONMENTAL REVIEW

Environmental review is required for major government actions that are thought to have a significant negative impact on the environment.

a. National Environmental Policy Act (NEPA) – Federal Environmental Review

NEPA [42 U.S.C. 4321 et seq.] "establishes national environmental policy and goals for the protection, maintenance, and enhancement of the environment"[11] and includes the order to "preserve…national aspects of our national heritage, and maintain, wherever possible, and environment which supports diversity."[12] Section 102 of the law requires the federal government to incorporate environmental impacts into decision making and planning and "all federal actions significantly affecting the quality of the human environment" to prepare an **Environmental Impact Statement** (EIS). All discretionary action on the part of a government agency is subject to environmental review, which includes issuance of permits and/or allocation of funds by a government agency. The public plays an important role by providing input and submitting comments on the EIS to the

11 U.S. EPA National Environmental Policy Act - Basic Information – Compliance and Enforcement http://www.epa.gov/compliance/basics/nepa.html (5/28/2012)
12 42 U.S.C. § 4331 (b)(4); NEPA § 101 (b)(4)

lead agency, or the agency in charge of carrying out the discretionary action and the environment review. The lead agency must take these comments into consideration.[13]

b. SEQR – State Environmental Quality Review

New York State implements NEPA through SEQR, the State Environmental Quality Review Act [6 NYCRR Part 617; ECL § 3-0301(1)(b), §3-0201(2)(m), §8-0013]. Just like NEPA, SEQR requires local and state agencies to consider the environmental impacts of their actions in advance and to weigh alternatives to the proposed actions in order to minimize the environmental impacts. The New York State Department of Environmental Conservation (DEC) is not responsible for reviewing SEQR applications, and SEQR is self-enforcing. This means that each agency of government is responsible for ensuring it is in compliance with the requirements of this law. The DEC has no authority to review the implementation. However, the DEC does issue the regulations and provide information about the SEQR process. If there is a project that is believed to have failed to properly go through environmental review, citizens may take legal action against the agency under Article 78 of the New York State Civil Practice Law and Rules.[14] This can potentially stop a project or proposal from going through and require that a new review with stronger compliance be carried out.

Local governments or state governments may designate areas as Critical Environmental Areas if they own, manage, or regulate these areas. All land use decisions within these Critical Environmental Areas are considered to be a Type 1 action under the Environmental Review process. Critical Environmental Areas are designated as such due to their unique and exceptional character in one of the following areas: a benefit or threat to human health; a natural setting (e.g., fish and wildlife habitat, forest and vegetation, open space and areas of important aesthetic or scenic quality); agricultural, social, cultural, historic, archaeological, recreational, or educational values; or an inherent ecological, geological or hydrological sensitivity to change that may be adversely affected by any change.[15] The only area in NYC currently designated as a Critical Environmental Area is Jamaica Bay.

c. CEQR – City Environmental Quality Review

In the City of New York, CEQR [RCNY Title 62 Ch. 5; Executive Order 91; Title 43] is the environmental review process used most often because City agencies are responsible for issuing permits and funding capital projects in the City. CEQR is required for Type I discretionary actions directly undertaken by a City agency, funded by a City agency, or approved by a City agency.[16] Type I actions (found in 6 NYCRR § 617.4) are actions that are likely to have a significant impact on the environment. Type II actions (found in 6 NYCRR § 617.5) are not required to undergo the CEQR process, nor are Ministerial actions, which are non-discretionary actions such as issuance of building permits or granting a fishing license.

If an action is determined to be significant, either because it is listed as Type I, or it falls into a substantive impact area, a lead agency is established, which then prepares an **Environmental Assessment Statement** (EAS). The EAS will discuss the proposed action, the location, and the type of impacts the proposed action will have on the environment.

13 U.S. EPA National Environmental Policy Act - Basic Information – Compliance and Enforcement http://www.epa.gov/compliance/basics/nepa.html (5/28/2012)
14 SEQR – NYS Dept. of Environmental Conservation http://www.dec.ny.gov/permits/57036.html (5/28/2012)
15 SEQR – New York State Department of Environmental Conservation http://www.dec.ny.gov/permits/6184.html (5/28/2012)
16 New York City Office of Environmental Coordination – City Environmental Quality Review FAQ http://www.nyc.gov/html/oec/html/ceqr/faq.shtml (5/28/2012)

During the EAS phase, documents for the proposed action are prepared which contain the Criteria of Significance – 12 topics or consequences of actions that are reasonably expected to have a significant impact. These 12 criteria include impacts on air and water quality, flora, fauna and habitat disturbances, community impacts, energy impacts, hazardous impacts, and even cumulative impacts of two or more criteria or two or more separate projects. From this, the lead agency determines whether or not there will be a positive or negative declaration. A positive declaration means the impact on the environment is significant and a **Draft Environmental Impact Statement** (DEIS) must be prepared. A negative declaration ends the CEQR process and the action is allowed to occur.

The DEIS contains all the impact areas, which are determined by the scoping process (see below), what the adverse impacts in these particular areas will be, alternatives to the proposed action, and any mitigation proposed. There are 20 impact areas and they are: land use, zoning and public policy, socioeconomic conditions, community facilities, open space, shadows, historic resources, urban design, visual resources, neighborhood character, natural resources, hazardous materials, waterfront revitalization program, infrastructure, solid waste and sanitation services, energy, traffic and parking, transit and pedestrians, air quality, noise, construction impacts, and public health.

A Notice of Completion is sent out when the DEIS is completed, which starts the public review period where comments are sought. The DEIS is used to complete a Final Environmental Impact Statement (FEIS), which the lead and involved agencies use to issue a Statement of Findings. The Statement of Findings determines whether the CEQR requirements have been met after considering the impacts and weighing social, economic, and other considerations.[17] New York State's Department of Environmental Conservation works with City agencies to provide expertise and to ensure that reviews are consistent.

Established by Section 192(e) of the New York City Charter, the **Mayor's Office of Environmental Coordination** (OEC) assists City agencies with environmental reviews and stores all CEQR documents. OEC also works with state and federal agencies and the Mayor on environmental issues and policies. Executive Order 149 of 2011 defines OEC's responsibilities to include implementation of the City's green building law.[18] CEQR is very similar to SEQR [6 NYCRR Part 617; ECL § 3-0301(1)(b), §3-0201(2)(m), §8-0013], which makes it permissible for local governments to promulgate and implement their own environmental review procedures.[19]

CEQR and Biodiversity–The EIS procedure of CEQR addresses biodiversity because it gives consideration to federally and state listed endangered and threatened species; it addresses cumulative impacts to the environment; noise and shadow impacts; noise and shadow impacts; and also impacts on existing infrastructure such as waste, sewer, transportation, and stormwater. In the EIS process, scoping involves the review of many impact areas that a proposed development may have. The scoping topic "natural resources" addresses biodiversity and is found in Chapter 11 of the CEQR Technical Manual.

The CEQR Technical Manual defines a natural resource in Chapter 11 as follows:

(1) the City's biodiversity (plants, wildlife, and other organisms);

17 New York City Office of Environmental Coordination – City Environmental Quality Review FAQ http://www.nyc.gov/html/oec/html/ceqr/faq.shtml (6/04/2012)
18 New York City Office of Environmental Coordinator – Mayor's Office of Environmental Coordination (6/04/2012)
19 New York City Office of Environmental Coordination – City Environmental Quality Review http://www.nyc.gov/html/oec/html/ceqr/ceqr.shtml (1/11/08)

(2) any aquatic or terrestrial areas capable of providing suitable habitat to sustain the life processes of plants, wildlife, and other organisms; and

(3) any areas capable of functioning in support of the ecological systems that maintain the City's environmental stability.

Chapter 11 also elaborates that "a natural resources assessment considers species in the context of the surrounding environment, habitat or ecosystem and examines a project's potential to impact those resources." The CEQR Manual lists and describes the types of habitats that should be included in an environmental review, identifies the resources and agencies that should be consulted, and requires applicants to consider species or habitats that have been designated sensitive or critical by the State or Federal Government, such as Significant Coastal Fish and Wildlife Habitats and Critical Environmental Areas. The environmental review also requires that the applicant is consistent with other City plans and policies such as the Waterfront Revitalization Plan and PlaNYC. (For more information about PlaNYC see section 5 – Relevant organizations, agencies, and programs.)

In addition, the environmental review process considers the indirect or unintended effects of projects. An example on page 244 of the CEQR Manual is "A change that would increase the frequency of bird collisions with built structures due to increase in height, architectural design or lighting infrastructure."

3. WETLANDS AND WATERFRONT PLANNING

a. Vision 2020: New York City Comprehensive Waterfront Plan

The 1992 Comprehensive Waterfront Plan was the City's first full inventory of its waterfront. Now updated, the city's waterfront plan provides a framework from which to guide land use along the waterfront. Vision 2020 goes further than the 1992 plan by expanding public access from waterfronts to include waterways, and to consider the impacts of climate change on rising sea levels and more severe weather. The plan includes goals to improve water quality, improve access for recreation, and maintain and improve water-dependent industry.[20]

There are several entry points through which biodiversity can be integrated into Vision 2020's plans. For example, goals 1 and 2, expanding public access to the waterfront/enlivening the waterfront with attractive uses, is a natural fit for the development/expansion of greenways that include biodiverse plants and insects. Similarly, goal 4, improve water quality, is a natural fit since it would reduce pollution and increase the areas for wildlife to thrive. The most intriguing category for biodiversity is likely goal 6, enhancing the "Blue Network." The Blue Network is a new functional category that recognizes that New York City's waterways are a connected network of rivers, bays, inlets, and streams that "connect our boroughs, complete our ecology and offer a diversity of uses and activities that extend our experience beyond the edges of the land." The plan works to identify opportunities to expand the use of the water for transportation, recreation, and education; to improve water quality; and to address the challenges posed by global warming and sea-level rise.

Goals 4, 5, 6, and 8 have particular relevance to the City's biodiversity. Below are the strategies the City has laid out to meet these goals.

Goal 4: Improve water quality

- Build new cost-effective gray infrastructure (e.g., roads, drainage systems, utilities) and optimize

20 Vision 2020: New York City Comprehensive Waterfront Plan – March 2011 http://www.nyc.gov/html/dcp/html/cwp/cwp_2.shtml (7/14/12)

existing systems to meet goals for water quality throughout the City.
- Maximize the use of green infrastructure (designed and managed natural systems such as bioswales, etc.) and other source controls to capture rainfall on impervious surfaces, helping reduce combined sewer overflows and other discharges.
- Restore natural systems to improve ecological productivity, reduce pollution, and provide habitat, recreation, and climate-adaptation services.
- Improve monitoring and public awareness of water quality.

Goal 5: Restore the natural waterfront
- Acquire and augment protection of wetland and other shoreline habitat.
- Increase scientific understanding, public awareness, and stewardship of the natural waterfront.
- Promote ecological restoration that enhances the robustness and resilience of local and regional ecosystems.

Goal 6: Enhance the Blue Network
- Promote water recreation in suitable locations with access points, docks, and on-shore facilities.
- Clarify and enhance regulatory and organizational mechanisms to ensure safety of water recreation and reduce potential conflicts among various users of the waterways.
- Increase waterborne public transportation.
- Increase New York City's preparedness for waterborne emergency evacuation.
- Increase public knowledge and awareness of the waterfront and waterways.
- Explore renewable energy opportunities on our waterfront and in our waterways.

Goal 8: Increase climate resilience
- Conduct a citywide strategic planning process for climate resilience.
- Develop a better understanding of the City's vulnerability to flooding and storm surge and examine a range of physical strategies to increase the City's resilience.
- Explore regulatory and policy changes to improve resilience of new and existing buildings to coastal flooding and storm surges.
- Work with the Federal Emergency Management Agency (FEMA) and the insurance industry to encourage the consideration of more accurate data on current and future risks of flooding and storm surges.
- Assist with local resiliency planning.
- Integrate climate change projections into NYC's emergency planning and preparedness efforts.

The regulatory changes recommended by the Comprehensive Waterfront Plan have been largely implemented through two means: the Waterfront Revitalization Program and the Waterfront Zoning Amendments.

b. Waterfront Vision and Enhancement Strategy (WAVES)

WAVES is a program of the New York City Economic Development Corporation, which is working to create a Waterfront Action Agenda to complement Vision 2020. It will do so by identifying new approaches to waterfront issues and establishing a set of high-priority initiatives to be implemented over the next three years.

c. Waterfront Revitalization Program

New York City has a New Waterfront Revitalization Program (WRP), which stems from the Federal Coastal Zone Management Act of 1972, and encourages states to develop and implement management policies that "preserve, protect, develop, and where possible, to restore or enhance the resources or the nation's coastal zone."[21] In 1981, New York State established the New York State Waterfront Revitalization and Coastal Resources Act, which requires that actions taken by state agencies are consistent with the policies of this Act. The state coastal program, administered and enforced by the New York State Department of State's Coastal Resources Division, allows municipalities to adopt their own local waterfront revitalization program.[22] New York City adopted its own **Local Waterfront Revitalization Program** (LWRP) in 1982 and revised it in 2002. It is called the **New Waterfront Revitalization Program** (WRP) and has been adopted by the NYS Department of State in concurrence with the U.S. Department of Commerce. The WRP is being revised again through a 197-a Plan (community-based improvement plans guided by section 197-a of the City Charter) to incorporate new policies to advance the goals and priorities laid out in Vision 2020.

The jurisdictional reach of the WRP is known as the Coastal Zone Boundary and "extends waterward to the Westchester and Nassau County and New Jersey boundaries, and to the three-mile territorial limit in the Atlantic."[23] Federal lands and facilities are not included in the coastal zone and do not undergo consistency review in accordance with federal regulation. Federal, state, and city discretionary actions within the city's coastal zone "must be consistent, to the maximum extent practicable with the WRP policies."[24] The boundary includes the following "coastal features": Significant Maritime and Industrial Areas; Significant Coastal Fish and Wildlife Habitats; Special Natural Waterfront Areas; Staten Island Bluebelts; Tidal and Freshwater Wetlands; Coastal Floodplains and Flood Hazard Areas; Erosion Hazard Areas, Coastal Barrier Resources Act Areas; Steep Slopes, Parks, and Beaches; Visual Access and Views of Coastal Waters and the Harbor; Historic, Archaeological, and Cultural Sites Closely Associated with the Coast; and Special Zoning Districts.

d. WRP Policies Relevant to Biodiversity

The WRP contains 10 policies that govern development and use of the City's waterfront, and it provides the basis for determining the consistency of discretionary actions with these specific policies. Consistency review is required for all local discretionary actions including ULURP, CEQR, variances and 197-a plans.

The policies in the WRP that are particularly relevant to biodiversity are presented below.

- Policy 4: Protect and restore the quality and function of ecological systems within the New York City coastal area.
- Policy 5: Protect and improve water quality in the New York City coastal area.
- Policy 6: Minimize loss of life, structures and natural resources caused by flooding and erosion.
- Policy 7: Minimize environmental degradation from solid waste and hazardous substances.

The areas most relevant to biodiversity are the **Special Natural Waterfront Areas** (SNWA), described as "large

21 *The New Waterfront Revitalization Program.* 2002. New York City Department of City Planning. Page 3.
22 *The New Waterfront Revitalization Program.* 2002. New York City Department of City Planning. Page 3.
23 *The New Waterfront Revitalization Program.* 2002. New York City Department of City Planning. Page 5.
24 *The New Waterfront Revitalization Program.* 2002. New York City Department of City Planning. Page 4.

areas with concentrations of the natural resources, including wetlands, habitats and buffer areas…" Activities proposed within these areas must be consistent with Policy 4.[25] Alternatively, when an area is devoid of natural features and not located in a specified SNWA, Policy 4 would not be considered in the consistency review.[26] There are three Special Nature Waterfront Areas that are listed under Policy 4. These areas include Northwest Staten Island Harbor Herons Area, Jamaica Bay, and East River Long Island Sound Area.

e. Revisions to the WRP

The Department of City Planning is in the process of revising the WRP pursuant to Section 197-a of the City Charter. The changes do not substantially alter the policies or structure of the program, but rather seek to incorporate the myriad of new initiatives the City has developed with respect to the waterfront, most notably Vision 2020, and update the coastal policies in a way that is consistent with Vision 2020's goals. The revised WRP has been subject to public review and reviewed by the City Planning Commission and the City Council in 2012. Relevant revisions include:

- The Program Description in Part 1 includes a better explanation of the purpose, intent, and structure of the WRP and mentions Vision 2020 and the NYC Waterfront Action Agenda.
- Requiring projects to assess the risks associated with sea-level rise and climate change.
- Creating and mapping a new designation called the Ecologically Sensitive Maritime and Industrial Area (ESMIA) that promotes industry but preserves habitats located near these areas.
- Identifying small sites of ecological significance called Recognized Ecological Complexes and promoting their restoration.

f. Waterfront Zoning Amendments

Waterfront Zoning applies to development along the City's waterfront, and it includes the general goal "to protect natural resources in environmentally sensitive areas along the shore."[27] It establishes and defines use and bulk regulations as well as public access, walkways, visual corridors, and upland access for waterfront areas. Waterfront Access Plans are established as a zoning text amendment. In adopting a Waterfront Access Plan, the City Planning Commission must find that the plan "would improve public use and enjoyment of the waterfront" and meets one of seven criteria. Two examples of these criteria that are relevant to biodiversity protection are that the plan "…is necessary to accommodate unique topography or natural features, such as wetlands conditions, significant grade changes, geologic formations, natural vegetation or wildlife habitats, which natural features or topography would not be adequately accommodated by the provisions of Sections 62-34, 62-40 and 62-60" (these sections lay out the zoning regulations applying in waterfront areas); or the plan "…is necessary to link 'public parks' or other public areas along the waterfront or to the waterfront, and such linkage would not necessarily be achieved solely by the provisions of Sections 62-34, 62-40 and 62-60."[28]

- To date, Brooklyn has one Waterfront Access Plan and Queens has two. Multi-Borough Waterfront Access Plans are also possible, but none have been created. For details of these plans, see the Zoning Resolution

25 *The New Waterfront Revitalization Program*. 2002. New York City Department of City Planning. Page 17.
26 *The New Waterfront Revitalization Program*. 2002. New York City Department of City Planning. Page 7.
27 *The Zoning Resolution – The City of New York*. 2007. Department of City Planning. Art. IX Ch. 3 Section 93-00 (c) - updated 1/19/05.
28 *The Zoning Resolution – The City of New York*. 2007. Department of City Planning. Art. VI Ch. 2 Section 62-813 (a)(1) and (a)(3) - updated 10/29/97.

Article VI, Chapter 2, Section 62-831 (BK-1: Greenpoint-Williamsburg – 3/1/06), Section 62-851 (Q-1: Northern Hunters Point – 7/26/01) and Section 62-852 (Q-2: Downtown Flushing – 9/17/98).

A study released in 2008 called *New York City Wetlands: Regulatory Gaps and Other Threats*[29] finds that existing federal and state regulations protect New York City's tidal wetlands and large freshwater wetlands from threats related to land use and development. However, the report also emphasizes that State law does not protect freshwater wetlands smaller than 12.4 acres and does not require a protective buffer for those unprotected wetlands. These wetlands may also be outside the scope of Federal protection.

4. RELEVANT FEDERAL, STATE, AND CITY LAWS

Below is a select list of laws and regulations that are implemented either by the city, state, or federal government and in some way affects the biodiversity of New York City. The federal laws supersede state and city laws, and the state laws supersede city laws, where the higher level of government has jurisdiction.

a. Federal Laws

The purpose of the Federal Water Pollution Control Act (1972) 33 U.S.C. §1251-1387, especially §1341, 1342, 1344, more commonly known as the **Clean Water Act** (CWA), is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[30] This is a comprehensive law that establishes regulatory programs for controlling discharges into surface waters of the United States. The principal provisions relevant to NYC biodiversity are as follows: §401 (33 U.S.C §1341) states that Water Quality Certification must occur for any license or permit issued by a federal agency to ensure water quality standards will not be violated from a permitted activity. §402 (33 U.S.C §1342) prohibits the discharge of pollution from a point source into the waters of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit.[31] §404 (33 U.S.C §1344) establishes the program that regulates "the discharge of dredged or fill material into waters of the United States, including wetlands."[32]

In 1987, the **Water Quality Act** was passed, amending the Clean Water Act to include the provisions in section 402(p) that specifically address stormwater discharges. "New section 402(p) required that dischargers of storm-water, including large and medium municipal separate storm sewer systems (MS4s), obtain permits by October 1992. The amendments also required the Environmental Protection Agency (EPA) to conduct studies on stormwater discharges not already covered by CWA §402, with the goal of identifying any other sources contributing to water quality degradation and to provide a basis for establishing a comprehensive program to regulate such sources."[33] Issued in 2008, NYC developed the Sustainable Stormwater Management Plan to address water quality issues and combined sewer overflows (CSO) impacts by requiring source controls and green design elements in new construction and public projects.

The **National Estuary Program** (NEP), created in §320 of the 1987 CWA amendments, directs the EPA to protect our nation's estuaries through the creation of plans that will attain or maintain water quality in the

29 New York City Wetlands: Regulatory Gaps and Other Threats. http://www.nyc.gov/html/om/pdf/2009/pr050-09.pdf (3/25/13)
30 33 U.S.C. § 1251(a); FWPCA §101(a)
31 Red Lodge Clearinghouse, *Legislation and Regulations – Clean Water Act* http://rlch.org/content/clean-water-act (5/10/13)
32 US EPA Wetland Regulatory Authority, *Regulatory Requirements* http://water.epa.gov/type/wetlands/outreach/upload/reg_authority.pdf (5/10/13)
33 Waterkeeper Alliance Report, "All Stormwater is Local: A manual for reading, understanding, and advocating for effective municipal stormwater permits in the United States," Chapter 3. Revised in 2009 (7/23/12)

estuary. There are 28 NEPs and each program must come up with a Comprehensive Conservation Management Plan for their region. The NY/NJ Harbor Estuary Program was established in 1988 and is a multi-year project that includes participants from local, state, and federal environmental agencies, scientists, citizens, business interests, and environmentalists and has been successful at acquiring open space and restoring vital habitats. Similarly, Long Island Sound was officially designated an Estuary of National Significance and a Management Conference for the Long Island Sound Study was convened in March of 1988.[34] The Clean Water State Revolving Fund (CWSRF) has also been used to protect and restore estuaries in areas surrounding the City. "In 2000, the City of Rye, NY used a $3.1 million CWSRF short-term, zero interest loan to acquire and protect crucial land in the Long Island Sound Estuary."[35]

The **Waterfront Resource Development Act** (WRDA) H.R.2864 (2005) has a number of projects in NY and NJ for coastal protection, land acquisition, and restoration projects. It is administered by the Army Corps of Engineers (Corps) and is being used as a potential funding source for the Harbor Estuary Program. The WRDA appropriates funding for project categories as well as specific projects.

The **Rivers and Harbors Appropriations Act** (1899) §10, 13, 33 U.S.C. §403, 407 prohibits the creation of any obstruction to the navigation of waters of the U.S. including the excavation, fill, or alteration of course to the waters of the U.S. except when authorized by Congress or by the Secretary of War with plans recommended by the Chief of Engineers. This law also prohibits the deposition of refuse into any navigable water, including into any water or banks that may wash into navigable water.[36]

The **Fish and Wildlife Coordination Act** 16 U.S.C. §661-666c helps to coordinate government efforts so that fish and wildlife receive equal consideration in water resource development projects and provides the authority for the Fish and Wildlife Service to be involved in evaluating the impacts of these projects. "It also requires Federal agencies that construct, license or permit water resource development projects to first consult with the Service (and the National Marine Fisheries Service in some instances) and State fish and wildlife agency regarding the impacts on fish and wildlife resources and measures to mitigate these impacts."[37]

The **Endangered Species Act** (ESA) 16 U.S.C. §1531-1544 (1973) protects endangered and threatened species and includes in that protection the natural systems upon which they depend. The Secretary of Commerce or the Secretary of the Interior are required to list species determined to be endangered or threatened as well as designate a listed species' critical habitat.[38] Citizens are able to petition to force species listing determinations.[39] The law also requires that the Secretary develop and implement species recovery plans.[40] The ESA prohibits the sale, import, export, or transport of an endangered species, prohibits the "taking" of an endangered species, and prohibits the removal or damage of endangered plants on federal land or anywhere else if in knowing violation of state law.[41] There are criminal and civil penalties for violating the provisions of this Act, and it

34 Long Island Sound Study, Introduction of the Plan: http://longislandsoundstudy.net/about/our-mission/management-plan/introduction/
35 NYS Dept. of Environmental Conservation, 2002 *NYS Open Space Conservation Plan* – Chapters 8 & 9 http://www.nysl.nysed.gov/scandoclinks/ocm50762235.htm (5/10/13)
36 36 EPA Water and Wetlands – Section 10 of the Rivers and Harbors Appropriation Act of 1899 http://water.epa.gov/lawsregs/guidance/wetlands/sect10.cfm (12/17/12)
37 U.S. Fish and Wildlife Service – Fish and Wildlife Coordination Act – http://www.fws.gov/laws/lawsdigest/fwcoord.html (5/10/13)
38 16 U.S.C. §1533(a)
39 16 U.S.C. §1533(b)
40 16 U.S.C. §1533(f)
41 16 U.S.C. §1538

provides for citizen suits to help with enforcement. The ESA requires all federal agencies to have programs to conserve endangered and threatened species and ensure that their actions do not jeopardize endangered and threatened species or adversely modify or destroy their habitat.[42] Incidental take permits may be issued for those persons who have an approved habitat conservation plan so long as it will not significantly reduce the likelihood of the species survival or recovery in the wild.[43]

Federal Species Protection Laws include the following:

The Neotropical Migratory Bird Conservation Act of 2000 establishes a grant program for public-private partnerships for projects in the U.S., and elsewhere that promote the long-term conservation of neotropical migratory birds and their habitats. http://www.fws.gov/birdhabitat/Grants/NMBCA/index.shtm

The Habitat and Land Conservation Act of 2007 provides tax relief for individuals and corporations who make charitable donations for conservation of endangered species. It provides tax relief for habitat restoration and protection easements for endangered species, as well as allowing taxpayers to deduct remediation costs for brownfields. http://www.cbo.gov/ftpdocs/87xx/doc8739/LandConservation.pdf

The Marine Mammal Protection Act prohibits the "take" of any marine mammal from U.S. waters, with certain exceptions, or by a U.S. citizen on the high seas. It also prohibits the importation of marine mammals or marine mammal products into the U.S. http://www.nmfs.noaa.gov/pr/laws/mmpa/

The Migratory Bird Treaty Act was passed in 1918 and prohibits the taking, killing, or possessing of all migratory birds. The 2008 Birds of Conservation Concern initiative identifies specific migratory and nonmigratory bird species that may warrant stronger conservation efforts. National conservation plans for landbirds, waterbirds, and shorebirds help to inform the species selections for this initiative.[44]

b. State Laws

Alienation of Parkland. Under the Public Trust Doctrine, municipal parkland in the State of New York cannot be converted to a non-recreational use without approval of the State Legislature. According to NYS common law, parkland is for public enjoyment and therefore "non-park use" is not permitted unless it is approved by the State first through a procedure called alienation.[45] Activities that trigger this process include a lease for any purpose, parking (unless for the park itself), museums, municipal facilities, schools, and construction of streets. The New York State Office of Parks, Recreation and Historic Preservation publish a guidebook for this process called the Alienation Handbook, which lays out the specific policies for parkland alienation in New York State.[46]

As part of the alienation process, even if the alienation is approved, "state law provides leverage to get something equivalent in exchange—new parkland or park improvements—as mitigation."[47] For example, if the City has received funding from the State to acquire or improve upon a City park or its recreational facilities, it creates other restrictions on the alienation process. Both state and federal programs have been established where funding provided to municipalities requires alienation legislation. These include Park and Recreation Land

42 16 U.S.C. §1536 (a), (e)-(f)
43 16 U.S.C. §1539(a)
44 US Fish and Wildlife Service, Office of Migratory Bird Management http://www.fws.gov/migratorybirds/AboutUS.html (5/10/13)
45 Parks & Trails New York, Parkland Alienation Policy, http://www.ptny.org/advocacy/index.shtml
46 NYSOPRHP. The Alienation Handbook http://nysparks.state.ny.us/publications/default.aspx
47 Schwartz, Anne. State Protections for City Parkland Gotham Gazette. October 2002. http://www.gothamgazette.com/article/parks/20021001/14/609

Acquisition Bond Acts of 1960 and 1965, Outdoor Recreation Development Bond Act of 1965, Environmental Quality Bond Act of 1986, Environmental Protection Act of 1993, Clean Water/Clean Air Bond Act of 1996.[48]

State Endangered Species Law (1972) N.Y. Envtl. Conserv. Law §11-0535
"The New York code for endangered species defines endangered species as any species which meets one of the following criteria: native species in imminent danger of extirpation or extinction in New York; or species listed as endangered by the United States Department of the Interior in the Code of Federal Regulations (50 CFR part 17)." http://www.animallaw.info/statutes/stusny11_0535.htm

> Listed species known to occur in New York State — The DEC Vertebrate Checklist contains an updated checklist of amphibians, reptiles, birds and mammals for New York including their legal status. It does not include invertebrates, however. http://www.dec.ny.gov/docs/wildlife_pdf/vertchklst0410.pdf

The **Freshwater Wetlands Act** (1975) N.Y. Envtl. Conserv. Law §8 protects wetlands larger than 12.4 acres, and certain smaller ones of "unusual local importance" designated as such by the Commissioner of the DEC. Advocates may petition to the Commissioner to protect certain wetlands within their local community.[49]

Under this Act, the DEC has the authority to regulate freshwater wetlands and the adjacent 100 feet buffer area in New York State. DEC must map and categorize freshwater wetlands so they can be regulated through the permit program laid out in the Freshwater Wetlands Permit Requirement Regulations (ECL 6NYCRR Part 663).[50] These regulations specify the exempt and regulated activities, as well as minor and major projects.[51,52] Wetlands across the state are classified according to their basic functions and benefits, which mean permits will reflect more or less protection based on their classification.[53] Freshwater wetland permit standards require the applicant to avoid or minimize the impact to the wetland.[54]

There is no law protecting vernal or ephemeral ponds in New York State unless they are more than 12.4 acres and protected under the Freshwater Wetlands Act.[55] The **Clean Water State Revolving Fund** (CWSRF) was created in the 1987 CWA amendments to fund projects that improve water quality; however, it can also be used for wetland acquisition. The CWSRF has been used in California by partnerships of land trusts, conservancies, and government agencies, to purchase and protect vernal pool landscapes.[56] In NYS, the funds are used to purchase lands and waters that are consistent with comprehensive conservation management plans or will improve water quality in some way.

The **Tidal Wetlands Act** (1973) N.Y. Envtl. Conserv. Law §25 et seq. protects the tidal wetlands, and the unique

48 NYSOPRHP. The Alienation Handbook http://nysparks.state.ny.us/publications/default.aspx
49 Riverkeeper, Wetlands Protection In New York State www.riverkeeper.org/document.php/161/Wetlands_Protec.doc (10/23/07)
50 NYS Dept. of Environmental Conservation, Part 663: Freshwater Wetlands Permit Requirements http://www.dec.ny.gov/regs/4613.html (10/9/07)
51 NYS Dept. of Environmental Conservation, List of Exempt and Regulated Activities Under the Freshwater Wetlands Act http://www.dec.ny.gov/permits/6279.html (5/10/13)
52 NYS Dept. of Environmental Conservation, Freshwater Wetlands Permit Program: Is this Project Major or Minor? http://www.dec.ny.gov/permits/6275.html (10/9/07)
53 NYS Dept. of Environmental Conservation, Freshwater Wetlands Permits http://www.dec.ny.gov/permits/6058.html (10/9/07)
54 NYS Dept. of Environmental Conservation, Freshwater Wetlands Permit Program: Application Procedures http://www.dec.ny.gov/permits/6277.html (10/9/07)
55 New York Natural Heritage Program, NYNHP Conservation Guide – Vernal Pool. Updated: October 19, 2007 http://www.acris.nynhp.org/report.php?id=9902 (10/19/07)
56 US EPA, Wetlands Protection – Using the CWSRF http://water.epa.gov/type/wetlands/outreach/upload/state_rev_fund_pr.pdf (5/10/13)

and important habitats they provide, from dredging, filling, and human activity.[57] In New York City, tidal wetlands are found along Long Island Sound, the Hudson River, and the Atlantic Coast. Through their Tidal Wetlands Land Use Regulations (6NYCRR Part 661), DEC administers the Tidal Wetlands Regulatory Program, for which they issue permits to restrict the use and activities allowed in or around tidal wetlands.[58] Activities proposed within a 300-foot buffer, or a 150-foot buffer in New York City, require a permit.[59] Classifications of wetlands as well as designations of minor or major projects[60] guide the determination of permit scope and applicability.

The New York State Official Tidal Wetlands Inventory, maintained by DEC's Bureau of Marine Resources in the Tidal Wetlands Inventory and Geographic Information System Unit, was created in 1974 and is used to control and manage the development, filling, and dredging of areas in and around tidal wetlands.

The Tidal Wetlands Regulatory Program is designed to prevent "despoliation and destruction of tidal wetlands by establishing and enforcing regulations that 1) preserve, protect, and enhance the present and potential values of tidal wetlands; 2) protect the public health and welfare; and 3) give due consideration to the reasonable economic and social development of the state."[61]

The **Invasive Species Prevention Act** (signed in 2012 and commencing in 2013) amends N.Y. Envtl. Conserv. Law §9-1709. Beginning in September 2013, New York State will regulate the possession, propagation, sale, importation, introduction, and transport of certain invasive species, both flora and fauna. The amendment also calls for the creation of a list of prohibited and regulated species.[62]

Biological Diversity – Identification, Research and Conservation Act N.Y. CLS Educ. §235-a, 235-b established the Biodiversity Research Institute and the New York Natural Heritage Program for better conservation of biological resources on state-owned lands. (The Biodiversity Research Institute no longer exists. The Natural Heritage Program is now administered by SUNY College of Environmental Science and Forestry.)[63]

State Conservation (Protection of Natural and Man-made Beauty) N.Y. ECL §49 provides for state land acquisitions and easements for various purposes, among them to protect environmental assets and natural resources and areas of significance for reasons such as ecological character. It also directs the DEC to conduct surveys, inventories and studies of the state's natural resources and provide a clearinghouse with this information.[64]

Review of State Owned Lands (Ecosystem Management Policy) N.Y. ECL §3-0302.—DEC is required to conduct a review of state-owned lands for identification of rare species of plants, animals and ecological

57 NYS Dept. of Environmental Conservation, Tidal Wetlands http://www.dec.ny.gov/lands/4940.html (10/10/07)
58 NYS Dept. of Environmental Conservation, Tidal Wetlands Permit Program http://www.dec.ny.gov/permits/6039.html (10/10/07)
59 NYS Dept. of Environmental Conservation, Tidal Wetlands Permit Program: Application Procedures http://www.dec.ny.gov/permits/6357.html (5/10/13)
60 NYS Dept. of Environmental Conservation, Part 661: Tidal Wetlands-Land Use Regulations – Page 2 http://www.dec.ny.gov/regs/13338.html (10/9/07)
61 NYS Dept. of Environmental Conservation, Tidal Wetlands Permit Program http://www.dec.ny.gov/permits/6039.html (10/24/07)
62 N.Y. ECL §9-1709 http://assembly.state.ny.us/leg/?default_fld=&bn=S06826&term=2011&Summary=Y&Actions=Y&Text=Y&Votes=Y
63 Environmental Law Institute. 2001. The New York State Biodiversity Project Needs Assessment. New York City: American Museum of Natural History. Accessible online: http://www.nybiodiversity.org/data/NYSBP_Needs_Assessment.pdf
64 Environmental Law Institute. 2001. The New York State Biodiversity Project Needs Assessment. New York City: American Museum of Natural History. Accessible online: http://www.nybiodiversity.org/data/NYSBP_Needs_Assessment.pdf

communities. This law would apply to state lands in the City.[65]

State Environmental Protection Act N.Y. ECL §54 — authorizes assistance to state, local, and public entities who perform waste management and conservation efforts, such as open space land conservation, recycling, historic preservation, municipal park and urban cultural park projects, waterfront revitalization, and coastal rehabilitation projects.[66] It also states that one of the most fundamental obligations of the state government is "the preservation, enhancement, restoration, improvement and stewardship of the state's environment."[67]

Fish & Wildlife Law N.Y. ECL §11 — prohibits the taking (wounding, trapping, killing) of fish, wildlife, shellfish, harbor seals, crustacea, or insects that are protected by law.[68] The DEC is directed to manage fish and wildlife resources of the state efficiently, taking into consideration ecological issues and "the need for restoration and improvement of natural habitat and the importance of ecological balance in maintaining natural resources."[69]

Parks, Recreation & Historic Preservation Law §3.01 et seq. — mandates the responsibility of the Office of Parks, Recreation and Historic Preservation (OPRHP) to "conserve, protect, and enhance the natural, ecological, historic, cultural, and recreational resources…for future generations."[70] The law also requires the OPRHP to "identify, protect, manage, and conserve important ecological and natural areas, including plants, animals, and ecological communities that are rare in New York State, located on state parks, parkways, historic sites, recreational facilities, and other lands under the jurisdiction of the Commissioner."[71]

State Bird Conservation Area Program N.Y. Envtl. Conserv. Law §11-2001 et seq. — This program allows sites to be designated as an "important bird area" in order to safeguard and enhance wild native bird populations and their habitats. The law lists the criteria necessary for designating a site an "important bird area" and establishes an advisory council that shall manage and utilize the areas under this program consistently with its purpose.[72]

New York State Open Space Conservation Plan — This plan authorizes the state to acquire lands to conserve a variety of open space across New York State, including NYC. Biodiversity is one of the considerations in the priority ranking for land acquisition. The goals of this plan are to protect water quality, support fish and animal life, and protect habitat for the plants and animals that sustain the state's ecosystems.[73] The plan does not provide funds to manage land once it has been set aside.

Hudson River Estuary Management Act N.Y. ECL §11-0306 — The Act establishes the Hudson River estuarine district "which shall include the tidal waters of the Hudson River, including the tidal waters of its tributaries and wetlands from the federal lock and dam at Troy to the Verrazano-Narrows"[74] and a management program

65 Environmental Law Institute. 2001. The New York State Biodiversity Project Needs Assessment. New York City: American Museum of Natural History. Accessible online: http://www.nybiodiversity.org/data/NYSBP_Needs_Assessment.pdf

66 N.Y. ECL §54

67 Environmental Law Institute. 2001. The New York State Biodiversity Project Needs Assessment. New York City: American Museum of Natural History. Accessible online: http://www.nybiodiversity.org/data/NYSBP_Needs_Assessment.pdf

68 N.Y. ECL §11-0107

69 N.Y. ECL §11-0303

70 Parks, Recreation and Historic Preservation §3.02. http://law.onecle.com/new-york/parks-recreation-and-historic-preservation/PAR03.02_3.02.html (5/10/13)

71 Parks, Recreation and Historic Preservation §3.09. http://law.onecle.com/new-york/parks-recreation-and-historic-preservation/PAR03.09_3.09.html (5/10/13)

72 N.Y. ECL §§11-2001, 11-2003

73 DEC, OPRHP, and DOS. 2009. New York Space Open Space Plan of 2009. http://www.dec.ny.gov/lands/47990.html (5/10/13)

74 N.Y. ECL §11-0306(1)

to protect, preserve, restore, and enhance the shoreline, fish and wildlife habitats, and natural resources therein. The law also created the Hudson Estuary estuarine sanctuary to protect "areas of special ecological significance" in the estuarine district and associated shorelines.[75]

c. CITY LAWS

Local Law 3 — Passed in 2010, this law creates a standard for the replacement of trees on public property which were removed during construction. Any trees damaged or destroyed must either be replaced by the developer or paid in restitution to the City, which then replaces the lost trees with those funds. The total caliper of all trees planted in the course of restoration must be at least the total caliper of all trees removed. The provisions of this law also apply to all City agencies, including the NYC Department of Parks and Recreation, which often removes trees in the course of natural areas restoration and must replace in kind with native species.[76]

Local Law 31 — Established in 2009, this law requires the City to amend the administrative code to create a comprehensive wetlands protection plan for The City of New York. In May of 2012, the Mayor's Office of Long-term Planning and Sustainability released the New York City Wetlands Strategy in accordance with this law.[77]

Local Law 5 — Established in 2008, this law requires the City to amend the administrative code in order to develop and implement a sustainable stormwater management plan. The OLTPS created the Sustainable Stormwater Management Plan in 2008 pursuant to this law.[78]

Local Law 71 — The New York City Administrative Code §24-537, known as Local Law 71, directs the Commissioner of the NYC Department of Environmental Protection (DEP) to complete a watershed protection plan for the watershed/sewershed of Jamaica Bay to "restore and maintain the water quality and ecological integrity of Jamaica Bay."[79] The Jamaica Bay Watershed Protection Plan (JBWPP) was completed by the DEP in October 2007 and can be found on their website.[80] The law lays out specific items that must be in the JBWPP as well as actions to be taken, including, but not limited to, best management practices for the minimization and control of soil erosion and stormwater runoff and reduction of point and non-point source pollution; measures to address threats to aquatic habitat; land acquisition and land use planning practices and opportunities; a protocol for coordination with appropriate federal, state, and city government entities that have jurisdiction over the Jamaica Bay area; and a schedule for implementing the measures and achieving the goals included in the plan.

Local Law 83 of 2005, Local Law 37 of 2006, and Local Law 13 of 2007 — This New York City law was introduced and enacted by the City Council "to create a temporary task force to study the feasibility of transferring City-owned wetlands to the jurisdiction of the Department of Parks and Recreation."[81] In 2007, the City released a report of the Wetlands Transfer Task Force (WTTF) recommending transfer of City-owned wetlands to the New York City Department of Parks and Recreation (DPR) and the New York City Department of Environmental

75 N.Y. ECL §11-0306(5)
76 The New York City Council Int. No. 4-A, Law number 2010/003. (12/11/12)
77 The New York City Council Int. No. 506-A, Law number 2009/031. (6/27/12)
78 The New York City Council Int. No. 630-A, Law number 2008/005. (6/27/12)
79 New York City Administrative Code §24-527 http://law.onecle.com/new-york/new-york-city-administrative-code-new-/ADC024-527_24-527.html (5/10/13)
80 Department of Environmental Protection: Jamaica Bay Watershed Protection Plan http://home2.nyc.gov/html/dep/html/dep_projects/jamaica_bay.shtml (1/25/08)
81 New York City Council – Local Law 83 of the City of New York for the year 2005

Protection for protection and management.[82]

5. RELEVANT ORGANIZATIONS, AGENCIES, AND PROGRAMS

a. New York City's **Office of Long-Term Planning and Sustainability** (OLTPS) was created as part of the Mayor's Office by local law in 2006. The Office coordinates with all other City agencies to develop, implement, and track the progress of **PlaNYC** and other issues of infrastructure and the environment, which cut across multiple City departments. Released in 2007 and updated in 2011, PlaNYC is an unprecedented effort undertaken by Mayor Bloomberg to prepare the City for one million more residents, strengthen the city's economy, enhance the quality of life for all New Yorkers, and deal with climate change. In addition to producing **PlaNYC**, the OLTPS promotes the integration of sustainability goals and practices into the work of City agencies and the lives of New Yorkers.[83]

b. **New York City Department of Environmental Protection** (DEP) is a city agency that manages the City's water supply, wastewater, and sewer needs, as well as air quality, noise, and hazardous waste issues. The relevance to biodiversity pertains to its protection of air, water, and land related to human, toxic, and hazardous waste. DEP is also responsible for drafting the Jamaica Bay Watershed Protection Plan, which responds to the critical habitat and disappearing salt marshes in the bay. http://www.nyc.gov/html/dep

c. The **New York City Department of City Planning** (DCP) is in charge of strategic planning for the City of New York and oversees land use and environmental review for the five boroughs. The DCP provides staff support to the New York City Planning Commission and is advised by the borough and community boards on issues of planning, land use applications, and environmental reviews. The DCP is proposing and has adopted some green initiatives. Some of these are text amendments that set green standards for parking lots, enhance yards and open space, and require street tree planting.

d. The **New York City Planning Commission** (CPC) approves, disapproves, or approves with modification most land use and zoning changes for the City. The CPC also administers coastal consistency review in most cases for proposals affecting the City's WRP. http://www.nyc.gov/html/dcp/

e. The **New York City Office of Environmental Remediation** (OER) was created in 2008 to expedite the cleanup of contaminated brownfield sites throughout New York City as outlined in PlaNYC.

f. The **New York City Brownfield Cleanup Program** (BCP) is an OER operated program designed to help land owners and developers clean up contaminated property and facilitate redevelopment. New York City is home to approximately 11,000 acres — roughly the size of Manhattan — of underutilized land, much of it brownfields. Remediating this land and thus regaining access to it would allow for the development of community gardens and other critical green spaces.

g. The **New York City Department of Parks and Recreation** (DPR) protects and manages City-owned parklands, including the flora and fauna therein, for the benefit of its residents and their quality of life. DPR maintains

82 New York City Wetlands Strategy, Mayor's Office of Long term Planning and Sustainability, May 2012. http://www.nyc.gov/html/planyc2030/html/publications/publications.shtml (6/27/12)

83 PlaNYC Website – http://www.nyc.gov/html/planyc2030/html/about/who-we-are.shtml (6/27/12)

~28,000 acres, and "providing clean, safe, and accessible green spaces is at the heart of Parks' mission."[84] DPR has seven different divisions, each one with their own responsibility or mission.

One of the 132 PlaNYC initiatives, DPR along with the New York Restoration Project is responsible for **Million Trees NYC**, which aims to plant and care for one million new trees across the City's five boroughs by 2017.[85]

Most relevant to biodiversity is the DPR's **Natural Resources Group**, whose mission is "to conserve New York City's natural resources for the benefit of ecosystem and public health through acquisition, management, restoration, and advocacy using a scientifically supported and sustainable research."[86]

The **Forever Wild Program** is an initiative of the DPR to protect and preserve the most ecologically valuable lands within the five boroughs. The 51 Forever Wild Nature Preserves include over 8,700 acres of towering forests, vibrant wetlands, and expansive meadows.[87]

There are many neighborhood and borough groups that advocate for the environment through parks and open space. See the New Yorkers 4 Parks and Partnerships for Parks websites.[88]

The New York City Charter lays out the powers and duties of the Commissioner of Parks and Recreation, who may appoint three deputies and is the head of the Department of Parks and Recreation. The Commissioner of Parks and Recreation operates the Department of Parks and Recreation, has jurisdiction over the City's park-lands, and must establish and enforce the rules and regulation for the use, governance and protection of public parks. The Commissioner has the duty "to plan, conduct, supervise, coordinate and promote conservation, environmental, and nature educational programs and research and demonstration projects relating thereto and to…manage areas and facilities for conservation and the preservation of natural beauty."

The laws, codes, and ordinances for the City are found in the New York City Administrative Code, and Title 18 pertains to Parks. There are no laws that directly address biodiversity and/or ecology. The laws contain provisions relating to specific areas, jurisdiction of public beaches, prohibitions on beaches, and definitions and jurisdictions of trees and vegetation, to name a few.

Park rules and regulations are laid out in the Rules of the City of New York under Title 56. Relevant provisions relate to permitted uses such as fishing and planting, and prohibited uses such as cutting or planting trees and other vegetation. Variances may be issued when "there are significant practical difficulties, or unnecessary hardships, not created or caused by the applicant, in the way of carrying out the Rules, or where the beauty and utility of property within the jurisdiction of the Department would be preserved by compliance with the terms and conditions of such variance."[89]

84 McNeil, J. S. 1998-1999 Biennial Report: Eight Seasons. City of New York Parks & Recreation. Accessed online at: http://www.nycgovparks.org/sub_newsroom/biennial_report/index.html (12/19/07)

85 Million Trees NYC: http://www.milliontreesnyc.org/html/about/about.shtml

86 About the City of New York Parks and Recreation: Natural Resources Group http://www.nycgovparks.org/sub_about/parks_divisions/nrg/nrg_home.html (12/19/07)

87 NYC Parks, Natural Resources Group, Forever Wild, http://www.nycgovparks.org/greening/nature-preserves

88 New Yorkers 4 Parks http://www.ny4p.org/ (5/10/13)
Partnerships for Parks http://www.cityparksfoundation.org/partnerships-for-parks/ (5/10/13)

89 RCNY Title 56: Department of Parks and Recreation §1-01 (c) http://24.97.137.100/nyc/RCNY/entered.htm (1/25/08)

h. The **State Department of Environmental Conservation** (DEC) is authorized and governed by New York State Environmental Conservation Law. The regulations are codified in six New York Codes, Rules and Regulations (6NYCRR). It has many divisions that work in the state, which is broken into nine DEC regions; NYC is DEC Region 2. The Fish, Wildlife and Marine Resources Division is responsible for much of the state's species conservation programs. Among them are:

New York Natural Heritage Program — The mission of New York's Natural Heritage Program is to enable and enhance the state's rare animals, rare plants, and significant ecosystems through natural resources planning, protection and management. http://www.dec.ny.gov/animals/29338.html

Natural Heritage Areas Program — The goal of this program is to protect rare plants, rare animals, and significant natural communities through better land management on state-owned land. http://www.dec.ny.gov/animals/36987.html

Endangered Species Program — This program is designed to prevent species extinction by identifying and solving fish and wildlife problems. http://www.dec.ny.gov/animals/7181.html

State Wildlife Grants Program — This program provides federal funds to state wildlife agencies for the conservation of fish and wildlife species in greatest conservation need. The program is implemented through a Comprehensive Wildlife Conservation Strategy and conservation projects focused on the species of greatest conservation need. http://www.dec.ny.gov/animals/7179.html

Landowner Incentive Program — This is a program that promotes protecting habitats of rare and at-risk species on private lands through DEC and private property owner partnerships. http://www.dec.ny.gov/animals/32722.html

i. **Division of Coastal Resources of the New York State Department of State** — Administers and enforces the State Waterfront Revitalization of Coastal Areas and Inland Waterways Act. It also enforces coastal policies contained with the New York State Coastal Management Program as well as any Local Waterfront Revitalization Program or Regional Coastal Management Program.

j. **The New York State Office of Parks, Recreation and Historic Preservation** (OPRHP) owns and manages ~894 acres of parkland comprising seven parks in the City. The State also owns the Hudson River Park—a 550 acre park in Manhattan administered by the Hudson River Park Trust, which is a collaboration between the State and the City. Their mission is to "provide safe and enjoyable recreation and interpretive opportunities for all New York State residents and visitors and to be responsible stewards of our valuable natural, historic and cultural resources."[90] The City's State Park branch is located in Manhattan, but the environmental management division is located in Albany.

The OPRHP has a recreation and preservation mandate (through the Land and Water Conservation Fund), which they implement through the application of SCORP, the Statewide Comprehensive Recreation Plan. This provides a standard application process and procedures for major projects within the park system.

k. **U.S. Army Corps of Engineers** — Administers regulation and permitting for navigable waters and coastlines.

90 New York State Parks Planning Bureau. 2008. Statewide Comprehensive Outdoor Recreation Plan. NYS Office of Parks, Recreation and Historic Preservation. http://www.recpro.org/assets/Library/SCORPs/ny_scorp_2009-2013.pdf (5/10/13)

l. **U.S. Fish and Wildlife Service** (FWS) — They are responsible for co-administration of the federal Endangered Species Act (ESA) and several other important conservation programs.

m. **National Oceanic and Atmospheric Administration** (NOAA) — They are responsible for co-administration of ESA and several other important conservation programs.

n. In New York City, the **National Park Service** (NPS) owns and manages the **Gateway National Recreation Area**. Broadly, the mission of the National Park Service is to "preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world."[91]

All federal parklands are governed by federal law and agency rulemaking. According to USC §36.1, the mission of the National Park Service is "to conserve scenery, natural and historic objects, and wildlife, and to provide for the enjoyment of those resources in a manner that will leave them unimpaired for the enjoyment of future generations."[92] The NPS has the discretion to manage national parks and determine the level of impacts that are allowed as long as the natural resources and values are not impaired for current and future generations. The term "impairment" can be broad and generally means an impact that is extensive enough to affect a resource or value that 1) was fundamental during establishment of the park, 2) is critical to the natural or cultural integrity of the park, or 3) is identified as a goal of the park's management plan or other planning document.[93]

Jamaica Bay is the largest and most natural unit of Gateway National Recreation Area and it is managed by the NPS, but other fundamental players include the National Parks Conservation Association and the Jamaica Bay Institute. Also, due to the declining salt marsh habitat within the Bay, the City of New York enacted Local Law 71, which required the New York City Department of Environmental Protection to develop and implement a Watershed Protection Plan for the Bay. The Jamaica Bay Watershed Protection Plan is a management plan for this area that includes upland areas and is heavily based on mitigating nutrient inputs through wastewater treatment plant upgrades to improve the water quality and ecology that are severely threatened.

This issue is very complex and involves numerous stakeholders; in addition to those already mentioned, the U.S. Army Corps of Engineers, the Port Authority of New York and New Jersey, the Harbor Estuary Program of NY and NJ, the U.S. Fish and Wildlife Service, New York State's Department of Environmental Conservation, community groups and local environmental organizations all play a role in protecting these important natural resources, rare species, and endangered habitats.

91 National Park Service – Mission http://www.nps.gov/aboutus/mission.htm (12/19/07)

92 NPCA – Statement of Thomas C. Kiernan – Congressional Testimony http://www.npca.org/protecting-our-parks/policy-legislation/congressional/testimony042502.html (5/10/13)

93 National Park Service – Park Protection – National Park Service Management Policies http://www.nps.gov/protect/policy_section.htm (12/20/07)

List of Acronyms Used in Appendix A.

BSA:	Board of Standards and Appeals
CEQR:	City Environmental Quality Review
CPC:	City Planning Commission
CSO:	Combined Sewer Overflows
CWP:	Comprehensive Waterfront Plan
CWA:	Clean Water Act
CWSRF:	Clean Water State Revolving Fund
DCP:	New York City Department of City Planning
DEC:	New York State Department of Environmental Conservation
DEIS:	Draft Environmental Impact Statement
DEP:	New York City Department of Environmental Protection
DPR:	New York City Department of Parks and Recreation
EAS:	Environmental Assessment Statement
EIS:	Environmental Impact Statement
EPA:	Environmental Protection Agency
ESA:	Endangered Species Act
FEIS:	Final Environmental Impact Statement
FEMA:	Federal Emergency Management Agency
FWS:	U.S. Fish and Wildlife Service
JBWPP:	Jamaica Bay Watershed Protection Plan
HEP:	New York-New Jersey Harbor Estuary Program
NEP:	National Estuary Program
NEPA:	National Environmental Policy Act
NOAA:	National Oceanic and Atmospheric Administration
NPDES:	National Pollution Discharge Elimination System
NPS:	National Park Service
NYC:	New York City
OEC:	Mayor's Office of Environmental Coordination
OER:	New York City Office of Environmental Remediation
OLTPS:	Mayor's Office of Long-term Planning and Sustainability
OPRHP:	New York State Office of Parks, Recreation and Historic Preservation
SEQR:	State Environmental Quality Review
SNWA:	Special Natural Waterfront Areas
ULURP:	Uniform Land Use Review Procedure
WAVES:	Waterfront Vision and Enhancement Strategy
WRDA:	Waterfront Resource Development Act
WRP:	Waterfront Revitalization Program
WTTF:	Wetlands Transfer Task Force

Appendix B.
Plant and Animal Species Lists with Conservation Status

In determining rarity and whether to consider monitoring and management of a particular species or habitat, it is helpful to consult species lists and conservation status compiled by experts to gain a range-wide perspective as well as a regional and local perspective. The following list provides some examples of where to look for more information. Please let us know of other resources you come across.

Federal Lists (covering all taxa)

U.S. List of Endangered and Threatened Species (http://www.fws.gov/endangered/species/us-species.html) — The U.S. Fish and Wildlife Service oversees the listing of species under the federal Endangered Species Act. A species is classified as **endangered** if it is "in danger of extinction within the foreseeable future throughout all or a significant portion of its range." A species is classified as **threatened** if it is "likely to become endangered within the foreseeable future." Species of animals listed as federally endangered or threatened may not be killed, harmed, or otherwise taken on public or private land whereas plants are only protected on federal lands or if federal funds are used in a project that affects them or their habitat. Updated lists are published in the Federal Register, and can be obtained from the U.S. Fish and Wildlife Service website.

Other National Lists (covering all taxa)

NatureServe (http://www.natureserve.org/) – NatureServe maintains a database (NatureServe Explorer) of over 70,000 plants, animals, and ecological communities of North America including their conservation status. Additionally, there is a wealth of related information on their website, including a new climate change vulnerability index.

State Lists (covering all taxa)

Endangered, Threatened, and Special Concern Fish and Wildlife Species of New York State (http://www.dec.ny.gov/animals/7494.html) — This list became part of the state Environmental Conservation Law in 1983, and has been updated on an irregular schedule since then. At publication time, the most recent update was in August 2007. **Endangered** species include any species occurring in New York and listed as endangered under the federal Endangered Species Act (see above), and other native species deemed to be in imminent danger of disappearing from the State. **Threatened** species include those listed as threatened under the federal Endangered Species Act, and other native species that have declined significantly and may become endangered in New York State if conditions in their environment continue to worsen and successful management actions are not undertaken. **Special Concern** species are believed to be declining or vulnerable in the State and may become threatened or endangered in the future; for many of these species, too little is known about their population levels and ecology to reach conclusions about their actual vulnerability and status. **Protected** wildlife species are defined in the Environmental Conservation Law, and include protected wild birds, wild game, most

amphibians and reptiles, and all endangered or threatened species. Protected species may not be taken, transported, possessed, or sold without a permit from the Department of Environmental Conservation.

New York State Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html) — In the fall of 2001, federal legislation established a new State Wildlife Grants (SWG) program that provided funds to state and Tribal wildlife agencies for fish and wildlife species in greatest need of conservation. The State Wildlife Grants program provides funds for conservation efforts aimed at preventing fish and wildlife populations from declining, reducing the probability that these species will be listed as endangered. In order to access these grant funds, New York State was required to develop a Comprehensive Wildlife Conservation Strategy (CWCS) that focuses on the "species of greatest conservation need." This includes animal species that are deemed rare or imperiled and those for which a conservation status has not yet been established.

New York Natural Heritage Program (http://www.dec.ny.gov/animals/29338.html) — The New York Natural Heritage Program (NYNHP) surveys and monitors rare plants, animals, and significant ecological communities throughout the State. It publishes "active inventory" lists for rare plants and animals and updates them periodically. The active inventory lists for animals include species in all vertebrate groups and selected invertebrate groups (and species) such as butterflies, moths, beetles, dragonflies, damselflies, mayflies, stoneflies, non-marine bivalve mollusks, gastropods, cave amphipods, and crayfish. The active inventory lists for plants include species of flowering plants (including conifers), ferns, and fern allies only. A list of rare mosses was compiled in 1993 and updated in 2008. The NYNHP active inventory lists include many of the species listed as Endangered, Threatened, and Special Concern by the DEC, and many other species considered rare or vulnerable in the State. (See the plants section below for details about the state's rare plant list.)

Some species may be rare statewide but have not been listed by NYNHP because of a lack of adequate data, or delays in evaluating data. Many groups of invertebrate animals, as well as the liverworts, algae, lichens, and fungi have not been reviewed by NYNHP. Each listed species and ecological community has been assigned a global and a state rarity rank by the NYNHP; these rankings are reviewed and updated every year (plants) or every few years (animals and ecological communities) on the basis of an increasing body of data gathered by NYNHP and other biologists and ecologists around the state. **A detailed description of the ranking system is on the NYNHP website. Additional information on NYNHP listed species is available at www.acris.nynhp.org/.** They also have informative fact sheets for many plant species found in the state.

To find a map of the Heritage species and natural communities in your area, check the environmental resources mapper program, which allows you to map your location and get a printout of what's in the area. Locations shown may be approximate, in order to protect certain rare species from collection or other harm.

Selected Lists By Taxonomic Group

Birds

There are many lists of rare or declining bird species in North America. While most afford no legal status, some of the included species also occur on state lists of rare species, or are protected by state laws. These lists also provide useful perspective to guide conservation planning and management decisions. (All native birds in New York are fully or partly protected by federal and state laws.)

The North American Bird Conservation Initiative (NABCI) (http://www.nabci-us.org/) — U.S. North American Bird Conservation Initiative (NABCI) Committee is a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the long-term health of North America's native bird populations. The Committee is dedicated to advancing integrated bird conservation, based on sound science and cost-effective management, to benefit all birds in all habitats. NABCI incorporates many of the following bird initiatives under its broad umbrella: North American Waterbird Conservation Plan, North American Waterfowl Management Plan, Partners in Flight North American Landbird Conservation Plan, U.S. Shorebird Conservation Plan, and the Atlantic Coast Joint Venture. Additionally, there are various watch lists and state of birds reports and other similar resources on the main website.

USFWS Migratory Bird Program (http://www.fws.gov/migratorybirds/AboutUS.html) — The U.S. Fish and Wildlife Service Migratory Bird Program maintains regularly updated lists of migratory bird species of conservation and management concern. (An older publication by Schneider and Pence [1992] identified a subset of northeastern species in decline based on the national list, and provided important information on species life histories).

USGS Breeding Bird Survey (BBS) (https://www.pwrc.usgs.gov/bbs/) — The BBS is a cooperative effort between the U.S. Geological Survey's Patuxent Wildlife Research Center and Environment Canada's Canadian Wildlife Service to monitor the status and trends of North American bird populations. Following a rigorous protocol, BBS data are collected by thousands of dedicated participants along thousands of randomly established roadside routes throughout the continent, including the New York area. Data are available on the website.

New York State Bird Conservation Area Program (BCA) (www.dec.ny.gov/animals/30935.html) — The state BCA program was established in 1997 to safeguard and enhance bird populations and their habitats on State lands and waters. The goal of the program is to integrate bird conservation into agency planning, management, and research projects, within the context of agency missions. It is modeled after the National Audubon Society's Important Bird Areas (IBA) program, which began in New York in 1996. The BCA program applies criteria developed under the IBA program to state-owned properties. To date, 52 BCA sites have been designated, including the various islands used by nesting herons (Harbor Herons Program) in NYC and Clay Pit Ponds on Staten Island. Maps and site lists are available online.

New York State Breeding Bird Atlas (http://www.dec.ny.gov/animals/7312.html) — There have been two Breeding Bird Atlases completed in New York State (1980–1985; 2000–2005). Comparisons between data collected during the two atlas periods will provide a useful assessment of current trends in bird populations. In addition, breeding bird surveys are also conducted at specific locations (e.g. Central Park Breeding Bird Survey).

Christmas Bird Counts (http://birds.audubon.org/christmas-bird-count#) — These are now coordinated by the National Audubon Society and when analyzed over time can provide trend assessments for individual species. Counts have been conducted since 1900 with New York City's Central Park being one of the first locations. All data are available online for various count circles that are covered.

New York State Ornithological Association (http://www.nybirds.org/) — The objectives of this organization are to document the ornithology of New York State and foster interest in birds.

Audubon New York (http://ny.audubon.org/) is a chapter of the National Audubon Society. Its mission is to conserve and restore natural ecosystems, focusing on birds. They sponsor conservation initiatives and status for grassland birds, coastal nesting birds, and other declining species. They also focus on regional bird conservation (e.g. Hudson River Valley), among many other programs.

- Birds of Conservation Concern in New York (http://ny.audubon.org/sites/default/files/documents/birdsofconservationconcerninny.pdf)
- Important Bird Areas (protecting priority birds) (http://ny.audubon.org/important-bird-areas-12)

Amphibians and Reptiles

For information about the national and regional status of amphibians and reptiles, consult the **Partners in Amphibian and Reptile Conservation (PARC)** (http://www.parcplace.org) and the **Northeast regional section of PARC (NEPARC)**. (http://www.northeastparc.org/). Additional information about this group of animals can be found at the **North American Amphibian Monitoring Program** website (http://www.pwrc.usgs.gov/naamp/), which is conducting national surveys of calling amphibians (frogs) and now has over 10 years of data to begin trends assessments.

Amphibian and Reptile Atlas (Herp Atlas) Project (www.dec.ny.gov/animals/7140.html) provides species lists and distributional maps for all of New York's amphibians and reptiles. Some of this information was presented in Gibbs et al. (2007).

- Gibbs, J.P., A.R. Breisch, P.K. Ducey, G. Johnson, and J. Behler. 2007. The amphibians and reptiles of New York State: Identification, natural history, and conservation. Oxford University Press, New York, NY. 504 p.

Fish

The National Marine Fisheries Service provides information on rare marine species on their website (http://www.nmfs.noaa.gov/pr/species/fish/). **Fish Base** (http://www.fishbase.org/search.php) is an online relational database of all fish species. Although it can be used to generate identification guides, it does not provide information about conservation status.

Invertebrates

The **National Marine Fisheries Service** provides information on marine invertebrates on their website (http://www.nmfs.noaa.gov/pr/species/invertebrates/).

Freshwater Mollusk Conservation Society (http://molluskconservation.org/) provides information about the status and conservation needs of all species in the U.S. with links to local resources.

The Xerces Society (http://www.xerces.org/) tracks the status of selected invertebrate groups, such as freshwater invertebrates and pollinators, including bumble bees.

Dragonflies and Damselflies (Odonata)

New York Dragonfly and Damselfly Survey (http://www.dec.ny.gov/animals/31061.html) — This survey was conducted from 2005–2009 in New York State to establish a baseline of species distribution. Future atlases can be used to determine trends over time.

Dragonfly Society of the Americas/Odonata Central (http://odonatacentral.org/) maintains a database of dragonfly/damselfly species locations for the US and more.

Butterflies and Moths (Lepidoptera)

Butterflies and Moths of North America (http://www.butterfliesandmoths.org/) is a website devoted to collecting and sharing information about butterfly and moth distribution across the U.S.

North American Butterfly Association (NABA) coordinates the Fourth of July Butterfly counts (http://www.naba.org/butter_counts.html), an ongoing program to count the butterflies of North America (United States, Canada, and parts of Mexico) and to publish the results. Volunteer participants select a count area with a 15-mile diameter circle and conduct a one-day count of all butterflies within that circle.

Plants

Center for Plant Conservation (http://www.centerforplantconservation.org/)—The mission of this organization is to conserve and restore the imperiled native plants of the U.S. They maintain live collections of rare species, and their website provides information on conservation status and links to other botanical research initiatives.

New York State Protected Native Plant List (http://www.dec.ny.gov/animals/7135.html)—This list ranks species as Endangered, Threatened, Rare, or Exploitably Vulnerable. **Endangered** plants are native species "with 5 or fewer extant (still in existence) sites, or fewer than 1000 individuals, or restricted to fewer than four USGS 7 ½ minute series maps, or species listed as endangered by the United States Department of Interior in the Code of Federal Regulations." They are "in danger of extinction throughout all or a significant portion of their ranges within the State and requiring remedial action to prevent such extinction." **Threatened** plants are native species "with 6 to fewer than 20 extant sites, or 1,000 to fewer than 3,000 individuals, or restricted to not fewer than four or more than seven USGS 7½ minute series maps, or species listed as Threatened by the United States Department of Interior in the Code of Federal Regulations." **Rare** plants are native species with 20 to 35 extant sites, or 3,000 to 5,000 individuals throughout the State. **Exploitably Vulnerable** plants are native species "likely to become threatened in the near future throughout all or a significant portion of their ranges within the State if causal factors continue unchecked." This list is updated irregularly. Plant species listed as endangered, threatened, rare, or exploitably vulnerable may not be picked, removed, or damaged without the consent of the landowner. However, the landowner has no requirement to preserve rare or endangered species since there is no legal status for plants in the State.

New York State Flora Atlas (http://newyork.plantatlas.usf.edu/)—The New York Flora Atlas is an online resource for information including distribution of all the vascular plants that occur in New York State.

Regional and City-wide Lists

Information about regional or City-wide significance is a useful tool for biodiversity assessment and conservation. Although all existing populations of every rare species in the region are not known, the regional ranking serves as a measure of relative rarity. Regionally-rare plants and animals may be, but are not necessarily, declining or in danger of disappearing from the region. The presence or absence of these species may provide useful diagnostic information about habitats. They are often good indicators of rare or uncommon habitats, and their presence can alert us to the potential occurrence of statewide rare species. Many are sensitive to habitat

conditions, and rely on habitats that are under particular pressure from land development or other human activities. Generally speaking, species that are highly mobile and occasionally show up in this area as "accidentals" but do not use habitats of New York City on a regular basis (particularly birds, butterflies, and dragonflies) are not considered of special conservation significance in this Handbook. Regional lists are typically compiled for purposes of biodiversity assessments and conservation planning; they have no legal status.

To date, no official, comprehensive regional or City-wide lists of species of conservation need have been developed, but experts in the following groups or organizations are generally familiar with which species are regionally rare.

Birds

New York City Audubon (http://nycaudubon.org/) conducts research on rare species in the City, the Breeding Bird Census of Central Park, and monitors long-legged wading birds with the Harbor Herons Program.

Invertebrates

Although invertebrates are the most species-rich category of animals on the planet, they are mostly little known. Only certain groups (butterflies and some moths, freshwater mussels, a few estuarine invertebrates, and dragonflies) have been well-studied in New York City and the surrounding region. The following are some species lists from past local projects. Much more survey work needs to be done. The **New York Entomological Society** (http://www.nyentsoc.org/index.html) also meets monthly and is a good local source of invertebrate expertise.

Butterflies of the New York Metropolitan Region

- Cech, R. and G. Tudor. 2005. Butterflies of the East Coast: An observer's guide. Princeton University Press, Princeton, NJ. 360 p.
- Glassberg, J. 1993. Butterflies through binoculars: A field guide to the Boston-New York-Washington Region. Oxford University Press. New York, NY. 160+ p.
- Schweitzer, D.F., M.C. Mionno, and D.L.Wagner 2011. Rare, declining, and poorly known butterflies and moths (Lepidoptera) of forests and woodlands in the eastern United States. Forest Health Technology Enterprise Team, Technology Transfer Bulletin, FHTET-96-34. 113 p.
- Steve Walter's New York Butterfly Records (http://www.stevewalternature.com/)

Crickets and Katydids of New York City (www.discoverlife.org/cricket)—A 2009 targeted survey of seven species based on the results of a 24 hour "cricket crawl" survey of New York City and the metro region sponsored by numerous partners including the Center for Biodiversity and Conservation/AMNH and the U. S. Geological Survey. Provides locational information only, not conservation status.

Dragonflies and Damselflies of New York City

- Staten Island Dragonfly Atlas Project–Staten Island Natural History Museum. (http://www.sethwollney.com/SIDragonfly/)
- The Dragonflies and Damselflies of Central Park–Ed Lam (http://www.edlam.net/DD_CP.html)
- Steve Walter's New York Dragonfly Records (http://www.stevewalternature.com/)

Freshwater Mussels of the New York City Metro Region and New Jersey (http://cbc.amnh.org/mussel/) This website and key was developed by the Center for Biodiversity and Conservation at the American Museum of Natural History and the New Jersey Division of Fish and Wildlife's Endangered and Nongame Species Program.

Plants

Metropolitan Flora Project (http://www.bbg.org/research/nymf/) — This Brooklyn Botanic Garden program provides mapped, distributional web-based information on plants of the metropolitan region. It does not actually rank them as rare or common but does provide good current information on their current and historic distribution. Generally speaking, a species that occurs at a larger number of locations within a region is likely to be more abundant at individual sites and less vulnerable to extirpation.

New York City Native Plant Conservation Initiative (NPCI) (http://www.nycgovparks.org/sub_about/parks_divisions/gnpc/nyc_npci_list.html) — NPCI is a partnership between the Department of Parks and Recreation's Greenbelt Native Plant Center (GNPC) and the Brooklyn Botanic Garden (BBG). An analysis by BBG of their Metropolitan Flora Project revealed that all but 75 or so of the species still extant in the five boroughs of NYC (roughly 750) have continued to decline in the last 100 years (so upwards of 90% of all species are in decline). NPCI was conceived as an initiative to examine species health in a complementary approach to more established land management practices within Parks by focusing on the health of individual populations of species. The intent is to survey populations, estimate size, identify conditions and threats and formulate management and monitoring strategies for individual populations to reverse declines and create sustainable levels within populations. A pilot was proposed to test and demonstrate the protocols. 34 species were selected to broadly represent the variety of vascular plant reproductive and life history strategies, and research was begun with mountain laurel (*Kalmia latifolia*), sheep laurel (*Kalmia angustifolia*), and black huckleberry (*Gaylussacia baccata)*. For more information, contact the GNPC.

Torrey Botanical Society (http://www.torreybotanical.org/) — This Society is the oldest botanical society in the US and provides information on plants of local interest through meetings, field trips, and publications.

Appendix C.
Additional Resources

Biodiversity

Laverty, M., E. Sterling, A. Chiles, and G. Cullman. 2008. **Biodiversity 101** (Science 101). Greenwood Press, Westport, CT. 220p.—Provides a good overview of biodiversity, what it is, and why important.

The **Center for Humans and Nature** (http://www.humansandnature.org/)—Explores the concepts of environmental ethics and intrinsic values of biodiversity in more depth.

Threats to Biodiversity

New York Invasive Species Clearinghouse (http://www.nyis.info/)—The Clearinghouse provides scientific and policy information to guide decision-making about preventing, eradicating, controlling and managing invasive species in New York State. New York City falls into two regional groups for invasive species management (PRISMs): 1) the Long Island partnership includes Brooklyn, Queens, and Staten Island along with the rest of Long Island and 2) Manhattan and the Bronx are included as part of the Lower Hudson Partnership.

New York Invasive Species Research Institute (http://nyisri.org/)—This institute coordinates invasive species research to help prevent and manage the impact of invasive species in New York State.

NatureServe Climate Change Vulnerability Index (CCVI) (http://www.natureserve.org/prodServices/climatechange/ccvi.jsp)—This model is useful for predicting the vulnerability of species and habitats to climate change in the future.

USDA Forest Service Climate Change Atlas (http://www.nrs.fs.fed.us/atlas/)—This website provides projections for climate change effects on the distributions of birds and trees in the northeastern United States.

Wildlife Adaption Strategy for Climate Change (http://www.wildlifeadaptationstrategy.gov/about.php)—This website offers background information as well as resource for planning for climate change and wildlife management.

Planning for biodiversity

Conservation Measures Partnership (http://www.conservationmeasures.org/)—This is a partnership of organizations working to improve conservation monitoring and evaluation systems. See the Open Standards for the Practice of Conservation (http://www.conservationmeasures.org/wp-content/uploads/2010/04/CMP_Open_Standards_Version_2.0.pdf).

Northeast Landscape Conservation Cooperatives (LCC) (http://www.fws.gov/northeast/science/lcc.html)—A program of the U.S. Fish and Wildlife Service, LCCs are science and planning partnerships developed for more effective landscape conservation and management.

Plant Stewardship Index (http://www.bhwp.org/psi/What-is-the-Plant-Stewardship-Index-.htm) — This index was developed for Pennsylvania and New Jersey Piedmont areas but may also be useful for New York City. It is a method of determining habitat quality based on plant species composition and the proportion of nonnative species.

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Newgarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Conner, and D. Wilkie. 2008. **A standard lexicon for biodiversity conservation: Unified classifications of threats and actions.** Conservation Biology 22:897-911.

The Nature Conservancy's Conservation Gateway (http://www.conservationgateway.org/ConservationPlanning/Pages/conservation-planning.aspx) — This website includes information about planning, prioritizing and tracking conservation actions, measuring success, as well as discussion about landscape resilience and other conservation topics.

Restoration, Management, and Monitoring

For professionals:

Natural Areas Association (http://www.naturalarea.org/) —The mission of the Natural Areas Association is to advance the preservation of natural diversity. The Association works to inform, unite, and support persons engaged in identifying, protecting, managing, and studying natural areas and biological diversity across landscapes and ecosystems.

U.S. EPA. 2000. **Principles for the Ecological Restoration of Aquatic Resources.** EPA841-F-00-003. Office of Water (4501F), United States Environmental Protection Agency, Washington, DC. http://www.epa.gov/owow/restore/principles.html — This document provides information on effective restoration approaches and practices.

Society for Ecological Restoration (SER) (https://www.ser.org/) — SER's primary focus is to advance the science and practice of ecological restoration as a tool for recovering biodiversity and ecosystem services. There is also an active regional (Mid-Atlantic) chapter.

For everyone:

Bio-Integral Research Center (BIRC), an Integrated Pest Management (IPM) research institute. (http://www.birc.org/) — They assist homeowners, farmers, cities, park and water districts, schools, and pest control professionals in pesticide use reduction, offering many resources related to IPM for lawns, gardens, and landscaping plants.

Union of Concerned Scientists. 2010. **The Climate-Friendly Gardener**. (http://www.ucsusa.org/assets/documents/food_and_agriculture/climate-friendly-gardener.pdf) — Provides science-based gardening recommendations.

Gardening with New York City Native Plants (http://www.nycwildflowerweek.org/nyc_native_plant.pdf) —A useful guide to local gardening written by Marielle Anzelone, published by the New York City Department of Parks and Recreation.

Sustainable Sites Initiative (SITES) (www.sustainablesites.org) — SITES is an interdisciplinary effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at The University of Texas at Austin and the United States Botanic Garden to create voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance practices.