Description of the Basin

The Lower Hudson-Long Island Bays watershed covers 1.7 million acres of land and nearly 1 million acres of open water in the southeastern portion of New York State. The basin extends from the Bear Mountain Bridge across the Hudson River to the eastern end of Long Island. The coastal waters included in the basin are the New York waters of New York Harbor to an imaginary line drawn from Rockaway Point to Sandy Hook, N.J.; all of the bays on the south shore of Long Island to lines drawn across the ocean side of the inlets to those bays; and the New York waters of Long Island Sound and Block Island Sound to an imaginary line drawn from the intersection of the New York, Connecticut, and Rhode Island state lines east of Fisher's Island to Montauk Point. The oceanic portions of the state waters (>32 parts per thousand (ppt.) salinity) are included as part of the Atlantic Ocean Basin section of this strategy. These two basins are inextricably linked and conservation actions conducted in each should be well coordinated. The western boundary of the watershed extends to Greenwood Lake to include two sub-watersheds; the Raritan, that includes the New York state portions of the drainages of the Passaic and Ramapo Rivers, and Newark Bay that includes the New York state portion of the drainage of the Hackensack River. The New York state sections of the St. Johns basin, which drains to the Housatonic River, then to Long Island Sound, have been combined with this basin as well. See Lower Hudson-Long Island Bays Figure 1 for a graphic depiction of the estuarine waters included in the Lower Hudson-Long Island Bays Basin.

According to U.S. Environmental Protection Agency's (USEPA) Multi-Resolution Land Classification (MRLC), the dominant land cover types in the basin are "low intensity residential," "mixed forest," and "deciduous forest." The basin overall is 41.8% developed with structures and hardscape, with another 9.38% of developed green space, including parks, lawns, golf courses, pastures, hay fields, and row crops. The remaining 41.35% of land cover in the basin is forested, with deciduous forests dominating. A complete list of the land classification types and corresponding percentages are found in Lower Hudson-Long Island Bays Table 1.

Water is a significant feature in this basin. In addition to the lake and stream features found within land forms, the basin contains estuarine (0.5-18 ppt. salinity) waters within the lower Hudson River (downstream of Peekskill or Bear Mountain Bridge) and the many bays and harbors in the greater metropolitan region of the state. In addition to the lower Hudson River, significant bays and estuaries include New York Harbor, Long Island Sound, Great South Bay, and the Peconic Bays. This basin has 3 of only 28 Estuaries of National Significance included in the Federal National Estuary Program, Long Island Sound, New York-New Jersey Harbor, and Peconic Bay.

There are over 124,000 acres of state park lands in the basin and an additional 17,199 acres are owned and managed by New York State Department of Environmental Conservation (DEC). The names and acreage of these lands are listed in Lower Hudson-Long Island Bays Tables 4 & 5. There are also several federally owned and managed properties in the basin, including the units of the Long Island National Wildlife Refuge System, and the Gateway National Recreation Area.

The 2000 census recorded about 12.2 million residents in the basin making this basin the most heavily populated in the state, yet there are portions that are still very rural with low housing and road density. Population density ranges from 0 to more than 380,000 people per square mile with an average population density of 35,000 people per square mile. This basin contains over 4% of the entire population of the United States. Population growth projections for this portion of the state indicate that the population will grow by over 14% in the next 20 years (Demographia.com, 2005). Six of the top 11 ranked counties for population growth in New York are found in this basin.

Hudson River, Highlands and Western Units

In the northern portion of the basin, the Hudson River, its valley, and the surrounding highlands are dominant geographic features. The nearly 50 mile section of the river from the Bear Mountain Bridge in the north to the southern tip of Manhattan is part of a tidal estuary. The river becomes measurably salty near the Tappan Zee Bridge, but the extent of salt varies throughout the year depending on rainfall. To either side of the river near the Bear Mountain Bridge is the Hudson Highlands region of the state. These highlands are steep cliffs that cradle the sediment laden river as it winds toward the Atlantic Ocean. On the west side of the river sits Bear Mountain and Harriman State Parks. There are several New York City water supply reservoirs on the east side of the river, within the watershed. The entire Hudson Highlands area is of ecological significance for the great species diversity found there, though the majority of the Highlands physiographic region is outside of this basin and in the Upper Hudson and Delaware basins.

The eastern shore of the river is lined with rail road tracks that have created impoundments and sloughs. There is intense urban/suburban development along both shores of the river punctuated with stretches of waterfront parks, National Estuary Reserves, Camp Smith Army National Guard base, West Point Military Academy, numerous power plants including Indian Point Nuclear Power Plant, and several smaller inland state parks. The Appalachian Trail traverses this section of the lower Hudson valley from southwest to northeast. Development density increases and spreads further from the river toward New York City. Land cover in Westchester County is dominated by low intensity residential development. The western extension, or the sub-watershed with coastal plains uplands in Rockland and Orange Counties, has fish associations found more commonly in New Jersey.

The Hudson valley has diverse natural habitat ranging for high altitude barrens to coastal lowland marshes. This area includes the rare tidal fresh and brackish marsh communities which are among the most diverse wetlands in the state. The Hudson River serves as a migratory corridor for a number of marine and freshwater fish and avian species, including striped bass, eels, and many species of herring which all move up and down the river to and from spawning grounds. The lower section within this basin is a major transition point in the salinity of the Hudson River from the oceanic and estuarine environment of the New York Bight to the freshwater environment of the upper river and tributaries. This is also an important nursery area for juvenile diadromous fishes.

New York–New Jersey Harbor Estuary

The New York-New Jersey Harbor Estuary forms the confluence of several large coastal rivers and sits at the apex of the New York Bight, a major feature of the Atlantic coastline of the U.S. It includes the tidal waters from the Piermont Marsh on the Hudson River, to an imaginary line from Sandy Hook, N.J. to Rockaway Point, N.Y. The core area of the estuary includes the bi-state waters of the Hudson River, Upper and Lower Bay, Arthur Kill, Kill Van Kull, and Raritan Bay. In New York, it includes the East and Harlem Rivers and Jamaica Bay. Other waters are included on the New Jersey side of the harbor.

Over 20 million people live and work around the harbor, creating many stresses on the air, land and water environments and the species that live there. Over 75% of the region's historic wetlands and much of its forests and grasslands have disappeared over the past century. Although water quality has improved dramatically in the past several decades, portions of the harbor still do not meet water quality standards. In spite of all the pressures placed on the harbor by humans, it still supports a surprisingly diverse array of habitats and living species.

The Bight funnels migrating birds, fish, and insects into the Harbor. Species entering the harbor are further constrained by the expanse of land occupied by intense development, which makes the remaining green spaces in the city all the more important. In spite of the staggering human population density in New York City, more than 270 bird species have been documented in Central Park alone. Several islands in the harbor are regionally important breeding areas for the state's colonial waterbirds and wading birds and the surrounding wetlands provide important foraging areas. Staten Island is the least developed of the 5 New York City boroughs and is home to globally rare plant communities in its wetlands and woods.

Over 100 species of marine, estuarine, and diadromous fish have been recorded in the harbor and Raritan Bay continues to support a commercial hard clam fishery.

Long Island

Long Island extends northeast from the apex of the New York Bight and is composed of glacial till. There are two prominent depositional moraine features that extend the length of the island and form the distinctive north and south forks of the east end. The moraines divide the island into distinctive areas.

The north shore of Long Island is dominated by glacial features bordering the Long Island Sound estuary. The Sound is a 150 mile long tidal strait connected to New York Harbor on the western end through the East River, and connected to Block Island Sound on the east end. Long Island Sound is morphologically similar to a fjord, deep and narrow with sills that separate the Sound into three basins. The Sound is generally poorly flushed and proximity to the dense development of New York City and Nassau County make the western basin prone to hypoxia in the summer months. Historically, the Sound has been most important commercially for lobsters and oysters.

The shoreline area between the Harbor Hill glacial moraine and the Sound is dominated by secondary deciduous forest cover, low density residential development, and shallow bays. A string of parks can be found along the moraine

ridge, extending from Staten Island to Nassau County. Beaches along the Sound range from coarse grained sand and gravel to cobble and several are designated as state, federal, or local parkland. The largest river on the north shore is the Nissequogue River in Smithtown, and it is bordered by three state parks, a Suffolk County park, and several smaller town parks.

The westernmost bays along the north shore are characterized by extensive mudflats and sparse fringing tidal marshes. There is generally more intensive industrial and commercial development in the western bays. Eastern north shore bays are more expansive and have fuller tidal marsh zonation. Development density generally decreases from west to east.

The north shoreline elevation peaks near Port Jefferson with nearly vertical sand bluffs. The bluffs decrease in height to the east. The easternmost portions of the north shore are still quite rural with extensive farmlands that have the highest market value production per acre in the state. However, eastern Suffolk County as a whole is under intense development pressure.

The south shore of Long Island is a glacial outwash plain that slopes down from the moraines to a series of lagoons enclosed by a barrier beach system. The south shore is more densely developed than the north shore. Much of the extensive salt marshes in the south shore bays have been negatively affected by dredging, mosquito ditching, marsh erosion, and filling for residential development, as well as inputs from upland development. The western barrier beaches have been intensively developed with high rise buildings and high density detached homes in Queens and Nassau Counties with some stretches of parkland at Breezy Point, Rockaway, and Jones Beach. The eastern barrier beaches are developed with lower density single-family homes punctuated by federal, state, county, and town parks (such as the Fire Island National Sea Shore and Jones Beach State Park) with limited development.

The south shore bays have traditionally been valuable for commercial and recreational hard clam fisheries, and recreational boating and fishing. The largest rivers on the south shore are the Connetquot and Carmens Rivers, but there are numerous tidal creeks and impoundments that drain to the bays. All of the south shore bays have been affected by dredging activity and nutrient enrichment due to human land use.

The east end of Long Island is home to the Peconic River and estuary, extensive pine barrens, and the largest remaining tracts of maritime heath, shrub, and grasslands in New York. The Peconic estuary is located between the north and south forks of Long Island, and consists of over 100 harbors, embayments and tributaries which span more than 128,000 acres of land and 158,000 acres of surface water. The estuary is relatively shallow and home to bay scallops, remnant beds of eelgrass, and many wintering waterfowl. The land side of the east end and Peconic area supports tiger salamanders, coastal ponds, and a high diversity of rare plant and animal species tracked by the New York Heritage Program.

Critical habitats of the basin and the species that use them

There are 229 species of greatest conservation need (SGCN) that currently occur in the basin and 44 species that historically occurred in the basin but are now believed to be extirpated. Lower Hudson-Long Island Bays Tables 4 and 5 list the current and historic species which are SGCN and associated with the Lower Hudson River-Long Island Bays Basin, respectively. Lower Hudson-Long Island Bays Table 5 also includes several species that were historically found in the basin, but whose current distributions and status are unknown, primarily moth and butterfly species. More information on specific distributions of these animals can be found in the insect taxa report in Appendix A. Lower Hudson-Long Island Bays Table 4 also includes information about the stability of the population of those animals currently within the basin. This basin has more of these SGCN than any other of all the basins in New York State, overall the basin contains 42.6% of all these species. The basin contains 75.4% of all the bird SGCN, 71.4% of the crustacea, 72.7% of the herpetofauna, 49% of the marine fish and 8% of the freshwater fish. Lower Hudson-Long Island Bays Table 6 contains further information regarding the species diversity of this basin.

Many of the marine fish and wildlife SGCN only occur in this basin or the Atlantic Ocean Basin statewide. Examples include all 25 marine fish species, the 5 species of sea turtles, and the seven species of salt marsh breeding birds. Long Island especially has increased plant and animal diversity due to its geographic location at the southern end of the geographic range of many northern species, and the northern end of the geographic range of many southern species. American lobster, winter flounder, and blue mussels are examples of northern species at the edge of their range on Long Island. This edge-of-range phenomenon is, in many cases, an added stressor to these species. It is thought that warmer water temperatures in Long Island Sound over the past few years have played a role in mass mortality events of lobsters there.

DEC staff members who compiled the SGCN information in the State Wildlife Grants database were asked to indicate habitats associated with critical life stages and activities for those species. During the analysis for each basin a listing of species occurring in the basin and the critical habitats associated with their life cycle at the system and subsystem level was extracted from the database. The resulting aquatic and terrestrial habitats are summarized in the tables below. The habitat classifications in the database were adapted from the New York Natural Heritage Program's *Ecological Communities of New York State, Second Edition* (Edinger et al., 2002). In most cases the habitats were simplified from the many vegetation associations listed in the community classifications. In the case of the lacustrine and riverine systems, the subsystems were modified to reflect the classifications most often used by fisheries managers at DEC, e.g. "cold water - shallow".

Each of these systems and subsystems are further refined into a habitat category in the State Wildlife Grants database. The habitat categories are excluded here for the sake of simplicity, but were considered during the basin analysis. A complete listing of habitat types used in the preparation of the CWCS can be found in Appendix B. The System-Subsystem classes that are listed as critical to species in

Lower Hudson River-Long Island Bays Basin are listed in Lower Hudson-Long Island Bays Table 7. These critical habitats are not a comprehensive listing of all habitat associations found in the basin, rather it is a subset of the habitats deemed critical to SGCN that occur in the basin.

There are excellent detailed discussions of the habitats of this basin found in the Comprehensive Conservation and Management Plans of the Long Island Sound Study, New York/New Jersey Harbor Estuary Program, and Peconic Estuary Program. The two state estuary programs, the South Shore Estuary Reserve Program and the Hudson River Estuary Program also have Comprehensive Management Plans that describe the habitats of those estuaries and the nearshore upland in detail. Another report produced by Cornell University and the DEC for the Hudson River Estuary Program (Penhollow et al., 2002) describes biodiversity "hot spots" within the estuary program boundaries in great detail. The Pine Barrens Reserve Management Plan and enacting legislation describe that habitat complex in detail. In addition, there are many OPRHP and DEC management area natural resource inventories, unit management plans, and park master plans that contain descriptions of the physical environment of those lands. Two federal publications, *Significant Habitats of the New York Bight* and *Northeast Coastal Areas Study*, both published by the U.S. Fish and Wildlife Service, have detailed ecological descriptions of this basin, the species that use it, and the primary threats to the species and their habitats. All of these publications were consulted in the process of drafting the descriptions and recommendations for this basin.

Open Upland Habitats

Terrestrial open uplands are the system-subsystem association critical to 57 SGCN, the most of any of the system-subsystem associations in the basin. This association includes grassland habitats that are critical to 53 of the species in the basin. An example of natural grassland habitats in the basin are the nearly extirpated Hempstead Plains grasslands that dominated Nassau County when European settlers first arrived on Long Island in the 17th century. The USDA has classified portions of central Suffolk County as "Grassland Wildlife Zones". There are also maritime grasslands on the eastern end of the south fork of the island that are influenced by salt spray from the Atlantic Ocean.

The grasslands of the lower Hudson River valley are primarily active and abandoned agricultural fields. These grasslands support grassland breeding birds, raptor hunting, eastern hognose snake, and, in some areas, the New England cottontail rabbit. These grassland areas of the basin are classified by the USDA as areas of grassland related biodiversity.

This association also includes the extremely rare serpentine barrens community known only from Staten Island. This community is a distinctive grass-savannah community with mixed tree and shrub cover. Plant species here are strongly influenced by the chemical properties of serpentinite soils and extremely well-drained, sandy soil. These barrens are critical habitat for the Arogos skipper, a SGCN of critical importance in this basin.

Long Island contains open upland habitats influenced by the adjacent ocean and estuaries. Open habitats range from the historic prairie grasslands of the Hempstead Plains in Nassau County, east to the maritime grasslands of Montauk Peninsula where grassland patches are interspersed among low shrubby

heathlands dominated by bearberry and beach heather, and maritime shrublands with native cherries and sumac. Six of only 13 known remaining natural populations of federally endangered sandplain gerardia, and 4 of the 7 new introduction sites, are found in the grasslands of Long Island.

Forested Habitats

Terrestrial forested habitats are also very important to SGCN in this basin. Forests are critical habitat for 52 SGCN in this basin. Most of Long Island's remaining forests are southern deciduous forests, but the eastern end of the island has an extensive area of pine barrens. The terrestrial barrens/woodland system-subsystem association in this basin provides critical habitat for 36 SGCN. Both the historic grasslands and pine barrens habitats on Long Island are fire-adapted communities, negatively affected by the suppression of fire in areas near human development. Long Island pine barrens contain interspersed coastal plain ponds and support eastern tiger salamander, eastern mud turtle, coastal barrens buckmoth, and banded sunfish among many other SGCN.

Montauk peninsula and the barrier beaches of southern Long Island contain the globally rare maritime oak-holly forest.

The lower Hudson valley forests are dominated by both mixed and deciduous forests. The entire Hudson Highlands region represents one of the few remaining large unfragmented landscape blocks in the entire state. This forest and wetland complex links the Mid-Atlantic States to New England. Dominant forest matrix community types in the Highlands include Appalachian oak-hickory forest, chestnut oak forest, and oak-tulip tree forest. The plant and wildlife communities in this region are among the most diverse in the state.

Wetland Habitats

Both freshwater and estuarine wetlands are used by large numbers of SGCN. The emergent marshes of both systems provide important nutrients, nesting habitat, and protective cover for many terrestrial and aquatic species.

There are a variety of freshwater wetland types in the basin ranging from forested wetlands like red maple swamps to emergent marshes with no woody vegetation to ephemeral wetlands like vernal pools. Freshwater wetlands of note in the basin include the string of wetlands associated with the unfragmented forested areas of the Highlands and the calcareous wet meadows found in the Harlem Valley. Freshwater wetlands in the Harlem Valley area provide excellent habitat for the federally threatened and state endangered bog turtle and the upland sandpiper. The interspersed wetland patches in the Hudson Highlands include inland white cedar swamps, rich graminoid fens, dwarf shrub bog, and highbush blueberry bog thicket.

Tidal wetlands in the basin range from fresh to brackish to estuarine. There are extensive marshes, sloughs, and flats all the way down the length of the Hudson River that cover the full range of salinities. Tidal fresh and brackish marshes in the Hudson River are among the most diverse in the world. Salt marshes have been severely compromised in the 5 boroughs of New York City, but in Queens, Staten Island, and the Bronx, important examples of these marshes remain, particularly those in Jamaica Bay and in Pelham Bay Park. Long Island tidal

wetlands have also been diminished over time, but still remain a vital nursery and primary production area for coastal marine species in New York. The largest expanses of salt marsh on Long Island are found in Great South Bay. All estuarine intertidal habitats including salt marsh, mudflats, and sand flats provide critical habitat to 52 SGCN in the basin. Of these species, 31 use intertidal marshes and 15 use intertidal mudflats.

Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) beds in the estuarine and brackish waters of the basin provide critical habitat to many juvenile species of fish, crustacea and bay scallops. The plants themselves are indicators of good water quality and important transformers of nutrients in the water column. SAV also attenuates suspended sediments in the water, increasing clarity. The photosynthetic activity of the plants can enhance dissolved oxygen in the water column. Dominant vegetation types in the mixohaline waters are eelgrass and, less frequently, widgeon grass. Beds in the brackish portions of the Hudson River are dominated by native tape grass and exotic water chestnut.

All of the habitats within the estuarine shallow subtidal system-subsystem association in the basin collectively provide critical habitat to 40 SGCN. The unvegetated sand and mud bottom areas of estuaries are important to hard clams, winter flounder, and other species.

Calcareous Ridge and Ledge Habitats

Another important habitat in the terrestrial open uplands system-subsystem association are the calcareous ridges and ledges found in the Taconic Highlands adjacent to the Harlem Valley. This area contains 11 documented hibernacula for state threatened timber rattlesnakes.

Cliff and Cave Habitats

In the Palisades and Taconic Highlands areas of the lower Hudson River there are cliff and cave areas that provide critical habitat to Indiana bat and timber rattlesnakes in the basin.

Beaches

Beaches in the basin provide nesting habitat for horseshoe crabs, piping plovers and colonial waterbirds including least terns and common terns. The beaches also provide important foraging area for transient shorebirds and other migratory birds in the spring. Many of these birds feed on the eggs laid by horseshoe crabs. The beach strand habitat at Orient Point has high quality nesting habitat for least tern, a most critical SGCN in this basin.

Island Habitats

Islands in this basin provide an important refuge for colonial-nesting herons and beach and island ground-nesting birds. The islands limit access to the birds' eggs and young by nestling and egg predators such as raccoons, foxes, and domestic and feral cats. Great Gull Island hosts common tern and roseate tern colonies of national significance. The islands in New York Harbor host regionally significant colonies of colonial nesting water birds.

Open Water Habitats

Some of the open water habitats of note in the basin include lacustrine coastal plain ponds, estuarine shallow and deep water habitats, coastal streams and inland streams. There are three freshwater fish SGCN in the basin that are most critical. The banded sunfish and swamp darter are both found in isolated ponds near the Peconic River on the east end of Long Island. Some of these ponds are not connected to any other waters and their isolation historically protected them from predators and competitors. Additional examples of these open water habitats at higher elevations are found in Rockland County, which previously contained two sunfish species (now extirpated there), banded sunfish and mud sunfish. Mud sunfish is identified as extirpated in Lower Hudson-Long Island Bays Table 5, though its status is poorly understood. Given the lack of certainty about this species, the protection of its habitat is a most critical priority. Dams have isolated these ponds and may have protected remnant populations from competitors. Studies about reintroduction into this segment are needed.

Open water habitats are utilized by as foraging habitat by a host of bird species including waterfowl (e.g. greater scaup, red breasted merganser and surf scoter), osprey, bald eagle, loons, terns, wading birds (e.g. snowy egret and great blue heron), and cormorants. Mammals such as river otter, harbor seal and harp seal forage in open water habitats. Turtles utilize both fresh water (e.g. painted turtle, snapping turtle, and eastern mud turtle) and marine water (e.g. diamondback terrapins, green sea turtles) habitats. Open water habitats are also used as foraging habitat by larval odonates. Significant populations of wintering waterfowl utilize open water habitat.

The shallow estuarine waters of the basin provide critical habitat to marine fish, mollusks and crustacean species. The lagoons of the south shore of Long Island once held abundant hard clam populations, and still provides important nursery habitat for many fish species. The Peconic estuary is critical habitat to juvenile sea turtles and scallops. The Hudson estuary is critical for spawning sturgeon. Deeper estuarine waters like Long Island Sound are critical for lobster and oyster toadfish.

Coastal streams provide a vital link to migratory fish species like American eel and rainbow smelt. Both of these species were once abundant in the marine district of New York. American eel is in decline coast-wide, and coastal stocks of smelt that once supported commercial fisheries have declined sharply in the past half century.

Overall Trends in the Basin

There were several Native American nations living in the basin at the time of European settlement in the 17th century. The Native Americans used the rich natural resources of the Hudson River valley and what is now New York City and Long Island. In the time since European settlement, the basin landscape has undergone dramatic changes. All New York City and Long Island forests were cleared at one time for firewood and shipbuilding. The locust tree was introduced to Long Island specifically for use in shipbuilding. The waste generated by the burgeoning population in the greater metropolitan area was channeled into the waters surrounding the settlements. Cholera outbreaks in the late 19th and early 20th centuries were traced to sewage in the waters around New York City, eventually resulting in the creation of the Interstate Shellfish Sanitation Commission. The problem still persists in the form of combined sewer outfalls (CSO). There are some 460 CSOs within the confines of the five boroughs of New York City. CSOs normally collect rainwater runoff and convey it to estuarine waters in order to avoid flooding. When it rains too intensely sewage treatment plants cannot handle the excess and they discharge treated and untreated sewage in to the same conduits that send rainwater runoff, hence, combined sewage outfalls. The average discharge of untreated sewage over the last several years is estimated at 27 billion gallons annually, while 75% of the wet weather flow is treated. While the New York City discharges are the most significant source of untreated sewage in the basin, an additional 6 million gallons of untreated sewage is discharged annually by the Westchester County-Yonkers Joint Treatment Plant into the Hudson River. Untreated sewage poses a health threat to humans and aquatic organisms.

Land use in the basin changed dramatically over the course of the 20th century. In 1900 about 45% of land in the basin was used for agriculture. Most of this farming took place outside the 5 boroughs of New York City, but even portions of Queens, Brooklyn, and Staten Island were still very rural. By the 1990s, residential and forested land accounted for 78% of total land use in the basin, while agriculture had dropped to 5%.

New York City

The urban and suburban development of the entire New York metropolitan area resulted in significant losses of natural habitats as well. In Bronx County alone, U.S. Fish and Wildlife Service studies indicate that 90% of large tidal wetland complexes were lost in the 10 year period between 1954 and 1964. These losses were due to dredging and filling activities associated with development. Comparisons between historic and modern geographic survey maps of the metropolitan region show similar losses of tidal wetlands throughout the 5 boroughs. Jamaica Bay, Flushing Meadows, and College Point all experienced significant fill activity throughout the 20th century.

There were an estimated 224,000 acres of freshwater wetlands in New York City prior to the Revolutionary War. Only a fraction of those wetlands remain today. Of those that have survived, many suffer significant impairments. In the decade between 1980 and 1990 there was virtually no net loss of freshwater wetlands in the basin. During this period, the acreage of shrub wetlands decreased and forested wetlands increased by 1,500 acres.

Long Island

Habitats on Long Island were also dramatically altered by human development. Most of Long Island was probably thickly forested at the time of European settlement, but likely contained embedded areas of pine barrens and grassland. Between 22% and 33% of Nassau County was covered by the Hempstead Plains grasslands, a native warm-season grass prairie. The Hempstead Plains were first altered by potato farming and other forms of agriculture, and then transformed into the first suburban neighborhoods in the country. In the years following World War II, returning servicemen and a booming U.S. economy fueled a great expansion of residential development onto Long Island. This was further enabled by the building of the New York State Parkway System by Robert Moses.

Prior to the adoption of the tidal wetlands laws and regulations in 1972, wetlands were subject to intense development pressure and were dredged, filled, and bulkheaded. In addition, during the 1930's, as part of the New Deal programs of the federal government, many of Long Island's salt marshes were ditched to control mosquito breeding. At the time, ditching was thought to control populations of mosquitoes by eliminating the standing water in upper marsh areas where mosquitoes breed. In Suffolk County, greater than 90% of the County's 11,000 acres of extant tidal wetlands have been ditched.

Threats

DEC staff members who compiled the SGCN information in the CWCS planning database were asked to indicate threats to SGCN and their habitats. During the analysis for the basin, a listing of threats for each species occurring in the Lower Hudson-Long Island Bays Basin was extracted from the database. The threats and summary figures compiled here are not listed in order of importance. The magnitude of a threat is measured by several variables including the species life history traits (i.e., its vulnerability), population trends, specific habitat type and geographic locale, and other rationales. The information provided does not quantify the magnitude of a particular threat. The information provided is intended only to paint a broad picture of the proportion of species/species groups to which a particular threat applies, and the frequency with which a particular threat was mentioned in the database. The purpose of this information is not to compare the severity of one threat against another.

There are 39 individual threats to SGCN listed in this basin, and all of the species are suffering the effects of multiple threats at once (Lower Hudson-Long Island Bays Table 8.). Almost all of the threats to SGCN in this basin can be traced back, directly or indirectly, to the density and extent of human development in the basin. The most frequently mentioned single threat to these species is the loss of habitat to human alteration. Other than actual loss of green space to structures and paving, there is much degradation of remaining habitat due to contamination by toxic substances, nutrients, and the spread of invasive species. These threats are the indirect results of many human activities on the land and water. Most of the threats to SGCN are complex and interrelated. For example, habitat loss generally increases fragmentation of habitat and negative edge effects in the remaining habitat patches. Some of the most prominent threats to SGCN in the basin are discussed in further detail below. A discussion of the threats to all the species can be found in Appendix A.

Habitat Loss and Fragmentation, and Edge Effects

The basin description and critical habitats section above describes much of the changes in the 400 years since European colonization of the basin. Habitat loss due to human development affects 71% of the species groups found in this basin. Many habitats, especially grasslands and tidal wetlands have been radically altered and reduced from historic levels. As discussed above, nearly half of the basin has been developed with structures that provide virtually no habitat to SGCN. The remaining green spaces in the basin are often filled with exotic or invasive species tolerant of pollution and disturbance. The remaining habitat patches, particularly in the New York City and Long Island portions of the basin, are often too small and isolated. This limits their ability to effectively support healthy populations of SGCN.

Lands under water in this basin have been drastically altered as well. The entire marine district of the state has been dredged and modified to accommodate shipping for more than a century and extensive sand mining has occurred in New York Harbor and Long Island Bays. Dredging continues today, consisting of maintenance dredging of channels and dredging in marinas. The oyster bars of the New York Harbor have been removed. Much of the marine district shoreline has been bulkheaded, creating a bathtub-like effect on the water side habitat with

abrupt and less productive edges. Two notable areas where human development has created a viable and important habitat for wildlife species are Shooter's Island in the Arthur Kill and the pile fields and pier areas of Manhattan. Shooter's Island is a man-made island that is part of the Harbor Herons nesting complex. The island was formed from dredge spoil. The pile fields and defunct piers on the west side of Manhattan provide important overwintering habitat for fish and crabs, including several SGCN.

The placement of shoreline structures like bulkheads, groins, and jetties can seriously alter the coastal habitat by modifying biological resources and habitat structure, causing cumulative ecological effects and changing physical and ecological processes such as the distribution of sand on beaches. Wave action and reflection off bulkheads causes sand scour immediately seaward of the structure. Over time, the intertidal portion of the remaining beach may disappear entirely. When the shoreline is hardened, habitats do not cease to exist but shift from one type to another which may have dramatic effects on species composition. Groins and jetties interrupt longshore currents and trap sand. Undeveloped beach immediately down-current from the structures becomes more prone to erosive forces. Placement of structures in the dunes and on the upper beach cause immediate loss of habitat for nesting and transient birds. Shoreline engineering, such as jetties, bulkheads and repeated beach nourishment are short-term strategies that weaken the barrier islands. These elements as well as construction in the beach and dune areas affects the ability of the system to respond naturally to human induced threats as well as storm events and sea level rise and therefore threatens the viability of all species who utilize the area throughout their lifecycle.

Barriers: Dams, Weirs, Culverts, Bridges

This basin is the point of entry for many diadromous fish species. Human development in this basin in the past 400 years has included building dams to provide power, control flooding, and create drinking water reservoirs. Dams are found in most tributaries on the Hudson River and rivers around Long Island. These structures block spawning and nursery areas and, in combination with over harvesting, pollution and interspecies competition, have adversely affected SGCN especially diadromous fish.

In the case of freshwater mussels, their gametes and larvae may need to disperse past these barriers to reach suitable habitat. Culverts under roads may also impede passage of fish species. On the Hudson River, railroad bridges may almost entirely block off side channels and small bays in the river shoreline.

Contaminants

Contaminants in this basin take many forms. There are heavy metals, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), dioxin, and pesticides that persist in the sediments of estuaries and upland lakes, ponds, and stream beds. Frequently these compounds are associated with organic sediments. The highest concentrations of these compounds in the estuary are found in the New York/New Jersey Harbor, especially in the East River, according to the sampling conducted by the National Status and Trends Program. In fact, the sediment and mussel samples taken from the area ranked highest among all the estuaries sampled by that program. Other areas of high contaminant

concentration within the New York portion of the New York/New Jersey Harbor are the western portion of Raritan Bay and the Arthur Kill.

Primary sources of these contaminants in New York Harbor include, but are not limited to, industrial discharges, sewage treatment plant discharges, combined sewer overflows, storm water runoff and other nonpoint source discharges, atmospheric deposition of mercury, and chemical and oil spills. Many of these contaminants are from historic sources and remain in the sediments and can be remobilized.

A number of wildlife species have been affected by contaminants. Examples of these are PCB effects on wading bird reproduction in New York Harbor, lead poisoning in geese, and PCB contamination in nearly all fish species in the Hudson River and some species in New York Harbor.

Atmospheric Deposition

Atmospheric deposition of acidifying pollutants, in particular nitrogen and sulfur (also known as acid rain), and mercury has pervasive, severe and large scale effects on many habitats and species, both aquatic and terrestrial. Forest dependent species suffer when forest health is reduced. Mercury is a neurotoxin that accumulates in the food chain, and is particularly damaging to higher-level consumers, such as loons and larger fish. Even smaller fish lower in the food chain may suffer reduced reproductive success. Although atmospheric deposition is known to be a severe threat in the Adirondacks and Tug Hill areas of New York, we have little information on the severity of this threat to Lower Hudson and Long Island habitats and species. Acidification does not seem to be a problem with lakes on Long Island due to better buffering than the waters in the Adirondacks, though the rain and snowfall on Long Island is acidified and there has been some acidification of Long Island's ground water. This is clearly a major research and information need.

Atmospheric deposition is likely a primary source of nitrogen to all of Long Island's estuaries. For example, an estimated 60% of the nitrogen loading to the Peconic Estuary is from atmospheric deposition. Predominant sources of nitrogen in atmospheric deposition include nitrogen oxides (from car exhaust, industrial emissions, etc) and ammonium (from livestock waste and fertilizer applications).

Degraded Water Quality

The quality of estuarine and fresh waters in the basin is compromised by low dissolved oxygen, eutrophication, toxic contaminants, and sedimentation. All of these factors are interrelated. Low dissolved oxygen is exacerbated by high temperatures and low mixing of surface waters. Increased nutrients can cause nuisance algae blooms that create decaying organic matter that further robs the water of oxygen. Low dissolved oxygen can result in death or reduced growth in many aquatic animals, especially those unable to move to areas of better water quality. Sedimentation caused by surface runoff carries contaminants, nutrients, and can cause suffocation and/or burial in sensitive aquatic species. In many areas of the basin, rain that falls onto land cleared of vegetation is not absorbed into the ground, but travels over the surface picking up dirt and contaminants until it reaches the nearest body of water. In urban and suburban areas of the basin, storm water may be directed into pipes and recharge basins, but it is still

common to have runoff directed into the nearest natural waterway. For example, chlordane, an environmentally persistent pesticide that was banned 20 years ago, is still found in fish from fresh water lakes, though the incidence is decreasing. Deep rooted vegetation like forest trees, shrubs, and wetlands can absorb the greatest amount of rainfall and discharge it slowly to surface and ground water. In the case of emergent wetlands, the plants absorb and sequester many contaminants, discharging cleaner water.

Climate Change

This threat affects many species through direct thermal stress. Winter flounder and American lobster in New York are at the southern limit of the species range. Warmer water temperatures appear to be causing stress to these animals and affecting their reproductive capability and susceptibility to disease. American lobsters have experienced a major die off in Long Island Sound. Increased water temperature has been implicated as a major cause of the die off, in conjunction with other factors.

Indirect effects of climate change include more frequent and more severe weather events, and rising sea levels. The rising sea level coupled with other factors is thought to play a significant role in decline in salt marshes in the basin. Hardened shorelines offer no place for natural marsh retreat, resulting in complete submergence. The amount of habitat available for beach dependent species will also be negatively affected by sea level rise as beach lands submerge. The effects of climate change also include changes in the timing of natural processes and the frequency of natural disturbances. For example, in fish and other species which breed or migrate according to temperature cues, their breeding seasons may become altered by changed annual average temperatures.

Collisions

Habitats fragmented by roads result in increased wildlife mortality due to collisions with vehicles. This is a severe problem in areas where roads have skirted protected wetlands. Many amphibian species forage in upland forested habitat and return to ponds to breed. During breeding season, roads directly adjacent to breeding ponds may be covered by salamanders during spring nights. Other species like turtles move between upland and pond habitats, too, and may suffer the same fate.

Other structures like cell phone towers, wind turbines, and large buildings can pose a serious threat to birds and bats. There is preliminary research that suggests that careful geographical placement and appropriate altitudes can reduce the negative effects of these structures on wildlife. Ongoing SWG funded research is investigating the migratory pathways of birds and bats in New York. Persistent coastal breezes make this basin an attractive area for placement of wind farms. The density of people in this area creates pressure for more communications towers of all kinds.

An emerging potential threat to aquatic SGCN is the placement of turbines powered by tidal flow into the estuarine waters of the basin. These structures are currently being tested as a new source of clean energy in a proposed six turbine array demonstration project in New York Harbor. Effects to aquatic species have not yet been determined, but resource managers have expressed concern about

potential mechanical stress or death to organisms that pass through the active turbines. Full power generation projects would consist of several hundred turbines permanently deployed in a confined area.

Entrainment

Power plants in this basin often use the Hudson River and other estuarine waters as a source of cooling water for their turbines. The older plants use once-through cooling systems that result in the intake and mortality of many types of marine life at various life stages. During reproductive seasons of some fish or bivalves, millions of larvae are pulled into power plants and killed by mechanical interaction or thermal stress from the turbines. While DEC has been working with the power generators and other regulatory authorities to minimize these effects, they are still significant. In the case of SGCN, small parent populations can ill afford to lose large quantities of larvae and juveniles to this type of mortality.

Entanglement

Another direct disturbance to SGCN in this basin is unintentional entanglement and bycatch of animals during fishing activities. This is most common in commercial fisheries using nets. The National Marine Fisheries Service (NMFS) has gear regulations on various fisheries to decrease the interactions of fishing gear with marine mammals and sea turtles. These non-targeted species are called bycatch. The stress of the netting process may result in mortality of the bycatch. In the New England area various gear modifications on the type of line and breaking strength were instituted by NMFS to decrease the bycatch mortality of right, humpback, minke, and fin whales in lobster and gillnet gear. Area closures were implemented as part of this same effort and further amendments related to pot, trap, and gillnet fisheries are pending. There are NMFS has also instituted gear modifications to sea scallop dredges in the middle Atlantic to decrease the capture of sea turtles in the gear.

Illegal or Unregulated Harvest

Humans harvest animals from the wild for food and the pet trade. There are many species of herpetofauna that are popular in the pet trade such as turtles, salamanders, snakes, and lizards. Commercial fisheries target finfish, mollusks, and crustaceans for human food and bait. Traditional fisheries management of these species may be ineffective due to confounding factors of disease, predator populations, and loss of habitat. Often fisheries and other types of wildlife collecting develop in advance of the state's regulatory authority to limit or manage that collection. Many of the bait species are not covered under fishery management plans. Some of the fisheries for these bait species do not require permit or reporting on the species and number harvested, which makes it difficult to estimate population effects. Some of the conservation actions in this strategy simply recommend regulation of harvest and fishery dependent monitoring of these animals.

Disturbed Predator-Prey Cycles

The health of populations of predatory SGCN in this basin depends, in part, on the availability of prey items at an abundance that can sustain them. In the case of prey SGCN, the prey populations must be able to withstand the predation rate, or no amount of habitat improvement will help them. In the case of estuarine forage

species of fish, their role as prey items for larger fish is not well enough understood. Predatory fish stocks are on the rebound (e.g. striped bass) while it is thought that forage species are in decline. This can have a cascading effect throughout the estuarine food web.

Predatory species like osprey may suffer from the decline of prey species. In the case of zooplankton, increased primary production has not resulted in increased production at higher trophic levels. Some researchers suspect that domination of the zooplankton in Long Island Sound by gelatinous species (i.e. jellyfish) results in increased predation on larval fish species in the zooplankton community. This may be exacerbated by increasing average winter temperatures that lengthen the activity period of the predatory zooplankton during the year. A better understanding of all these species interaction is integral to managing their survival.

Imbalanced populations of species such as raccoons, fox, opossums, and feral and free ranging domestic cats throughout Long Island have had negative effects on several SGCN, including birds and snakes. Populations of raccoons, opossum, fox, and cats are not kept in check by predation or disease, resulting in a disproportionate rate of predation on SGCN and other wildlife.

Interspecific Competition for Resources

In the face of shrinking habitat available for all species due to habitat loss and fragmentation, interspecific competition for habitat and food is heightened. It is comparable to a game of musical chairs, as humans and other threats take away more and more viable pieces of habitat, fewer species can be supported by the remaining patches. Species most effective at finding and defending those resources will survive. An example is the golden-winged warbler and its competitor, the blue-winged warbler. Both of these birds use the same types of habitat and have overlapping ranges. The blue-winged warblers are more effective at attracting mates of both species, and reproduce in greater numbers than golden-winged warblers.

Invasive Species

Invasive species are second only to outright habitat destruction as a threat to the ecological health of our ecosystems and species. Invasive plants that spread into natural habitats often out compete and eliminate native plants, and change habitat structure, to the detriment of the native insects, birds and animals that depend on native plants for food and shelter. Invasive plants also may change fundamental ecosystem processes such as nutrient cycling, decomposition rates, soil chemistry, hydrology, frequency of wildfires, vegetation structure, natural succession, and rate of soil erosion. Invasive, non-native species are a major cause, or contributing factor, in the decline of 49% of the U.S. species federally listed as threatened or endangered.

Invasive marsh plants like common reed and purple loosestrife can reduce the quality of nesting habitat for salt marsh breeding birds. Many of the estuarine and brackish salt marshes in the basin have become dominated by common reed. Common reed's woody nature is thought to make it less valuable for detritus production than other salt marsh grasses. However, it does sequester nutrients

more effectively than salt marsh cordgrass, a potential benefit in nutrient-enriched estuaries.

In portions of the Hudson River estuary, water chestnut, an invasive aquatic plant, has nearly eliminated light penetration in the bays where it occurs. This in turn kills the native aquatic beds that provide critical habitat to crabs and juvenile fish. Research also shows that dense water chestnut beds can reduce dissolved oxygen levels in the water column in the immediate vicinity.

There are invasive animals in this basin, and a huge potential for further introductions due to the heavy international shipping in this basin. Ships use water as ballast during their journey. The ballast water may be taken into the tanks in one part of the world then the tanks are emptied in the destination port as cargo is loaded. This is how zebra and quagga mussels are thought to have been introduced into the Great Lakes. Through competition for space and habitat they have decimated native mussel populations, and their predation on plankton has dramatically affected freshwater ecosystems.

There are also many live animal markets in the New York metropolitan region where exotic animals are sold as food. Many of these food animals have the potential to escape and wreak havoc on the basin's ecosystems. On the west coast of the U.S., Chinese mitten crabs escaped into the wild and have caused ecological as well as severe economic damage. There have been some near misses with Chinese mitten crabs in New York already, with shipments of live crabs intercepted at airports. Recent discovery of snakehead fish in Queens could have devastating ecological effects on pond communities if not isolated and eliminated. Vigilance regarding invasive species in this basin is essential to prevent potentially severe consequences.

In some areas of the basin, like Shooters Island, habitats altered by invasive species like tree-of-heaven and Japanese honeysuckle provide vital nesting habitat for SGCN. In this case, colonial-nesting herons use these trees for nesting. Free ranging cats are having significant effects on SGCN through predation.

Priority Issues

There are several existing management programs in the basin that have identified priority issues. They are listed below.

Hudson River Estuary Program

- Restoration of signature fisheries
- Contaminants in biota
- Restoration of habitat
- Conservation of biodiversity
- Water quality
- Monitoring and increased knowledge

Hudson River Estuarine Research Reserve

Research related to:

- Freshwater to brackish conditions along the Hudson River estuary
- Changes in the river's shoreline land use from north to south and the effect on the estuary
- Hydrological exchange between the marshes and the Hudson River through restricted openings in railroad embankments
- Describing the movement of particles through the system using natural and anthropogenic tracers.

New York - New Jersey Harbor Estuary Program

- Habitat loss and degradation
- Toxic contamination
- Pathogen contamination
- Floatable debris
- Nutrient and organic enrichment

Long Island Sound Study

- Hypoxia and nitrogen management
- Toxics
- Floatable debris
- Living resources and habitat management
- Development and land use

South Shore Estuary Reserve Program

- Nonpoint source pollution
- Coastal habitat protection and restoration
- Living resources
- Development and land use
- Monitoring and increased knowledge
- Public use
- Economic viability of the estuary
- Brown tide

Peconic Estuary Program

- Brown tide
- Nutrients
- Habitat and living resources
- Pathogens
- Toxics
- Critical lands protection

Central Pine Barrens Management Plan

- Ground water and habitat protection
- Nitrate management
- Pesticide management
- Fire management
- Invasive species management plan in development

The Nature Conservancy (Ecoregional Planning)

- Management for sustainable use of essential resources and their habitats (bay scallop; hard clam; eelgrass; salt marsh)
- Protection and restoration of natural shoreline, buffers and beach dependent species
- Barrier island natural processes
- Water quality
- Incompatible land use
- Fire management
- Reducing the threat of invasive species
- Global warming/sea level rise
- Atmospheric deposition
- Research, monitoring and stewardship to reinforce all initiatives

Vision, Goals and Objectives for the Basin

Vision

The Lower Hudson River-Long Island Bays Basin will have healthy and sustainable populations of all SGCN that currently occur here. Conservation partners will work together to reintroduce extirpated species to the basin where appropriate.

Existing conservation partnerships among federal, state, and local government partners, not-for-profit organizations, and other citizens groups will be strengthened. New and innovative partnerships will be formed.

Conservation partners in the basin will work together to collect, share, and analyze information on SGCN and their habitats in the basin. Information will be used to constructively manage species and habitats for the greatest benefit to biodiversity preservation while balancing human needs for use of the resources.

Members of the public will understand the value of healthy habitats and the species that they support.

Goals and Objectives

- Coordinate existing resource management structures in this basin like the National Estuary Programs, state estuary programs, Pine Barrens Commission, fisheries commissions, and others to improve monitoring, management, and protection of SGCN and their habitat basin-wide.
- Use the State Wildlife Grants program staff within DEC to strengthen partner agencies' and management structures' involvement in research, management, and restoration of SGCN and their habitats.
- Preserve and restore key representative habitats that support the basin's biodiversity.
- Ensure that no at-risk species becomes extirpated from the basin by better understanding the current distribution abundance and most immediate threats of these species and responding appropriately. Share this information with local governments in a way that helps inform their decision making related to local land use.
- Improve the health of remaining habitats for SGCN by reducing the limiting factors on them. On public lands this should include better monitoring and management of habitat health and balancing human recreational and other uses of viable habitat. On private lands this should include data sharing and incentive programs that assist landowners in habitat improvements.
- Town and Villages play a key role in protecting SGCN which can be improved by strengthening land use and zoning codes. Federal, State and County policies should also be strengthened.
- Develop a "stepped down", more targeted plan for the basin that expands upon the recommendations made here. This plan may focus on goals within the basin for specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented on the ground.

Priority Strategies/Actions for Basin-wide Implementation

The following recommendations do not appear in any priority order. All of these recommendations are intended to be of high priority to implement in this basin in the coming 5 to 10 years for the benefit of the most critical SGCN in the state. See the discussion of "*Development of Conservation Recommendations for Species of Greatest Conservation Need and their Habitats*" and their prioritization in the Introduction. All of the recommendations for SGCN found in this basin can be viewed in Appendix A.

Data Collection, Monitoring, and Analysis Recommendations for Critical Habitats

SALT MARSHES

- Salt marshes and their internal creeks and pools are critical habitat for 31 SGCN. There is evidence from New York and other locations on the eastern seaboard that salt marshes are in severe decline. Nearly all marshes have been ditched as part of mosquito control activities and many are sprayed with a variety of mosquito control pesticides. Because this habitat is a foundation of the health of the entire marine district of the state, establishment of a comprehensive salt marsh monitoring program is of critical importance. Reference locations in each major estuary should be selected for investigation as outlined in the Long Island Sound Study Tidal Wetland Workshop Findings Report. Key components of the program are measurements of overall acreage and health of marshes, evaluation of faunal community, development of a marsh health index trends analysis and buffer need assessment and recommendations for regulatory reform for more effective protection of salt marshes and their fauna. Priority species to monitor as part of this activity include: salt marsh breeding birds- especially saltmarsh sharp-tailed sparrow and sea side sparrow, fiddler crabs, horseshoe crabs, ribbed mussels, diamondback terrapins, and estuarine forage fish species.

- Comprehensive salt marsh monitoring programs should be designed with the required pre-monitoring of open marsh water management in mind, in case such a project is warranted to improve the health and functioning of the marsh in the future.

OPEN WATER HABITATS

- Open Water habitats are important forage areas for many SGCN. Recommend continuation and expansion of the benthic mapping and infauna index currently being done in select embayments. Map all major habitat types (including shallow water habitats) to establish baseline and use this as a basis for trends analysis. This work is important for winter flounder, northern puffers, bay scallops, hard clams and oyster toadfish.

- Study the use of oyster shell hash and reef structures by forage fish and invertebrate species, and juvenile stages of critically important marine finfish species including winter flounder and oyster toadfish.

SUBMERGED AQUATIC VEGETATION

Submerged Aquatic Vegetation beds provide critical habitat for SGCN and are an indicator of high water quality. Abundance of eelgrass declined sharply in the 1930s due a disease event throughout the eastern seaboard and has yet to rebound. Monitoring of SAV beds and their faunal community is critical to the health of estuaries in NY. Specific monitoring parameters should include:

- Select eelgrass bed reference sites and document their use by fauna, especially estuarine associates of SAV, winter flounder, oyster toadfish, northern puffer, estuarine forage species, bay scallops, and blue crabs.

- Map areal extent of eelgrass beds in all major estuaries of the state and analysis of trends in their health.

- Examination of habitat value of non-eelgrass forms of aquatic vegetation such as *Codium fragile*.

- Conduct research to identify and mitigate threats to seagrass recovery and improve restoration techniques. Conduct research to understand why eelgrass is not recolonizing and why restoration efforts to date have not succeeded in enhancing existing eelgrass populations.

- Investigations and long term inventories of the macroalgal biomass (including species and location) in each estuary should be conducted. Macroalgae may be affecting eelgrass abundance and distribution, may serve as a predominant nitrogen sink in the entire system, and may serve as an important alternate habitat to shellfish species affected by the dramatic loss of eelgrass beds.

FRESHWATER WETLAND HABITATS

- Vernal pool and upland buffer habitats are critical habitats for several species of amphibians. Mapping of vernal pools and upland buffer and monitoring their use by amphibian species of concern is necessary to protect vernal pool salamanders, especially tiger salamanders, and eastern spadefoot toads. Collect information on their productivity in vernal pools.

- Freshwater marshes are critical for many species of freshwater marsh nesting birds, Eastern box turtle and other herpetofauna, and odonates. Monitoring of these habitats should be conducted and specific parameters should include examination of the necessary adjoining upland habitat for these species.

OPEN UPLAND HABITATS

Grasslands and heathlands are important habitat areas for a number of birds and other SGCN. The agricultural lands in the upper portions of the basin east of the Hudson are a good area for biodiversity assessment. Specific activities should include:

- Map the historic and current distribution of grassland habitats.

- Monitor the distribution, abundance, and productivity of grassland birds and other SGCN.

- Map and monitor beach and island habitat availability especially the area above mean high water. This is important habitat for colonial nesting herons, piping plover, common and least terns, and horseshoe crabs.

FORESTED HABITATS

- The Central Pine Barrens Complex supports a large number of SGCN, including several most critical species such as tiger salamander, marbled salamander, blue-spotted salamander, pine barrens bluet, and eastern hognose snake. Pine barrens are also historic habitat for American burying beetle and the coastal barrens buck moth. The full range of habitats found in association with the pine barrens, including coastal plain ponds and grassy openings should be monitored for use by SGCN. Those monitoring data should be used to shape specific management and protection recommendations to the state, Central Pine Barrens Commission, and other conservation organizations. Forest habitat monitoring protocols developed for the USFWS, Upton Ecological Research Reserve, Brookhaven National Laboratory, Upton, NY have been used in forests of the Long Island Pine Barrens Core Preserve in the summer of 2005. Baseline data obtained in 2005 and data to be gathered in 2006 may be used to characterize and evaluate habitat quality for SGCN.

GENERAL HABITAT ASSESSMENT RECOMMENDATIONS

- Survey the recent Jamesport State Park acquisition for the presence of SGCN and their habitats in support of drafting the park's master plan.

- Identify key conservation areas for species or suites of species in order to strategize where limited funds should be directed. TNC's ecoregional assessments, Significant Habitat designations, NY Natural Heritage, NOAA habitat mapping, Long Island Sound Stewardship Program sites, Peconic Estuary Critical Land's Program sites, and others can assist with the effort.

- Identify and fill information gaps and research needs especially for overarching threats such as climate change, atmospheric deposition, invasive species, and estuarine ecology.

Data Collection, Monitoring and Analysis Recommendations for SGCN

There are several species in this basin that are poorly understood and mitigation of the threats to them is difficult or impossible without better understanding of their life history, habitat requirements, and reaction to specific threats in the environment. Implementation of the CWCS should complement and enhance existing data collection efforts for SGCN in the basin, as well as institute new data collection.

Early successional forest/shrubland birds

- Monitor trends of early successional species, in particular those that are not currently adequately monitored.
- Complete an inventory and analysis for high priority focus species (woodcock and grasshopper sparrow) that identifies core habitats (highest abundance) and geographic areas (where appropriate).
- Monitor the effects of West Nile Virus on these bird populations.

Wintering waterfowl

- Periodically monitor the levels of contaminants in wintering waterfowl and freshwater marsh-nesting birds and their eggs to assess trends and determine the effects of contaminants on reproductive success, eggshell thinning, behavioral modification, chick development, nesting success, and juvenile survival. The most critical species in this group are Greater scaup, American bittern, king rail, and pied-billed grebe.
- Monitor ongoing restoration projects of critical SGCN, such as those for beach and island ground-nesting birds, for evaluating the effectiveness of techniques.

Forest breeding birds

- Survey forest habitats for nesting long-eared owl, red-shouldered hawk and whip-poor-will.
- Track productivity of long-eared owl, red-shouldered hawk and whip-poor-will nesting pairs.
- Monitor the effects of West Nile Virus on these bird populations.

Butterflies, Moths and Odonates

- Develop standardized survey protocol to obtain repeatable, relative abundance estimates for barrens buckmoth, odonates (e.g. yellow-sided slider, Needham's skimmer, pine barrens bluet) and butterflies (Hessel's hairstreak, Arogos skipper).
- Survey populations to understand population status, trends and distribution.

Herpetofauna

- Investigate the life history of Eastern box turtle, diamondback terrapin, and hognose snake including sex ratio of Lower Hudson-Long Island Bays population, predator-prey relationships, and habitat use.

FRESHWATER FISH

- Monitor waters in Rockland and Suffolk Counties that are suited to banded sunfish and mud sunfish to better understand their population dynamics and their habitat needs.

MARINE FISH

- Sample bycatch in the commercial fisheries of the Atlantic Ocean to determine numbers and sizes of Atlantic sturgeon affected by commercial fishery activities in New York waters.

- Use telemetry techniques to tag and monitor adult and juvenile Atlantic sturgeon. Use telemetry data to identify specific spawning and nursery habitat use within the basin. Supplement this investigation with archival tags to gain information on the timing and location of seasonal movements of adult fish.

- Continue monitoring the distribution, abundance, and habitat use of Atlantic sturgeon in the basin.

- Sample tributaries in all estuaries for the presence of American eels, alewives, and other diadromous species, especially at the base of dams in historic streams.

- Document habitat use by alewife in estuarine waters of the state, including remnant spawning runs in coastal streams and lower Hudson River tributaries. Develop basic life history and stock profiles of estuarine New York alewife populations including fecundity, age at maturity, population age structure, and lifespan

- Develop and/or expand fishery-independent surveys for marine species of critical importance including: American eel, American lobster, winter flounder, oyster toadfish, estuarine forage species, horseshoe crab and rainbow smelt. Define the preferred habitat for varying life stages of these species. Link these preferred habitats with detailed benthic maps when possible and appropriate.

- Monitor diseases, pathogens, and pesticide effects on crustaceans in the basin, specifically American lobster. Specific parameters to investigate include evaluation of any lobster or other crustacean die-off for disease, pathogen, or pesticide contamination and lobster shell disease. Wherever possible, these parameters should be correlated and coordinated with ongoing overall water quality monitoring.

- Monitor horseshoe crabs to better understand their population dynamics and their significance to shorebirds migrating through NY, especially the red knot. These investigations need to be coordinated with similar research in other mid-Atlantic states. Specific research parameters include:
  - Investigate the existence of a terminal molt for adult horseshoe crabs to better understand the age structure of the population. Also develop reliable field methods for aging horseshoe crabs.
  - Conduct directed fishery-independent spawning and abundance surveys, including tagging of individuals to examine uniqueness of NY stock.

- Identify key spawning beaches for horseshoe crabs and their use by migrating shorebirds.
- Monitor the distribution, abundance, and habitat use of egg stage, larval, and juvenile horseshoe crabs, particularly on marshes and mud flats.

MARINE BIVALVES

❖ Increase monitoring for diseases, pathogens, and contaminant loads in marine bivalves used for human consumption. Specific parameters to investigate include the hard clam disease QPX; paralytic shellfish poisoning; vibrio; oyster diseases MSX, juvenile oyster disease, and Dermo; the suite of contaminants measured in the USEPA Mussel Watch study; and pesticides. Wherever possible, these parameters should be correlated and coordinated with ongoing overall water quality monitoring.

❖ Identify historic and current eastern oyster abundance and establish a list of potential oyster habitat restoration sites based on current water quality parameters necessary to support viable oyster populations.

❖ Determine optimal size for bed and reef areas, and optimal planting densities of seed and adult oysters in restoration areas.

BEACH AND ISLAND GROUND-NESTING BIRDS

❖ Continue annual surveys to collect nesting data including, but not limited to, number of nesting pairs, productivity, and number of active breeding sites.

TRANSIENT SHORE BIRDS

❖ Initiate annual shorebird monitoring program, using established protocols at 5-10 locations in New York State.

❖ Conduct field studies to document ecology of transient shorebirds, including important food items, habitat use and time/activity budgets.

Planning Recommendations

- Prepare a response plan for mass mortality events involving shellfish, finfish, and crustacean/meristomata, especially horseshoe crab, American lobster, and estuarine forage species. This will provide valuable management information in determining causes of these events.

- Develop species management plans that incorporate fisheries and habitat needs for eastern oyster, hard clam, bay scallops, northern puffer, oyster toad fish, and estuarine forage species.

- Update species management plans for American eel, American lobster, horseshoe crab, and winter flounder in coordination with the Atlantic States Marine Fisheries Commission which New York is an active member (Table 9).

- Expand fishery-independent surveys for marine fish and crustacean species and develop new survey protocols for non-fishery targeted species. Update existing sampling protocols to better record forage fish species encountered.

- Work collaboratively with the Long Island Sound Study Management Conference and its partners to implement the recommendations in the Long Island Sound Stewardship Initiative, where those recommendations meet the needs of SGCN.

- Develop a grassland management and restoration plan specific to this basin that incorporates the needs of all grassland dependent species, including grassland birds, barn owl, woodland/grassland snakes, and game species of concern.

- Explore the feasibility of fire as a habitat management and restoration tool in the appropriate habitats in the basin. Some fire management plans already exist for habitats on Long Island.

- Develop a management plan that provides guidance on maintaining, enhancing and restoring early successional forest/shrub bird species.

- Develop habitat management guidelines for early successional forest breeding birds in this basin. This is especially critical for golden-winged warbler where ongoing research in Sterling Forest can be used to guide habitat management that favors golden-winged over blue-winged warblers.

- Update management plans on state and other public beach lands to incorporate the needs of beach and island ground-nesting birds, transient shorebirds in seasonal site use and development, especially for common tern, least tern, piping plover, marbled godwit, purple sandpiper, red knot, and short-tailed dowitcher, and horseshoe crabs.

- Develop a management plan for terrestrial invertebrates in the basin.

- Develop population targets for Eastern box turtle and hognose snake on protected land parcels in this basin.

- Incorporate management and restoration recommendations for all SGCN into land management planning actions, including the creation of new Unit Management Plans (UMP) and UMP revisions.

- Prioritize all existing habitat restoration lists prepared by management programs in the basin for terrestrial and estuarine habitats in the basin for their benefits to SGCN. Coordinate implementation of their recommendations and seek to leverage additional funding from sources other than SWG.

- Develop a management plan to stop/reduce the introduction of aquatic nuisance species (ANS) into the waters of New York State. A number of plant, mollusk, and bird ANS have already been introduced into the waters of New York with varying effects on native wildlife. Marine species are probably under-represented, because marine ANS have not been studied as much in New York as freshwater ANS.

- Develop a management plan to stop/reduce the introduction of new terrestrial invasive species and mitigate effects from previous introductions in coordination with future recommendations of the Governor's Invasive Species Task Force.

Land Protection Recommendations

The second most commonly listed threat to SGCN in this basin is the loss of habitat. Acquisition and cooperative management of critical lands are an effective way to slow the trend of habitat loss and fragmentation in this densely populated basin.

EXISTING OPEN SPACE PLAN RECOMMENDATIONS

The 2002 edition of the New York State Open Space Conservation Plan (OSP) lists priority sites for protection. Many of these sites are valuable habitat for SGCN and are listed here as priority land protection areas for the basin.

- All of the Pine Barrens Core area recommendations have potential benefit to SGCN dependant on pine barrens habitat.

- Peconic Pinelands Maritime Reserve Projects, Tuckahoe Woods, Gardiner's Island, Cow Neck/Sebonac, Accobonac Harbor, Long Pond Greenbelt, Montauk Peninsula, Great Hill, Noyack Hills, and Stony Hill parcels all harbor important habitat for SGCN. Specifically there are several types of deciduous forest, tidal wetlands, freshwater wetlands, grasslands, and documented habitat for state threatened odonates.

- Within the Western Suffolk/Nassau Special Groundwater Protection Area the Pulling Estate and Held Property are documented habitat for tiger salamanders and several turtle species. The sites contain grassland, early successional forest habitats, and freshwater wetlands.

- Within the Long Island South Shore Estuary Reserve recommendations the Shinnecock Bay, Beaverdam Creek, and Barrier Island acquisition recommendations have potential benefits for protecting SGCN. The sites contain tidal and freshwater wetlands, and nesting habitat for critically important beach and island ground-nesting birds.

- Within the Long Island Sound Coastal Area recommendations, the Key Span - Shoreham site is a tidal wetland and shoreline habitat that benefits many coastal SGCN.

- All of the individual sites within the Harbor Herons Wildlife Complex include freshwater and/or tidal wetlands, and some forested areas.

- Within the Jamaica Bay Protection Area recommendations, the Hook Creek, Sea Girt Avenue Wetlands, and Spring Creek/Fresh Creek sites have freshwater and tidal wetlands to further benefit SGCN adjacent to the Gateway National Recreation areas in the Bay.

- All of the sites in the Long Pond/Butler Woods, Northeastern Queens Shoreline, Staten Island Greenbelt, and Staten Island Wet Woods contain many important natural habitats for SGCN, including vernal pools, other freshwater and tidal wetlands, and forested areas.

- The Rockland County Highlands Priority Project contains important habitat for SGCN including freshwater wetland areas.

- Acquisitions expanding the Sterling Forest State Park holdings that provide habitat for golden-winged warblers.

- The expansion of the Cranberry Lake Wildlife Management Area to protect the lake and surrounding forests.

- Expansion of the Piermont Marshes National Estuarine Research Reserve property in the Hudson River to protect SGCN that use brackish and freshwater tidal wetlands.

General Land Protection Recommendations

- Acquire and/or cooperatively manage emergent marsh habitat, lands that buffer marsh habitat, and lands adjacent to existing protected land through fee title or easement. Emergent habitat parcels support certain marsh bird species such as bitterns and rails. Other species which benefit from contiguous wetland habitat include various herons, waterfowl and shorebirds and sub-tidal animals that are sensitive to contaminants, nutrients, and sediments.

- Upland forest habitats within 1,000 feet of wetlands known to host breeding populations of herptile SGCN (mud turtle, tiger salamander, and bog turtle) should be acquired or managed to protect these species.

- The Peconic Estuary Critical Lands Protection Strategy created a prioritized list of properties for public acquisition within the estuary watershed, many of which are valuable habitat for SGCN. Protection of these parcels should be high priority for acquisition funds.

Management and Restoration Recommendations

- Conduct controlled habitat manipulations to determine effective habitat management parameters to benefit freshwater marsh-nesting birds. The most critical species in this group are American bittern, king rail, and pied-billed grebe.
- Expand and coordinate seasonal protection of beach and island ground-nesting birds and transient shorebirds. This should include fencing of key nesting areas, development of ideal nesting conditions on beaches with less recreational use pressure, selective removal of predators, and enhanced stewardship of nesting beaches.
- Restore and manage nesting islands for colonial waterbirds.
- Protect and restore grassland habitats in the basin.
- Support and expand use of fire as a habitat management tool in the Central Pine Barrens and grassland habitats on Long Island.
- Develop appropriate management measures to protect estuarine forage species of marine fish, including compliance monitoring of vessels trip reporting, and assessment of bait fish harvest.
- Develop multi-species modeling approaches for New York's Estuaries similar to the ongoing work in Chesapeake and Delaware Bays.
- Implement and monitor marine shellfish spawner sanctuaries.
- Conduct feasibility studies for re-introducing SGCN for restoration purposes (such as oyster, scallop, and rainbow smelt restoration).
- Restore diadromous fish runs in appropriate tributaries.
- On a case by case basis, evaluate the use of Open Water Marsh Management (OMWM) to restore wetlands. Develop OMWM guidance based upon the Suffolk County Vector Control Environmental Impact Statement.
- Implement the habitat restoration plans for all the estuary programs where those recommended sites provide critical habitat for SGCN.
- Protect and restore vernal pool habitats in the basin.
- Incorporate the construction of vernal/ephemeral wetlands into large civil works projects (e.g. beach nourishment, wetland restoration) to provide foraging habitat for shorebirds (piping plover, red knots) and breeding habitat for amphibians and odonates.
- Consistent with species recovery plans, support and implement the reintroduction or translocation of SGCN into suitable habitats.
- Restore salt marsh habitat.

- Create and monitor eelgrass sanctuaries in cooperation with local and federal government agencies.

- Support cooperative and coordinated interagency invasive species management and control.

- Establish a cooperative, interagency Lower Hudson invasive species management area similar to the Long Island Weed Management Area (LIWMA).

- Establish "weed prevention areas" in which native species are still dominant, invasive species infestations are still small, and the focus can be on the most cost-effective strategies, namely prevention and early detection/rapid response. These areas should be examined in conjunction with the selection of exemplary and representative habitats within the basin.

- Seek management and restoration opportunities that aim to restore natural shorelines in the basin.

- Where possible, reestablish high quality intertidal forage habitats by allowing overwash fans and other like formations to build naturally.

Regulatory and Legislative Recommendations

General

- Coordinate permit reviews for existing and new ground water wells on Long Island to avoid excessive drawdown and ensure that ponds providing habitat for vernal pool salamanders, odonates of coastal plain lakes/ponds, swamp darter, and banded sunfish remain viable.

- Pursue protection of wetlands less than 12.4 acres in size in this basin that provide habitat for SGCN under the 'unusual local significance' provisions of Article 24 of the ECL. Establish upland buffer protections for those wetlands that reflect actual usage by herptile species.

- Consider regulation on smelt harvest in the marine district of New York appropriate to the reduced populations of rainbow smelt found here.

- Collaborate with other state agencies and local governments to examine the need for and utility of regulations to reduce shoreline hardening, including docks, in aquatic habitats.

- Work with local governments to develop policies that discourage shoreline hardening structures.

- Assist local governments with strengthening zoning and planning regulations to be more wildlife friendly, including clustering, tree clearing, buffers, and native landscape plantings.

- Maximize open space protection funding to state Environmental Protection Fund, federal funds, and support of acquisition programs by local governments.

- Review existing regulatory framework for eelgrass protection and underwater habitats for SGCN >6 feet below low tide and enhance as necessary.

- Implement the regulatory recommendations of the Regional Greenhouse Gas Initiative and Acid Deposition Reduction Program.

- Examine the need for a moratorium on all harvest of SGCN herpetofauna to allow time for population assessments of these species. Examine the need for terrapin excluder devices on trap fishing devices.

- Enhance permit review of pesticide applications in or near documented habitat for herpetofauna SGCN.

Habitat Loss and Degradation

- Afford protected stream status under ECL §608.2 to Class D non-navigable stream segments that provide habitat for SGCN in the basin.

- Protection and restoration of salt marsh (management and restoration plan; modify codes and policies to encourage and guide restoration, buffer protection and address sea level rise)

- Coordinate with State efforts to respond to Pew Commission and U.S. Oceans Policy reports.

- Coordinate efforts with overlapping recommendations of Atlantic Ocean Watershed.

- Ensure that all management activities include an element for well trained enforcement entities in sufficient numbers to protect SGCN in the basin.

- Support enhanced implementation and enforcement of existing water quality protections under ECL §608, including stream buffers and other best management practices.

Incentives

- Work with private landowners and the agricultural community in the basin to identify people willing to participate in wildlife habitat and water quality improvement programs. Collaborate with the farm community and other land owners to refine existing programs to better meet their needs.

- Explore an amendment of §480a of the Real Property Tax Law that may provide for wide-ranging holistic stewardship on eligible tracts of private property. Consider the establishment of a Habitat Reserve component to encourage land owners to voluntarily conserve and manage significant habitats for wildlife and fish located on their lands through Real Property Tax exemptions.

- Support proposals to provide financial incentives to private property owners to preserve open space.

- Support pending state Community Preservation Fund legislation that would support local land acquisition programs.

- Work with local governments to develop tax and other incentive programs to shape new development to reduce negative effects on SGCN. Specific issues to address include:
  - Ground water withdrawal & negative effects on SGCN.
  - Nonpoint source pollution - especially in areas critical to SGCN.
  - Curbing the use of invasive plant species in landscaping.
  - Curbing the use of pesticides in landscaping and mosquito control.
  - Natural and soft alternatives to bulkheads.
  - Removal of existing bulkheads with native vegetation restoration.
  - Establish/expand natural buffer zones between developed areas and waterways and wetlands.

Information Dissemination Recommendations

- Develop targeted recommendations for the management of remaining farmlands on Long Island and in the Hudson Valley to assist farmers in wildlife friendly farming practices.

- Create basin-specific information for landowners, landscapers, and nursery retailers regarding wildlife-friendly landscaping, creation of wildlife habitat, alternatives to invasive plant species, and alternatives to pesticide use such as integrated pest management.

- Create public education information about invasive plant species that degrade wildlife habitat.

- Create consolidated summary of all marine fisheries research and catch data related to SGCN.

- Information about most SGCN is maintained in DEC's Master Habitat Databank. It is critical that the availability of this information be made known to land managers and decision makers. The Natural Heritage Program should have the capacity to maintain current data and to disseminate such data in a timely manner so that it is readily useable. In addition, NHP should continue to develop interpreted data products, such as maps and conservation guides, for use by decision makers so they can accommodate the conservation needs of SGCN early in project design.

- Educate and inform landowners of the importance of reducing development and associated impacts on barrier beaches.

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Tables and Figures

Tables

Figures