# 1974 – 1999

# **Vegetated Tidal Wetland Trends**

of the

New York Metropolitan Area

and the

**Lower Hudson River:** 

**Final Report** 

**Prepared** 

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#### **Preface**

The metropolitan areas first immigration occurred some 75,000 years ago in the form of glaciers being pushed southward (Burrows and Wallace, 1999). The glaciers cut and plowed the bedrock. About 25,000 years later during a warming period sculpturing rivulet fingers of melting ice continued to change the landscape. These fingers were a conduit, supplying rudimentary organic and inorganic building materials, providing a legacy for New York's contemporary wetlands. The prehistoric wetlands that first evolved functioned as wetlands do today. They attracted wildlife and not far behind hunters. Until about 2,500 years ago most human inhabitants were transitory. Later some began growing maize, squash and other vegetables along the seaward edges augmenting their hunting. As soon as an area became unproductive, however, the inhabitants left; allowing the area to reclaim and rebuild its resources(Burrows and Wallace, 1999).

During the European immigration and settlement beginning around 1624 (Squires 1981, Murphy, 1964) land took on a different meaning. Land became a commodity to be bought, sold and developed, as a source of income. The potential and productivity of the marshes was not realized. They were considered vectors for disease and an area for fast land (Taylor 1938). Thousands of acres were dredged, filled and developed.(Moehle 1995). The greatest losses occurring between 1920 –1964 (Caro 1975, Englebright 1975, Squires 1981, U. S. Fish and Wildlife, supplemental report, 1965, Moehle 1995) the auto-air-Amenity epoch. Population growth took place causing urbanization and metropolitization (Koebel et. al., 1975). There was a need for infrastructural growth as well to house and transport the labor force. Despite the phenominal past growth and potential lower projections, demographic and infrastructual needs persist and with them their associated past, present and future environmental impacts.

#### Introduction

In 1973 the New York State legislature found that "tidal wetlands constitute one of the most vital and productive areas in our natural world....". Through the Tidal Wetlands Act (the Act) (Article 25) the legislature declared that "the state preserve and protect tidal wetlands and prevent their despoliation and destruction...". In order to accomplish and implement the Act, an inventory of the state's tidal wetlands was necessary. In 1974 the New York State Department of Environmental Conservation (DEC) conducted a tidal wetlands inventory. The inventoried area covered tidal wetlands from the Tappan Zee Bridge on the Hudson River, south to and including Staten Island, east to Montauk and Orient points including Fishers Island; the state's "Marine District" (Figure 1). The Act, the inventory and two prior efforts; the Long Island Wetlands Act section 11-2307(repealed effective September 1, 1973) and Article 15, the Water Resources Law (section 15-0505) provided the impetus/ infrastructure for the tidal wetlands regulatory program and the Land Use Regulations 6 NYCRR Part 661, which became effective September 1977. Since the effective date of the regulations and subsequent regulatory program, a quantitative assessment of the program and tidal wetlands had not occurred. Prior to the enactment of the Act and the regulations, vegetative tidal wetland losses in Suffolk and Nassau Counties during the ten-year period 1954-1964 amounted to 8,217 acres. In three of New York's five boroughs, Brooklyn and Queens and the Bronx losses were 4,418 acres. These losses were due to demographics (Fallon and Mushacke 1996) and an infrastructual response that included the direct action of dredging and miscellaneous filling for housing, recreation and industry (U. S. Fish and Wildlife, supplemental report, 1965). Post regulation trends indicate however that the regulations and regulatory program are extremely successful. Wetland losses due to traditional "fill and build" projects are virtually non-existent. In fact, a total of only 1.09 acres were apparently lost due to filling of wetlands.

In order to quantitatively assess the effectiveness of the regulations a trends analysis is being conducted. The Study Area is the lower Hudson River and NYC's five boroughs (Figure 2). This area's northern limit is the Tappan Zee Bridge. The southern limit is Staten Island and its eastern limit is the Nassau County border, it includes the boroughs of New York City (Richmond, Kings, Queens, Manhattan and The Bronx). The study area is an integral part of the NY Bight and is classified as a significant habitat by the U.S. Fish and Wildlife Service.

#### **Materials and Methods**

Funding for the project was provided by the Hudson River Estuary Program and the Environmental Benefit Fund. The Hudson River Estuary Program, is a DEC management program that uses an integrated approach combining scientific research, active resource protection, management, public involvement and education to provide responsible protection, attain sustainable use and ensure diverse opportunities to achieve quality through measurable goals and objectives for the Hudson River and it's attributes. The Environmental Benefit Fund is a DEC program that uses fines generated from violations of the Conservation Law Article 25, Part 661. Through a request for proposals (RFP) the NYS Department of Environmental Conservation (NYSDEC) invited competitive bids, from perspective contractors, to map tidal wetlands using infrared aerial photography, within 3km of the existing most landward tidal wetland line and place the data gathered in a Geographical Information System (GIS). GIS technology allows geographic data, such as aerial photography and wetlands delineation to be computerized. Through the use of GIS software a current tidal wetlands line was delineated over 1999 scanned aerial photographs. The 1974 tidal wetlands inventory line was also added to the GIS for trend analysis.

The trend analysis project began in 1998 and was conducted under contract by Dames and Moore (now URS Corp.). URS conducted the tidal wetland assessment, stereo photographic interpretation, and tidal wetland field mapping, managed the GIS system and oversaw the production of subcontractors. TVGA a subcontractor of URS Corp. took the aerial photographs, produced the infrared color prints, scanned and rectified the acquired images. URS and their subcontractors met their contractual obligations and provided all the contracted project deliverables. They re-inventoried the tidal wetlands of the lower Hudson River (south of the Tappan Zee Bridge) and those in New York's five boroughs and created a 1999 vector coverage. Aerial infrared photos were taken by TVGA at an altitude of 6,000-6,500 ft.; the higher altitude was approved in the vicinity of Kennedy and La Guardia Airports due to air traffic concerns (altitudes and other specifications conform to the 1974 aerial photo criteria). The target Image scale was 1:12,000. The area of coverage was all tidal wetlands including areas within 3km of the most landward tidal wetland line. The aerial photos were taken within two hours of low tide on September 23 and October 6, 1999 with end and side overlaps of 60% and 30% respectively for stereo viewing. TVGA then registered the photos in New York Transverse mercator, North American Datum 27 (NYTM, NAD 27), (the coordinate system of the 1974 inventory), mosaicked and incorporated the IR's into the GIS as a base map for the contemporary tidal wetland boundary line. Stereo interpretation, wetlands identification, classification and field verification were conducted by URS Corp. Quality control was conducted by URS and the DEC project manager. Tidal wetlands half an acre and larger were identified as per the contract, later during quality control field verification, smaller tidal wetland areas were identified and placed in the GIS by the DEC project manager. Vegetated tidal marsh categories Intertidal Marsh (IM) (identified by Spartina alterniflora) and High marsh (HM) identified by (Spartina patens, Juncus gerardi, Distichlus spicata, Iva frutesceans, Baccharis halimifolia and Phragmites australis) were identified primarily by percent coverage of their diagnostic species. In order to be mapped specific species dominance greater than 50% needed to be present to be classified in a

specific wetland category.

A vector accuracy of 10m was established as per contract. Needed adjustments were made by the contractor and/or the project manager. Non-vegetated wetlands, Coastal shoals, bars and flats (SM) were described by depth and exposure at low tide. Depth soundings were not taken. Assessment was visual and is not quantitatively described in this report, a vector coverage exists however. The Littoral Zone (LZ) was not quantified and not part of the deliverables. The 1974 and 1999 tidal wetland boundaries, the base map and the metadata are on a CD (CD1) at the back of this report. Changes to the 1974 mapping conventions include placement of the inventory in a GIS rather than on mylar hard copy maps. The elimination of the Formerly Connected (FC) category in the 1999 re-inventory and identifying the predominate vegetation within the tidal wetland boundary as HM, IM, or other tidal wetland covertype. To compensate for the additional gains in tidal wetlands in 1999 the 1974 FC areas were photointerpreted and acreages were added to the respective 1974 TW category for trends purposes. The FC category is misleading; it described a condition, rather than a covertype, the tidal wetlands involved in the study area, receive restricted tidal inundation, they were not completely "cut off" as the category name implies. Another change involved replacing the generic Fresh Marsh (FM) class with more discrete vegetative specific classes to include the categories of Broad Leaf (BV), Graminoid (GV), Swamp Shrub (SS), Swamp Tree (ST), Fern Marsh (FR) and Dead Tree (TRD). These classes coincide with the nomenclature of the upper Hudson River estuary classes. These descriptions appear on the DEC website; www.dec.state.ny.us/website/dfwmr/marine/twcat.htm and are attached (Attachment 1). Attachment 2 contains the metadata of the GIS files used. Dredge spoil sites were not identified; the presumption was no new spoil areas were generated in vegetated tidal wetlands as a result of the regulations. Phragmites was identified as an HM species when they appeared to be tidally inundated. If there was a question regarding tidallity the conservative approach was taken and the phragmites were inventoried. Since the re-inventory was placed in a GIS, additional identifiers were incorporated, each unique wetland class was assigned a unique numerical code called twtype (Appendix 1). Another code is the polyn1 category, this category is used as a reference for ground and aerial oblique photos that may help identify an area, its tidal wetland class and their condition. These photos can be found on CD2 attached on the back cover. Individual photo files may contain multiple photos and some photos may contain additional adjacent tidal wetlands. Additional information found on CD1 are polygons that represent areas of tidal wetland species that have been "cut off" from tidal flow. These areas were not identified in 1974 or 1999. The sites were encountered during QA/QC field surveys and are provided as areas of possible restoration and or mitigation, most are located on Staten Island. The photos and the additional shapefiles were not part of the contract deliverables, they were added by the project manager.

In addition to the tidal wetland mapping, URS Corp. acquired the NOS hydrographic survey data from NOAA National Geophysical Data Center. The data was extracted and input into an Arc/Info coverage as points and line shape files (see attached CD 1). In order to effectively manage the data, describe trends and correlate change the study area was divided into 5 ecological regions (ecoregions) (Figure 3). These ecoregions were then further sub-divided into ecological marsh complexes(ecocomplexes) in an attempt to understand the wetland complex's effect on regional change, determine areas of greatest change within an ecoregional group, and within the overall study area and possibly determine reasons for the change. The ecoregional groups illustrated in (Figure 3) are the Lower Hudson River, Staten Island, Brooklyn/Queens (south shore), Bronx, and Queens (north shore), and Manhattan. Since there was less than a half an acre in Manhattan 1974 (0.33 acre) and in 1999 (0.15 acre) it was not graphed, a table was prepared however. The trends are expressed in tables, 1-35. Each table describes an ecoregion or ecocomplex. Table 1 describes overall totals within the study area. Attributes within the tables enumerate the comparitive years of the trends (1974 and 1999), type of tidal wetland analyzed (IM, HM, FM (GV)), acreage of each wetland type and the number of individual wetland polygons that comprise the acreage (frequency). Trends determined were acreage comparisons between years, total acre change, percent

change and rate of change.

The individual ecoregions and ecocomplexs were also compared to the total study area in a column labeled Percent of Study Area. The ecoregional percentages relating to the total are also graphed on a pie chart (Figure 3). This helped visualize the effect these areas had on the overall study area trends.

#### **Results and Discussion**

The tidal wetlands trends were analyzed using ArcView 3.2 GIS software. The GIS is comprised of two data components. The 1999 aerial photos or rasters, that form the registered and mosaic background base map and the digitized vector lines that form the tidal wetland polygons. These polygons are the delineated 1974 and 1999 tidal wetland boundaries (TWB) and are represented as themematic shapefiles found on CD1. The spatial data represented by the vectors (i.e. area, perimeter, etc.) are stored in tabular form as attribute tables within the GIS software and can be queried to determine trends.

#### **Study Area**

Vegetated marsh totals within the study area in 1974 were 4,391.82 acres and in 1999 the total was 4,205.72 acres, resulting in a net loss of 4.2% or 186.1 acres. In 1974 high marsh (HM) consisted of 1,342.67 acres and intertidal marsh (IM) acreage was 2871.63. In 1999 HM consisted of 2,239.55 acres and IM encompassed 1926.23 acres. During this 25 year period there was a gain in high marsh of 896.88 acres (66.8%) at a rate of 35.87 acres/yr and an 945.4 acre loss (32.9%) of intertidal marsh at a rate of 37.82 acres/yr, Table1. There was a vegetative shift in fresh marsh species (*Typha sp.* and *Scirpus sp.*) to *Phragmites sp.*. In 1974 fresh marsh species comprised 177.52 acres and in 1999 they totaled 39.94 acres a 77.5% shift, Table 1. The bulk of this vegetative shift occurring at Piermont Marsh on the Hudson River mile marker 25 see table 35 figure 4. While there was a net loss within the study area there was no apparent loss of high marsh. All ecoregional areas exhibited high marsh gains and except for Lemon Creek, Table 25, all the marsh ecocomplexes demonstrated HM gains as well. Except for the Staten Island and Hudson River ecoregions, Tables 24 and 33 all ecoregional areas exhibited IM loss. Ecoregional groups exhibited net gains because the HM compensated for IM loss except for the Brooklyn/Queens ecoregion which exhibited a net loss of 532.13 acres, 19.9%, Table 2

Overall, within the study area, there was a net loss of 186.1 acres 4.2% of vegetated tidal wetlands resulting in a negative rate of change of 7.44 acres/year. Excluding the FM(GV) category vegetative shift of fresh marsh species there was only a 48 acre net loss; HM gains nearly equaled IM losses.

#### **Brooklyn/Queens Ecoregion**

The ecoregion exhibiting the greatest loss was Brooklyn/Queens (south shore) Table 2, Figure 5. This ecoregion comprises 50.8%, 2136.63 acres of the study area (Figure 3) and contains 70.37% of the IM within the study area. This ecoregion had the greatest effect on the trends. The ecoregional extent ranges from the Queens/ Nassau border west to Upper and Lower New York Bays, and includes a small portion of the southern East River and the Rockaway Peninsula. Vegetated tidal wetlands were found in and around Gravesend Bay, Dead Horse Bay, Jamaica Bay and Woodmere Park, The ecocomplexes comprising this ecoregion are the Jamaica Bay islands, Jamaica Bay perimeter, Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Mill Basin, Dead Horse Bay/ Gerritsen Creek, Hook Creek, Channel and Perimeter Figure 5 Tables 3 - 12. Within this ecoregional area, IM exhibited the greatest loss 960.2 acres (41.5%). HM exhibited the second highest gain in HM, 428.07 acres, a 121.31% increase over 1974 HM acreage Table 2. The primary component of this ecoregional zone is Jamaica Bay, which is part of the Gateway Park System. It became part of the system in October 1972 (Tanacredi 1995).

Recently the bay has been the subject of intense discussion and analysis by the DEC, the U.S. National Park Service, and others since the notification and confirmation that tidal wetlands islands within the bay are disappearing at an alarming rate of 45 acres/year. (Fallon and Mushacke 2000). Under the present trends analysis, the marsh islands in Jamaica Bay indicate a loss of 780.91 acres or 42.7%, Table 3 with a loss rate of 31.24 acres/year. The rate of marsh loss is buffered due to the time differences between trends analysis. The referenced 45 acre rate took place between 1994-1999. Prior to this period, rates of loss were lower. High marsh among the islands however gained 203.97 acres or 123.9% over the same time period. While the gain in HM is encouraging, there was an overall net loss of 28.9% (576.94 acres) Table 3. Marsh island loss in Jamaica bay is the reason this ecoregion exhibits the highest in IM loss.

Another area of discussion regarding Jamaica Bay is the bay's perimeter marsh. The perimeter marsh encompassed vegetated wetlands around the entire bay south of the Belt Parkway, along the shore of John F. Kennedy Airport and the Rockaway Peninsula. The area between the black lines (Figure 5) and shaded yellow (Figure 6). Perimeter IM exhibits a 45.1%, 96.21 acre loss, Table 4. There was a gain in high marsh of 85.74 acres. Overall however, there was a 4.2%, 10.47 acre loss of vegetative perimeter marsh.

There are 5 channels that are directly connected to the bay proper. In order to determine the contribution of all wetlands within the bay these channelized creeks were examined for trends. From the early 1920's to the late 50's these once natural creeks in the west and northern portion of the bay's mainland marsh system were channelized, portions bulkheaded and the surrounding marsh filled and developed. Some vegetated wetlands remained. Figure 7(A) is a 1924 black and white aerial showing Shellbank Basin and environs during the filling and channeling operation. Figure 7 (B) is the 1999 aerial of the same location tables 5 - 11 show the trends. All channelized ecocomplexes exhibited IM loss except Hendrix and Fresh Creeks. Hendrix Creek table 7 was the site of a restoration project approximately 4.7 acres were created, Figure 8. In 1974 this creek did not contain tidal wetlands. Fresh Creek gained fringe IM and exhibited the smallest gain in HM 0.05acre, Table 6. Figures 9 and 10 graphically illustrate wetland trends described in this ecoregion.

#### **Queens (north shore) Ecoregion**

This ecoregional zone includes tidal wetlands found along the north shore in the Borough of Queens. The ecoregion comprises 213.82 acres (5.08%) of the total vegetated tidal wetlands within the study area. This ecoregion had the second highest gains in total vegetated tidal wetlands, 45.86 acres. There was a loss of 12.73 acres of IM, but a 68.29 acre gain in HM, Table 13, Figure 11. There are 4 ecocomplexes found within the borders of this regional zone. Alley Pond/Little Neck Bay, Udalls Cove, Powells Cove and Bowery/Flushing Bays (Figure 12). Tables13-17 presents the trends of each ecocomplex within the ecoregion. Both Alley Pond and Udalls Cove are located at the eastern end of the ecoregional limit, a residential location along the Nassau/Queens border. Alley Pond is located in the southern portion of Little Neck Bay. The city acquired the site for park purposes in 1929. Udalls Cove was first mapped as a park/preserve in 1972 and has had subsequent additions. The preserve was created by cooperative agreement between NYC Parks and the DEC. Ironically these two ecocomplexes are the only ones to have lost IM within this region. Alley Pond lost 6.22 acres and Udalls Cove lost 7.69 acres (17.5%) and (38.1%) respectively, Tables14 and 15. It appears to have been through perimeter erosion (Figures13 and 14). Overall though, there was a net gain in vegetated tidal wetlands. The high marsh increased (87.6%) in Alley Pond and 94.5% in Udalls Cove. These percentages include the vegetative shift of fresh marsh species to Phragmites (HM) in Udalls Cove

Powells Cove and the Bowery/Flushing Bay ecocomplexes Tables 16 and 17 are in the western portion of the Queens (north) ecoregion, a highly urbanized area; both marsh ecocomplexes exhibited gains in HM. An IM gain of 38.5% was seen in Powells Cove. The Cove was a site of a marsh restoration some years back. Bowery/Flushing ecocomplex only lost 0.51 acre even though a safety apron was constructed at the eastern

terminus of LaGuardia runway.

The losses are not evident in the trends, due to compensating IM fringe, approximately 4.52 acres identified along the northern edge of the airport, an area devoid of IM in 1974(Figure 15). Also not detected in the trends a narrow 1.7 acre fringe of IM identified in 1974 along the southern edge of Rikers Island which no longer exists. The apparent filling of 0.86 acre of FC occurred at an area named Berrian's Island, owned by Con-Edison (Figure 16).

#### **Bronx Ecoregion**

This ecoregion's extent is the Bronx /Westchester county border in the north, it extends south to and includes the shores of the East River. The eastern reach encompasses Eastchester Bay and City Island; the Hudson River comprises the western extent. The ecocomplexes are found on the south and east shores. These ecocomplexes include the Bronx River, Pugsley Cove /Westchester Creek, Eastchester Bay, the Hutchinson River and Orchard Beach/City Island (Figure 17). The Bronx ecoregion comprises 313.09 acres 7.4% of the study area. There was a 1.9%, 5.97 acre net gain in total vegetated wetlands between 1974 and 1999. Regarding 1999 vegetative covertypes, there was a near equal compensation of HM gains to IM loss. The HM gained 49.15 acres while the IM lost 43.18 acres Table 18. Intertidal marshes along the Bronx River and Pugsley Cove/Westchester Creek showed gains of 1.54 and 6.25 acres respectively, even though a 0.23 acre IM was apparently filled along the Bronx River Table 19, (Figure 18). Figure 19 shows comparative vegetative trends between the IM and HM within the ecoregion from 1974 to 1999. The Eastchester Bay and Hutchinson River ecocomplex exhibited near equal compensation in HM gains to IM losses as well; both ecocomplexes exhibited a net loss of vegetated wetlands, 0.36 acres and 2.66 acres respectively Tables 21 and 22. The Hutchinson River and Orchard Beach/City Island ecocomplexes exhibited the greatest losses in the ecoregion. The predominant mode of loss was perimeter erosion (Figures 19 and 20). Although not extensive, apparent internal ponding, a secondary mechanism of loss occurred in the Hutchinson River (Figure 21 and 22).

#### **Staten Island Ecoregion**

This ecoregion is at the southern portion of the study area (Figure 2). Staten Island is bordered on the east by Raritan Bay, the Arthur Kill to the west, Kill Van Kull to the north and the Narrows (Hudson River) to the northeast. The Island comprises approximately 59 square miles of land mass about 90% upland containing high and low residential, commercial and industrial development (Tiner 2000). The ecocomplexes that comprise this ecoregion include; Lemon Creek on the east side of the island, Mill Creek, Fresh Kills, Neck Creek and SawMill Creek on the west side along the Arthur Kill (Figure 24) Tables 25 -32. Currently tidal wetlands occupy 1262.74 acres of Staten Island 30.02% of the total tidal wetlands within the study area (Figure 2) Table 24. Surprisingly, Staten Island had the highest gain in both vegetative tidal wetland categories (Figure 23). Tidal wetland vegetative totals for HM and IM were 227.04 acres and 91.47 acres respectively Table 24. All ecocomplexes except Lemon Creek exhibited gains in HM. Lemon Creek experienced a 7.64, 21.4% "loss" in HM. The loss appears to be a vegetative shift from HM to IM possibly due to sea level rise Table 25. The 1974 IM acreage was 1.27 acres and in 1999 the acreage increased 6.5 acres to 7.77 acres a 511.8% increase. While HM decreased from 35.74 acres in 1974 to 28.1 acres in 1999. Lemon Creek 1974 vegetative totals equaled 37.83 acres and 1999 acres equaled 36.72 acres a net loss of only 1.11 acres 2.9%. Lemon Creek is also the only site on Staten Island containing tidal fresh marsh vegetation Spartina cynosuroides. The acreage remained stable between 1974 and 1999, 0.82 acres and 0.85 acres respectively Table 25, however the location of the tidal freshwater species apparently moved. In 1974 the tidal fresh marsh was located in the north corner of the marsh (Figure 25A) and the species was not identified in field data reports, recent

field visits show that the species located in that area is *Pragmites sp.*.

*S. cynosuroides* now appears along the main marsh creek about mid marsh (Figure 25B). Lemon Creek does not exhibit the typical ponding, perimeter loss or fragmentation observed in other ecocomplexes that experienced loss.

Mill Creek exhibited the smallest gain in HM and IM 3.34 acres and 0.92 acres respectively, Table 26 while Fresh Kills had the highest gains in high marsh 150.54 acres and was the only ecocomplex in the Staten Island ecoregion to lose IM, Table 27. Fragmentation of marsh interior due to coalescence of tidal pools and widening and extension of tidal channels appears to be the cause (Figure 26). The highest gains in IM were found in Neck Creek, 25.58 acres, Table 28. While fragmentation and ponding is occurring in other ecocomplexes there size has not affected trends.

#### **Lower Hudson Ecoregion**

This portion of the study area includes the Hudson River from the Tappan Zee Bridge to the Verrazano Bridge. This ecoregion comprised 6.54% of the total study area (Figure 3) Wetland totals along this stretch of the river in 1999 amounted to 278.1 acres, Table 33. The bulk of this from the Piermont marsh ecocomplex (Figure 27). Approximately 1 acre of the total is IM that is intermittently dispersed along the River's east and west shore. Since the Piermont marsh is the predominant ecocomplex in this ecoregion all further statistics and discussion will concern this area. The Piermont marsh can be found on the west shore of the Hudson River between mile marker 23 and 25. The marsh is in Rockland County and the majority of the wetlands are part of the Hudson River Reserve. The site occupies two miles of shoreline south of the mile-long Erie Pier and includes the mouth of Sparkill Creek, Table 34 (Figure 27). Trends indicate that in 1974 the vegetated tidal wetland configuration comprised 104.88 acres of HM, 12.10 acres of IM and 167 acres of FM (GV). 1999 acreage indicates HM totals to be 223.49 acres, IM 13.64 acres and FM (GV) 39.1 acres. Vegetative totals indicate a 7.75 acre 2.7% decrease. Fresh tidal marsh species Typha sp. and Scirpus sp. show a 76.6% 127.9 acre decrease while HM species, in this case dominated by stands of Phragmites sp., show a 113.1%, 118.61 acre increase. In 1974 HM encompassed 36.9% of the Piermont marsh and fresh tidal species covered 58.8% of the marsh proper. The latter predominately covered the landward (western) portion of the marsh. In 1999 however HM encompassed 80.9% of the marsh while fresh tidal species cover 14.15%, mostly in the center. There was an apparent change in biodiversity, an expansion of phragmites into a dominating role within the fresh tidal marsh portion of Piermont Figure 4. A small amount of perimeter erosion (IM) at the southern end of the marsh was also detected by photointerpretation, but was not indicated by the trends (Figure 28A and B).

#### **Manhattan Ecoregion**

The Manhattan ecoregion represents the smallest ecoregion regarding vegetated tidal wetlands in the study area. The only tidal wetlands mapped in 1974 were located on the Harlem River at Inwood Hill Park on Manhattan's northern shore (Figure 29A and B). IM totaling 0.33 acre existed in 1974, in 1999 there was a 54.5% decrease 0.15 acre. The IM appeared to be fragmented compared to the 1974 aerials (Figure 29A).

Another vegetated area found in this ecoregion along the Harlem River at Swindlers Cove, although it was not mapped as IM or HM in 1974, is. The mapping of these wetlands represents a gain of 0.61 acres in HM and a gain of 0.25 acres of IM respectively. A portion of the IM was due to restoration during park construction.

#### **Tidal Wetland Gains**

Overall there was a 66.8% gain in high marsh, 896.88 acres. The HM nearly compensating for the

IM loss(945.4 acres) in the study area. All ecoregions exhibited HM gains. All ecocomplexes containing HM in 1974, except Lemon Creek, Staten Island table 25 (-7.64 acres) gained HM as well. Pugsley Cove/Westchester Creek table 20 had the smallest gain, Jamaica bay table 3 had the highest gains. High marsh was not inventoried in the Bronx River ecocomplex in 1974, the 1999 inventory picks up .037 acres table19. The Staten Island ecoregion was the only ecoregion to experience gains in IM 31% ( 91.47 acres). All ecocomplexes within the Staten Island ecoregion exhibited IM gains tables 25-32, except Fresh Kills, table 27. Gains in IM were also seen in other ecocomplexes, Fresh Creek, Hendrix Creek, Powell's Cove, Bronx River, Pugsley Cove/Westchester Creek tables 6, 7, 16 19 and 20, respectively. Landward migration, conversion, and the identification of tidal phragmities as an HM species are reasons for these gains.

#### **Tidal Wetland Losses**

Causes of tidal wetlands loss can be natural and/or anthropogenic, although at times the line is blurred. These causes could be acting independently or synergistically.

Eighteen of the 27 ecocomplexes 66.66%, experienced tidal wetland loss, of those 16, 59.26% lost IM. These tidal wetland losses were observed in the field, through photointerpretation of aerial infrared photographs and through GIS trends analysis. The losses manifested themselves geomorphologically and floristically. Two of the eighteen 11.11% ecocomplexes; Lemon Creek and Piermont marsh exhibited floristic changes. Floristic losses included a vegetative shift, a change in biodiversity and dominance by Phragmites.

In Lemon Creek the area delineated as FM in 1974 is now Phragmites. 1974 field records from the area, regarding vegetation types, are not conclusive. The vegetative class of fresh marsh species shifted from a finger like projection in the north corner, to the center of the marsh along the main tidal creek where monotypic stands of, *Spartina cynosorides* exist. While the vegetation shifted, total area remained virtually the same 1974 (0.82) and 1999 (0.85) table 25. The existence of the *S. cynosorides* does not appear to be episodic. The area covered by the plant is extensive and species density is high. An examination of the 1974 IR was inconclusive. This is the only ecocomplex that experienced a loss of high marsh. The loss of HM seems to be compensated by the gain in IM, however. This could be a vegetative response to sea level rise, trends indicate a net loss of 1.11 acres however, there was no indication of ponding or significant erosion along the marsh edge to account for the loss.

Within the study area Piermont marsh exhibited the greatest vegetative shift from fresh marsh species (Typha sp. and Scirpus sp.) in 1974 to high marsh (Phragmites sp.) in 1999. This classification change occurred because the 1999 inventory considered *Phragmites sp.* part of the HM class. Phragmites dominated the marsh by 1999 there was an apparent insurgence and coalesence of phragmites throughout the marsh. Winogroud 1997 and Nieder 1997 mapped similar conditions within the Piermont marsh. (Winogrond concluded that the introduction of phragmites occurred as early as 1800. This is coincident with the use of the Sparkill creek as a transportation route for sailing vessels in the fur, lumber and agriculture trade. Perhaps the influence of a mesohaline environment, 6ppt (Winogrond, 1997), resulting from sea level rise and drought, the adaptability (18ppt or less, Chambers et al., 1999) and aggressive nature of Phragmites contributed to this dominance. A nutrient availability shift, exploitation of a limiting nutrient and/or the expansion of a more aggressive form of phragmites are additional potential reasons for the reed's expansion as well (Chambers et. al., 1999). Furthermore, (Anisfeld et al, 2002) hypothesize that phragmites root structure may be more effecient at trapping sediment, maintaining a higher rate of accreation. Since phragmites is bordering the edges of the Piermont marsh, the reed may be starving typha similar to conditions along the Quinnipiac River. Perhaps what also may be occurring is the edges of the marsh have become slightly higher in elevation and this phenomonom is causing a greater retention time of the tidal mesohaline waters allowing the Phragmites to outcompete the fresh

water species.

The remaining 16 ecocomplexes appear to have experienced physical changes that resulted in vegetated marsh loss. The marsh loss involved the IM *Spartina alterniflora*. Potential contributing factors include sediment budget disruption, sea level rise (SLR), dredging, wave energy, erosion, inlet stabilization, mussel dams on the marshes, and eutrophication.

Many of the IM sites experienced perimeter erosion. Marshes in all ecoregions exhibited some signs of peat breakoff, slumping and undercutting, although this condition was not always expressed in the trends. This condition can occur because of wind driven waves during storm events, ice shearing or ice scour and/or boat traffic; Alley Pond/Little Neck Bay, Udalls Cove and Hutchinson River, Inwood Hill Park and Jamaica Bay all exhibited loss possibly due to one or all of these erosional processes (Figures 13, 14, 19,21 and 29).

Internal marsh loss due to ponding was observed in the Jamaica Bay islands, Spring Creek the Hutchinson River, Old place Creek, Sawmill Creek and Neck Creek (Figures 21, 30, 31 and 32).

In Jamaica Bay ponding and the coalescence of the ponds appears to be one of the more prevalent causes of tidal wetland loss primarily caused by mussel dams or berms (Figures 30, 31 and 32). Bertness (1984) documented an increase in S. alterniflora growth as a result of mussels. In the Jamaica Bay islands, however, ponding caused by mussel berms appears to be having a negative impact (Franz, 2004). This phenomenon, according to Dr. Franz, is occurring because of high biodeposition and sediment trapping by the mussels and an increase in marsh edge elevation. Increased growth and biodeposition of mussels is probally due to nutrification as a result of sewage treatment plant discharge. The 2002 Harbor Water Quality Report corroborates this contention stating "Jamaica Bay has the highest algal activity in the NY harbor region and, since 1986, chlorophyll a (an indicator of nutrification) in Jamaica Bay has steadily increased". In 2002 chlorophyll 'a' averaged 44ug/L in Jamaica Bay. The water retained within the mussel dam, causes the spartina's roots to become water logged, anoxic conditions prevail and the plant is stressed eventually causing die-off. (Figures 30 and 31). This berming effect also entraps macroalgae such as sea lettuce, *Ulva sp.* another indicator of nutrification which could exacerbate plant mortality(Figure 32). Without the binding roots the peat eventually dissipates or collapses becomes "soupy" causing a pond or increasing an existing pond's area.

In other ecocomplexes where ponding has occurred the Hutchinson River (Figure 21 and 22) it may have occurred because of a depression in the peat, caused during winter ice grating or wrack build-up on the marsh (Bertness, 1992). These conditions can cause plant mortality. Over time the peat collapses and a depression is formed. The depression causes ponding. The pond holds water, soil salinity increases and O<sub>2</sub> levels drop. Vegetation within and along the pond's edges succumbs to these poor growing conditions and eventually dies. The peat collapse causes further depression and expansion of the "dead zone". (DeLaune et. al., 1994, Taylor, 1938).

The natural migration of the Rockaway barrier beach, construction of groins, dredging, filling and hardening of shorelines, can lead to sediment budget disruption and resulting marsh loss. It is believed that Jamaica Bay may be suffering from these historic albeit persistent natural and anthropogenic impacts. In 1923 the bay was over dredged. Rockaway inlet was stabilized in 1933 and the inlet dredged in anticipation of port construction (Moehle, 1995). Previous mean depth was approximately 3.3 feet. Eighty years of dredging at the rate of about 3 projects/year resulted in depths of approximately 16-65 feet; with a mean of 16 feet (Swanson et al., 1992) forever changing the bay's bathymetry. In 1942 Idelwild Airport (now John F. Kennedy Airport) was expanded and its elevation raised to 10 feet above sea level. This action caused the loss of approximately 5,000 acres of tidal wetlands and the deepening of Grassy Bay, an embayment within Jamaica Bay, to 65 feet due to the removal of 65,000,000 cubic yards of bottom material to be used as fill (Moehle, 1995). Later in 1962, the John F. Kennedy Airport runway extension changed the hydrodynamics of the bay (Figure 33).

These actions combined with the natural extension of the Rockaway peninsula (Figure 34) undoubtedly reduced the sediment budget possibly causing the bay's susceptibility to local sea level rise (SLR) estimated to be 2.7 mm/year (Hartig et al., 2002).

Further exacerbating the sediment budget are hardened shorelines, which have a twofold impact. The existence of the structure at the land/water interface prevents the landward migration of tidal wetlands responding to SLR and the structures prevent sediments in the watershed from entering into the waterway. The latter condition is enhanced because most runoff is collected by Sewerage Treatment Plants (STPs) and the sediments are "settled out" before the water is returned to the bay.

In order for a marsh to survive, accretion rates must follow sea level rise (Harrison and Bloom 1977). The ecocomplexes experiencing loss may not be in a balanced system however, as discussed above. Combined with the above anthropogenic disturbances sea level rise can exacerbate conditions. Local SLR (2.7mm/yr) is greater than global SLR (1.8mm/yr) according to (Gornitz et al., 2002 and Hartig et al., 2002) because of local subsidence resulting from crustal readjustments due to the removal of ice following the last glaciation. The effects of persistent past and continued anthropogenic impacts combined with natural events can cause further marsh loss as shown by the trends.

#### **Conclusions and Recommendations**

Trends revealed 16 ecocomplexes within the study area experiencing IM loss (Tables 1-35). The IM within the island marshes of Jamaica Bay which comprise 54.51% of the total IM in the study area (Table 3), exhibited the greatest losses and subsequently the Brooklyn/Queens ecoregion exhibited the greatest loss among the ecoregional groups. Review of the aerial IRs and ground observations confirm these losses. They further confirmed that the marshes throughout the study area are suffering similar mechanisms of loss including; internal marsh fragmentation, perimeter erosion, extension and widening of tidal creeks.

There is no single cause. Numerous contributing factors have been cited which could be acting singularly or synergistically. Expedited trends beyond the study area in suburban and rural areas within New York's marine district also revealed loss, with percentages approaching 50% (Mushacke and Fallon, 2002). Losses are occurring elsewhere as well. At a recent Long Island Sound workshop (June 2003), Connecticut scientists Ron Rosza and Shimon Anisfeld detailed similiar wetlands loss in Connecticut's Five Mile and the Quinnipiac Rivers. Scientists along the eastern seaboard and beyond are finding similar occurrences (Allen and Pye, 1992, DeLaune et al., 1994, Donham, 1995, Kearney, 2002,).

Except for Lemon Creek all ecocomplexes exhibited gains in HM. This is primarily due to the landward expansion of the HM, the loss of IM and the conservative delineation of phragmites. While it may appear that this trend is positive, primary productivity may be lower due to the more landward location of the HM, the lower tidal frequency coincident with new, full moon and storm tides and the lower efficiency of flushing of the biological products into the estuary. In cases where phragmites represents the landward boundary of the TW, this is particularly advantageous since the reed will be holding the land in "escrow" until the rise in sea level and higher salinities cause environmental changes conducive to purer high and intertidal marsh species growth.

Invasion and dominance of pragmites, another sign of antropogenic causes, should be explored as well. Sea level rise and drought may have given phragmites an advantage over the fresh marsh species Typha sp. and Scirpus sp. and /or the reed may be the faster growing European strain. Surface elevations should also be taken to determine wheather significant differences exist between the Phragmites and fresh marsh species found on the marsh.

There is no easy answer to the problem. Remediation will be diverse and costly. In ecoregions such as Brooklyn/Queens where loss rates of IM are calculated at 38 acres/yr, immediate action should

be taken. Largescale tidal wetland restoration projects are necessary and should be developed and implemented. In the Queens (north shore) and Bronx ecoregions where loss rates are low, studies should be initiated to determine causes. Comparative studies of affected and unaffected marshes should be conducted; perhaps with marshes in Staten Island. Once the causes are identified strategies should be implemented to reduce and /or eliminate the causative impacts. The effected wetlands should then be restored or remedial action taken. Monitoring with periodic aerial infrared photography should be conducted at regular intervals, every 5-7 years is recommended.

**Figure 1. NY Marine District** 

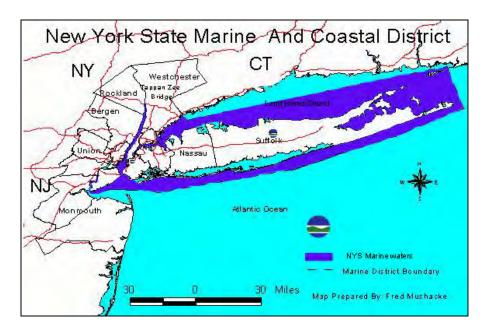
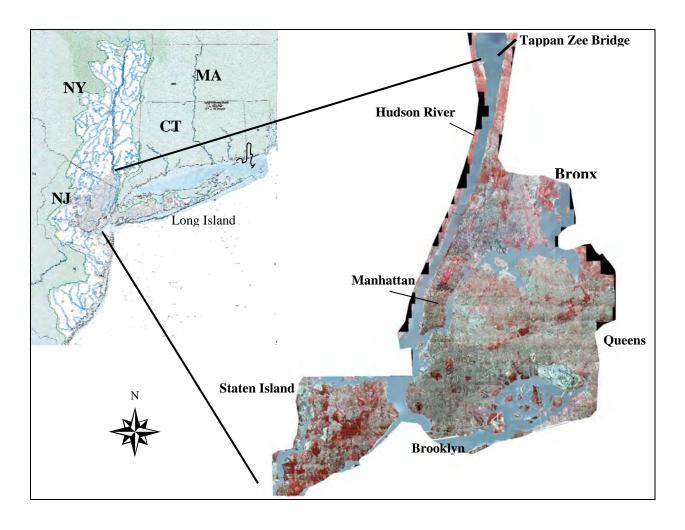


Figure 2. Study Area, NY Metropolitan area and the Lower Hudson River



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Figure 3. Ecological Regions within the Study Area, and Percent of Vegetated Tidal Wetland Contribution to the study area.

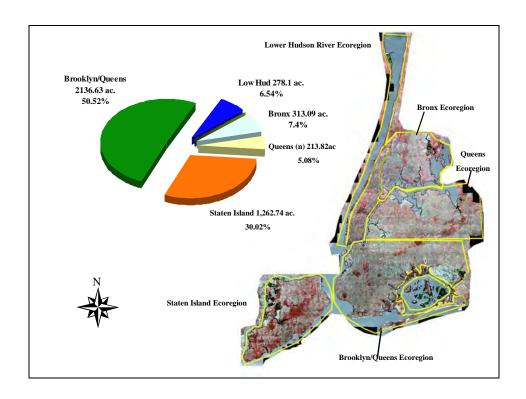
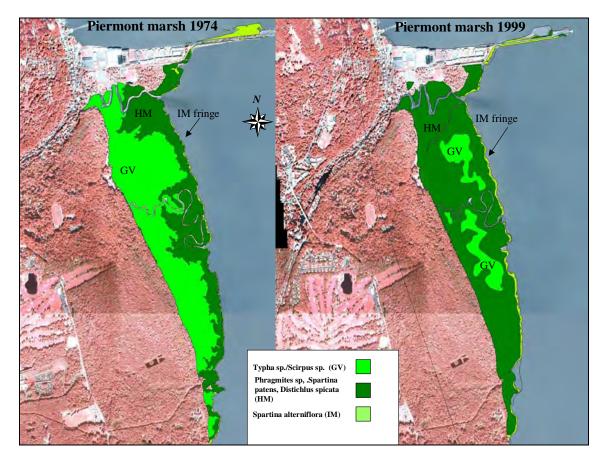


Figure 4. Piermont marsh vegetative shift comparison 1974 – 1999.



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### Table 1.

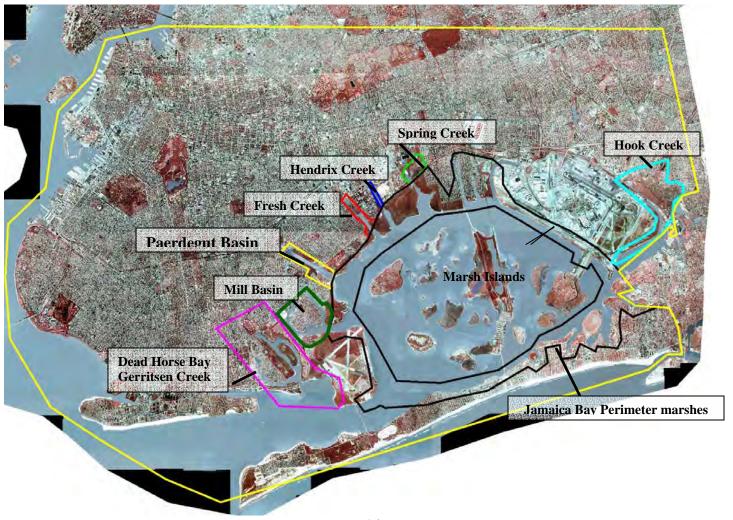
Study Area	197	74	199	9	Total	Percent	Rate of
Total Vegetative T W Trends	Frequency	Acres	Frequency	Acres	Acre Change	Change	Change Acres/Yr
High marsh (HM)	600	1342.67	464	2239.55	+896.88	+66.8%	35.87
Intertidal marsh (IM)	644	2871.63	1002	1926.23	-945.4	-32.9%	37.82
Fresh Marsh (FM,1974) (GV 1999)	9	177.52	9	39.94	-137.58	-77.5%	-5.5
Totals	1253	4391.82	1475	4205.72	-186.1	-4.2%	-7.44

# **Brooklyn/Queens Ecoregion (south shore)**

Table 2.

Brooklyn/Queens	1974		1999		Total Acre	Percent	Rate of	Percent of
Ecoregional trends	onal trends Frequency Acres Frequency Acres Change	Change	Change	Change Acres/Yr	Study Area			
High marsh (HM)	288	352.93	180	781	+428.07	+121.3%	+17.12	34.9%
Intertidal marsh (IM)	366	2315.83	559	1355.63	-960.2	-41.5%	-38.41	70.37%
Totals	654	2668.76	739	2136.63	-532.13	-19.9%	-21.28	50.8%

Figure 5. Brooklyn/Queens Ecoregion



# Table 3.

Jamaica Bay Marsh island	1974		199	9	Total Acre Change	Percent Change	Rate of Change	Percent of Study	
ecocomplex	Frequency	Acres	Frequency	Acres	O	C	Acres/Yr	Area	
High marsh (HM)	149	164.9	56	368.91	+203.97	+123.9%	+8.16	16.47%	
Intertidal marsh (IM)	211	1830.88	206	1049.97	-780.91	-42.7%	-31.24	54.51%	
Totals	360	1995.82	262	1418.88	-576.94	-28.9%	-23.08	33.71%	

# Table 4.

Jamaica Bay	1974		1999	9	Total Acre	Percent Change	Rate of Change	Percent of Study
perimeter ecocomplex	Frequency	Acres	Frequency	Acres	Change	C	Acres/Yr	Area
High marsh (HM)	27	33.96	56	119.7	+85.74	+252.5%	+3.43	5.34%
Intertidal marsh (IM)	85	213.39	201	117.18	-96.21	-45.1%	-3.85	6.08%
Totals	112	247.35	257	236.88	-10.47	-4.2%	-0.42	5.63%

# Table 5.

Paerdegat Basin			1999	)	Total Acres	Percent Change	Rate of Change	Percent of Study
ecocomplex	Frequency	Acres	Frequency	Acres		C	Acres/Yr	Area
High marsh (HM)	1	0.71	4	9.86	9.15	1,288.7%	+0.37	0.44%
Intertidal marsh (IM)	4	7.37	2	4.36	-3.01	-40.8%	-0.12	0.23%
Totals	5	8.08	6	14.22	6.14	76%	+0.24	0.34%

# Table 6.

Fresh Creek ecocomplex	1974		1999		Total Acres	Percent Change	Rate of Change	Percent of Study Area
севевиргея	Frequency	Acres	Frequency	Acres			Acres/Yr	
High marsh (HM)	7	6.87	3	6.92	+0.05	+0.7%	+0.002	0.31%
Intertidal marsh (IM)	4	5.32	4	6.49	+1.17	+22%	+0.047	0.34%
Totals	11	12.19	7	13.41	+1.22	+10%	+0.54	+0.32%

# Table 7.

Hendrix Creek	1974		1999		Total Acres	Percent Change	Rate of Change	Percent of Study Area
ecocomplex	Frequency	Acres	Frequency	Acres		Ü	O	
High marsh (HM)	0	0	0	0	0	0	0	0
Intertidal marsh (IM)	0	0	1	4.72	4.72	0	0	24.5%
Totals	0	0	1	4.72	4.72	0	0	24.5%

### Table 8.

Spring Creek ecocomplex	1974	1974		1999		Percent Change	Rate of Change	Percent of Study Area
ccocompicx	Frequency	Acres	Frequency	Acres			Acrea/Yr	
High marsh (HM)	15	7.1	13	10.38	+3.28	+80.4%	+0.13	0.46%
Intertidal marsh (IM)	7	20.48	13	17.81	-2.67	-13%	-0.11	0.92%
Totals	22	27.58	26	28.19	+0.61	+2.2%	+0.024	0.67%

# Table 9.

Mill Basin ecocomplex	1974		1999	)	Total Acres	Percent Change	Rate of Change	Percent of Study
ccocomplex	Frequency	Acres	Frequency	Acres			Acre/Yr	Area
High marsh (HM)	3	21.65	3	38.02	16.94	+80.4%	+0.68	1.7%
Intertidal marsh (IM)	3	11.43	19	10.05	-1.38	-12.1%	-0.05	0.52%
Totals	6	33.08	22	48.07	15.56	+45.3%	-0.62	1.14%

<sup>\*</sup>FC stats (0.57 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

#### Table 10.

Table 10.								
Dead Horse	1974		1999	)	Total Acre	Percent	Rate of	Percent of
Bay/					Change	Change	Change	Study
Gerritsen	Frequency	Acres	Frequency	Acres			Acre/Yr	Area
Creek								
ecocomplex								
High marsh	3	4.39	10	39.78	+35.39	+806.2%	+1.41	1.77%
(HM)								
Intertidal marsh	24	67.39	81	37.51	-29.88	-44.3%	-1.2	1.95%
(IM)								
Totals	27	71.78	91	77.29	+5.51	+7.7%	+0.22	1.84%

#### Table 11.

I abic 11.								
Hook Creek ecocomplex	1974	1	1999	)	Total Acre Change	Percent Change	Rate of Change	Percent of Study
cedeompiex	Frequency	Acres	Frequency	Acres			Acrea/Yr	Area
High marsh (HM)	75	76.06	31	181.46	+105.4	+138.6%	+4.22	8.1%
Intertidal marsh (IM)	21	154.54	21	105.77	-48.7	-31.5%	-1.95	5.49%
Totals	96	230.53	52	287.23	+56.7	+24.6%	+2.27	6.83%

<sup>\*</sup>FC stats (11.54 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

#### Table 12.

I WOIC IZ.								
Channel and Perimeter	1974	1974		)	Total Acre Percent Change Change		Rate of Change	Percent of Study Area
ecocomplex	Frequency	Acres	Frequency	Acres			Acrea/Yr	·
High marsh (HM)	53	70.29	79	184.88	+114.59	+163%	+4.58	8.25%
Intertidal marsh (IM)	103	257.99	235	164.63	-93.36	-36.2%	-6.58	8.55%
Totals	156	328.28	314	349.51	+21.23	+6.5%	+13.98	8.31%

Figure 6. Jamaica Bay perimeter vegetated tidal wetlands extent.

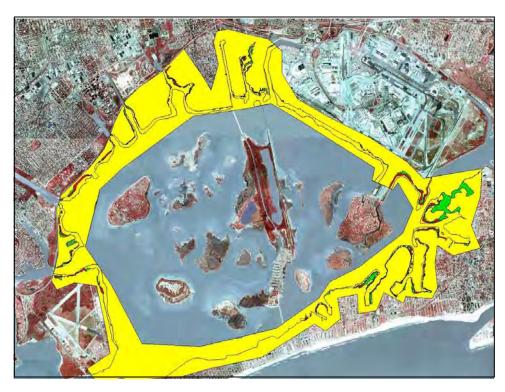


Figure 7. Shellbank basin, one site of many, showing early marsh filling, channelization and development.

A 1924 B&W B 1999 IR

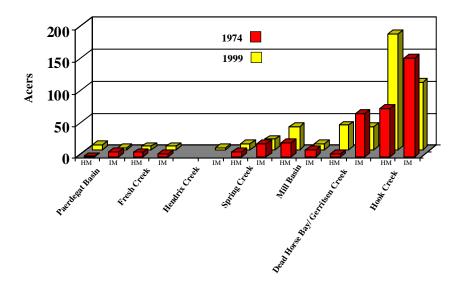


Figure 8. Hendrix Creek Intertidal Marsh Restoration



Figure 9. Brooklyn/Queens Ecoregional Trends 1974 - 1999

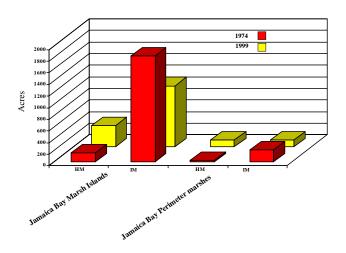
Jamaica Bay Creek and Channel Ecocomplexes Tidal Wetland Acre Comparison



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Figure. 10 Jamaica Bay Marsh islands and perimeter ecocomplex trends 1974 - 1999





# **Queens (north shore)**

Table 13.

Queens (north shore)	1974		1999	)	Total Acre Change	Percent Change	Rate of Change	Percent of Study Area
Ecoregional trends	Frequency	Acres	Frequency	Acres			Acres/Yr	
High marsh (HM)	22	79.51	34	147.8	+68.29	+85.9%	+2.73	6.6%
Intertidal marsh (IM)	38	78.75	60	66.02	-12.73	-16.2%	-0.51	3.43%
Fresh marsh (FM)	2	9.7	*	*	*	*	*	*
Totals	62	167.96	94	213.82	+45.86	+27.3%	+1.83	5.08%

<sup>\*</sup>Fresh marsh shifted to HM in 1999

Figure 11. Queens (north) Ecocomplex Trends 1974 - 1999

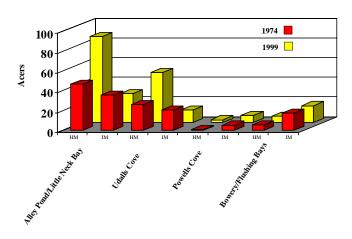
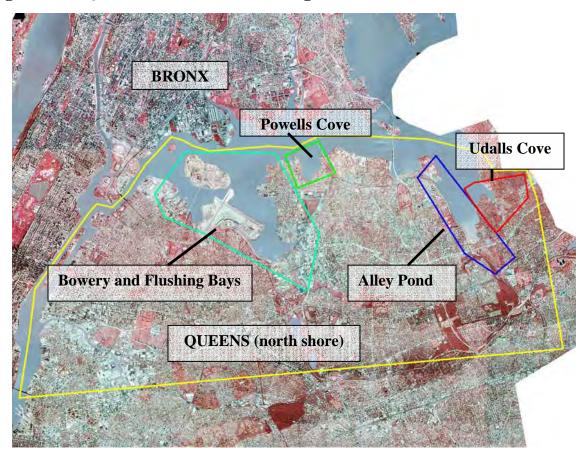


Figure 12. Queens (north shore) Ecoregion



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Table 14.

Tubic I ii	uote 1 ii										
Alley Pond/Little	1974	1974		)	Total Percent Acres Change		Rate of Change	Percent of Study Area			
Neck Bay	Frequency	Acres	Frequency	Acres			Acres/Yr				
ecocomplex											
High marsh (HM)	13	46.85	15	87.91	+41.07	+87.6%	+1.64	3.92%			
Intertidal marsh (IM)	17	35.46	21	29.24	-6.22	-17.5%	-0.25	1.52%			
Totals	30	82.31	36	117.15	+34.85	+42.3%	+1.4	2.78%			

<sup>\*1974</sup> FC stats (6.47 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 15.

Udalls Cove	1974	=	1999	)	Total Acres	Percent Change	Rate of Change	Percent of Study
ecocomplex	Frequency Acres Frequency Acres			Acres/Yr	Area			
High marsh (HM)	2	26	7	50.56	+14.86	+94.5%	+0.6	2.26%
Intertidal marsh (IM)	5	20.19	9	12.5	-7.69	-38.1%	-0.31	0.65%
Fresh marsh (FM)	2	9.7	*	*	*	*	*	
Totals	9	55.89	16	63.06	+7.17	12.8%	+0.29	1.5%

Fresh marsh shifted to HM in 1999

Table 16.

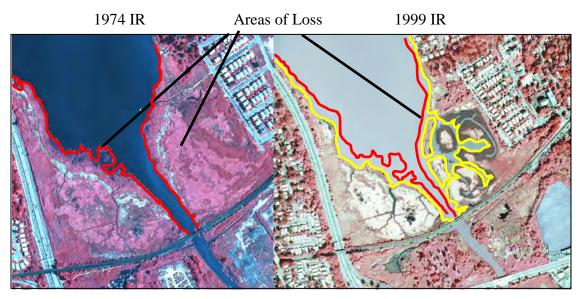
Powells Cove	1974		1999	)	Total Acres	Percent Change	Rate of Change	Percent of Study
ecocomplex	Frequency	Acres	Frequency	Acres			Acres/Yr	Area
High marsh (HM)	2	0.97	4	2.86	+1.89	+194.8%	+0.075	0.13%
Intertidal marsh (IM)	3	5.22	4	7.23	+2.01	+38.5%	+0.08	0.37%
Totals	5	6.19	8	10.09	+3.9	+63%	+0.16	0.24%

Table 17.

Table 17.								
Bowery/Flushing Bays	1974		1999		Total Percent Acres Change		Rate of Change	Percent of Study
ecocomplex	Frequency	Acres	Frequency	Acres			Acres/Yr	Area
High marsh (HM)	4*	5.44	8	6.46	+1.02	+18.7%	+0.04	0.29%
Intertidal marsh (IM)	12	17.55	26	17.04	-0.51	-2.9%	-0.68	0.9%
Totals	16	22.99	34	23.5	+0.51	+2.2%	+0.02	0.56%

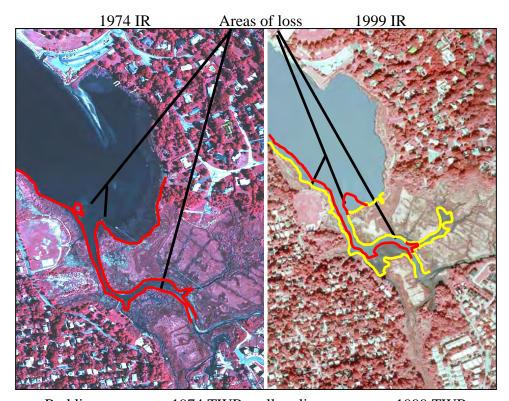
<sup>\*1974</sup> FC stats (5.07 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Figure 13. Alley Pond Park areas of vegetative tidal wetlands loss



Red line represents 1974 TWB; yellow line represents 1999 TWB

Figure 14. Areas of tidal wetlands loss within Udalls Cove



Red line represents 1974 TWB; yellow line represents 1999 TWB

Figure 15. LaGuardia Airport 1974 – 1999 Fringe Tidal Wetland Gains

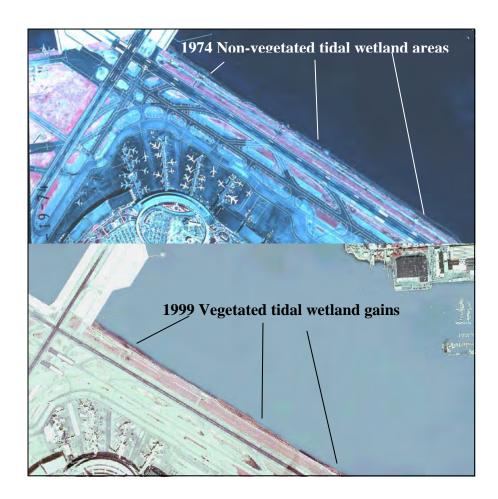


Figure 16. Filled "FC" area Queens (north), on Berrian's Island

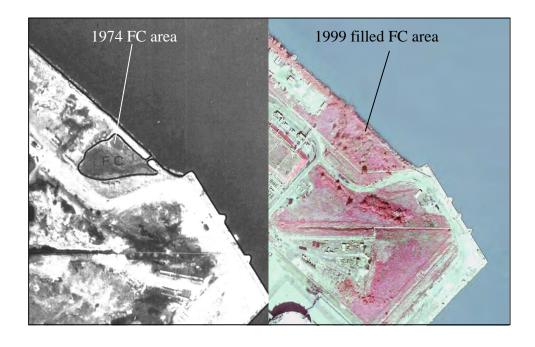
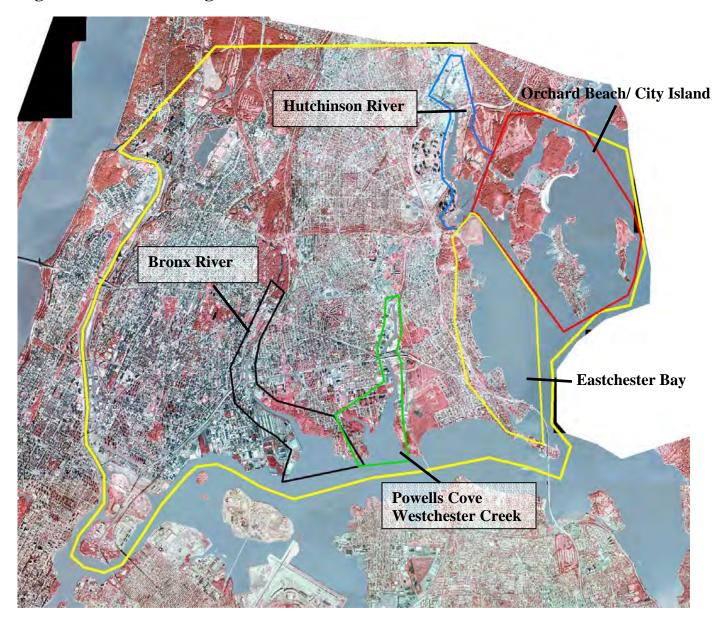


Figure 17. Bronx Ecoregion



# **Bronx Ecoregional Trends**

Table 18.

Bronx	1974		1999	)	Total Acres	Percent Change	Rate of Change	Percent of Study
EcoRegional trends	Frequency	Acres	Frequency	Acres	Acres	Change	Acres/Yr	Aera
Highmarsh (HM)	50	*159.94	51	209.09	+49.15	+30.7%	+1.97	2.19%
Intertidal marsh (IM)	70	147.18	153	104	-43.18	-29.3%	-1.73	5.4%
Totals	120	307.12	204	313.09	+5.97	+1.9%	+0.24	7.4%

<sup>\*1974</sup> FC stats (11.31 acres) were added to 1974 HM. FC vegetative profile met HM floral characteristics for 1999

# Table 19.

Bronx River ecocomplex			)	Total Acres	Percent Change	Rate of Change	Percent of Study	
ccocomplex	Frequency	Acres	Frequency	Acres			Acres/Yr	Aera
High marsh (HM)	0	0	1	0.037	+0.037		+0.001	0.0016
Intertidal marsh (IM)	1	0.23*	6	1.77	+1.54	+669.6%	+0.062	0.092
Totals	1	0.23	7	1.807	1.577	+685.7%	+0.06	0.043

<sup>\*</sup> Only IM on Bronx River in 1974 apparently filled Figure 18.

# Table 20.

Pugsley Cove/ Westchester	1974		1999	1999		Percent Change	Rate of Change	Percent of Study
Creek	Frequency	Acres	Frequency	Acres			Acres/Yr	Aera
eco complex								
High marsh (HM)	5	2.34	2	2.57	+0.23	+9.8%	+0.0092	0.11%
Intertidal marsh (IM)	8	11.65	26	17.9	+6.25	+53.6%	0.25	0.93%
Totals	13	13.99	28	20.47	+6.48	+46.3%	0.26	0.49%

# Table 21.

Eastchester Bay	1974	i	1999	99 Total Acres		Percent Change	Rate of Change	Percent of Study
ecocomplex	Frequency	Acres	Frequency	Acres			Acres/Yr	Aera
High marsh (HM)	4	0.88	8	3.63	+2.75	+312.5%	+0.11	0.16%
Intertidal marsh (IM)	10	7.04	38	4.65	-2.39	-33.9%	+.095	0.24%
Totals	14	7.92	46	8.28	+5.14	+4.5%	+0.2	0.2%

### Table 22.

Hutchinsen River	1974		1999	)	Total Acre	Percent Change	Rate of Change	Percent of Study	
ecocomplex	Frequency	Acres	Acres Frequency Acre		Change		Acres/Yr	Aera	
High marsh (HM)	20	106.07	16	131.71	25.64	+24.2%	+1.02	5.88%	
Intertidal marsh (IM)	13	51.18	41	28.20	-22.98	-44.9%	-0.92	1.46%	
Totals	33	157.25	57	159.91	2.66	+1.7%	+0.11	3.8%	

### Table 23.

Orchard	1974		1999	1999		Percent	Rate of Change	Percent of Study
Beach/	Frequency	Acres	Frequency	Acres	Acres		Acres/Yr	Aera
City Island	Trequency	710103	Frequency Acres				710103/11	71014
ecocomplex								
High marsh	21	50.66	24	71.14	20.48	+40.4%	+0.82	3.17%
(HM)								
Intertidal	37	76.85	39	51.24	-25.6	-33.3%	-1.02	2.66%
marsh (IM)								
Totals	58	127.51	63	122.38	-5.12	-4%	-0.2	2.91%

<sup>\*1974</sup> FC stats (11.31 acres) were added to 1974 HM. FC vegetative profile met HM floral characteristics for 1999

Figure 18. Bronx River apparent fill area.

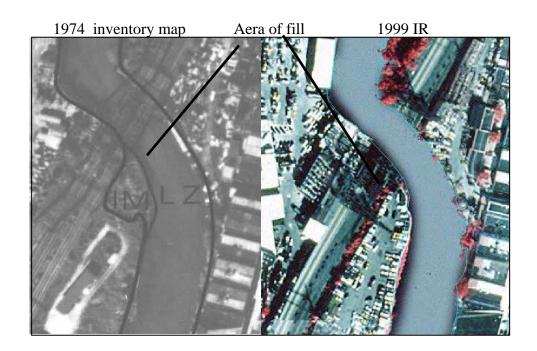


Figure 19. Bronx Ecocomplex trends 1974 - 1999

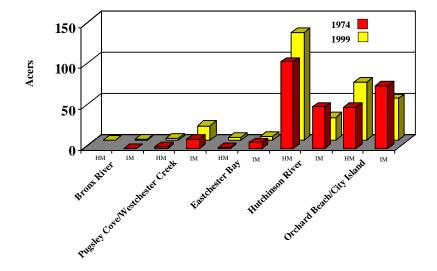
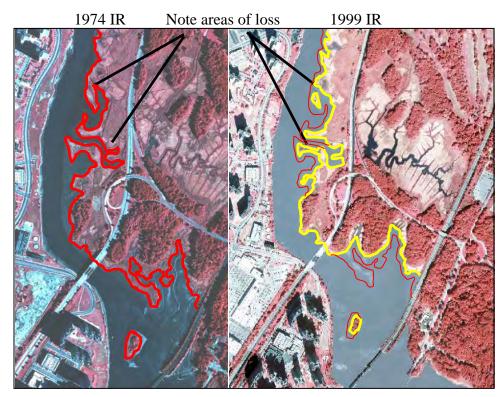
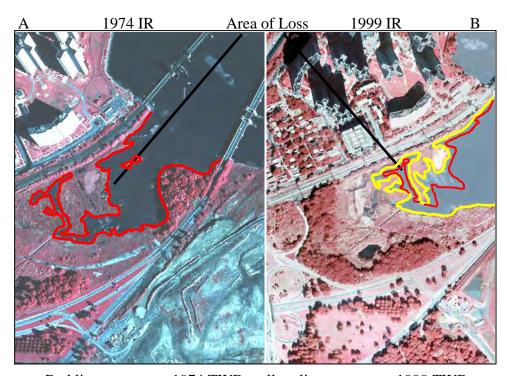


Figure 20. Perimeter loss along the Hutchinson River



Red line represents 1974 TWB; yellow line represents 1999 TWB

Figure 21. Ponding on the Hutchinson River



Red line represents 1974 TWB; yellow line represents 1999 TWB

Figure 22. Ground view of apparent Ponding area, Hutchinson River



Figure 23. Staten Island Ecocomplex Trends 1974 - 1999

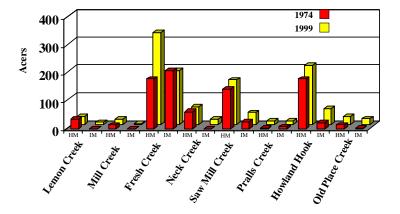
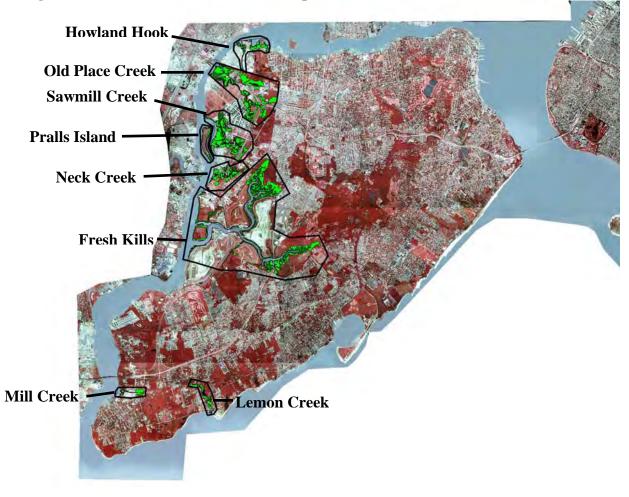


Table 24.

Staten Island	1974		199	999 Total Acre		Percent	Rate of	Percent of
Ecoregion Total vegetative profile	ve Frequency Acres Frequency Ac		Acres	Change	Change	Change Acres/Yr	Total	
High marsh (HM)	213	648.75	186	875.79	+227.04	+35%	+9.08	39.1%
Intertidal marsh (IM)	125	294.63	214	386.1	+91.47	+31%	+3.66	20.04%
Fresh marsh (FM 1974) (GV 1999)	1	0.82	6	0.85	+0.02	+3.7%	+0.15	2.13%
Totals	339	944.2	406	1262.74	+318.54	+33.7%	+12.74	30.02%

Figure 24. Staten Island Marsh Ecocomplexes



**Table 25**.

Lemon Creek Ecocomplex	1974	1974		9	Total Acre Change	Percent Change	Rate of Change	Percent of Total Study
Ecocomplex	Frequency	Acres	Frequency Acres				Acres/Yr	Area
High marsh (HM)*	7	35.74	19	28.1	-7.64	-21.4%	-0.3	1.25%
Intertidal marsh (IM)	5	1.27	12	7.77	+6.5	+511.8%	+0.26	0.4%
Fresh marsh (FM 1974) (GV 1999)	1	0.82	6	0.85	+0.03	+3.7%	0.0012	2.13%
Totals	13	37.83	37	36.72	-1.11	-2.9%	-0.12	0.87%

<sup>\*</sup>FC stats (7.19 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 26.

Mill Creek ecocomplex	1974		1999		Total Acre	Percent Change	Rate of Change	Percent of Total
ceocompien	Frequency	Acres	Frequency	Acres	Change		Acres/Yr	Study Area
High marsh (HM)*	3	15.3	8	18.64	+3.34	+21.8%	+0.13	0.83%
Intertidal marsh (IM)	1	2.31	8	3.23	+0.92	+39.8%	+0.03	0.17%
Totals	4	17.61	16	21.87	+4.26	+24.2%	+0.17	0.52%

<sup>\*</sup> FC stats (14.65 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

**Table 27** 

I WOIC #1									
Fresh Kills	1974		1999		Total Acre Change	Percent Change	Rate of Change	Percent of Total	
Ecocomplex	Frequency	Acres	Frequency	Acres	Change	Change	Acres/Yr	Study Area	
High marsh (HM)	127	180.38	38	330.92	+150.54	+83.5%	+6.02	14.78%	
Intertidal marsh (IM)	48	211.17	43	192.59	-18.58	-8.8%	-0.74	10%	
Totals	175	391.55	81	523.51	+131.96	+33.7%	+5.28	12.45%	

<sup>\*</sup>FC stats (2.8 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 28

Neck Creek	1974		1999		Total Acre	Percent Change	Rate Of	Percent of Total
Ecocomplex	Frequency	Acres	Frequency	Acres	Change	Change	Change Acres/Yr	Study Area
High marsh (HM)	4	63.37	11	62.26	+1.11	+1.8%	+0.04	2.78%
Intertidal marsh (IM)	3	1.67	23	18.29	+16.62	+995.2%	+0.66	0.95%
Totals	14	65.04	34	80.55	+15.51	+23.8%	+0.61	1.91%

<sup>\*</sup>FC stats (48.6 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 29

Saw Mill Creek	1974		1999		Total Acre	Percent Change	Rate of Change	Percent of Total
Ecocomplex	Frequency	Acres	Frequency	Acres	Change		Acres/Yr	Study Area
High marsh (HM)	30	144.3	30	161.07	+16.77	+11.6%	+0.67	7.19%
Intertidal marsh (IM)	25	27.05	36	42.43	+15.38	+56.9%	+0.61	2.2%
Totals	55	171.35	66	203.5	+32.15	+18.8%	+1.3	4.84%

<sup>\*</sup>FC stats (15.7 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 30

Pralls Island	1974		1999		Total Acre	Percent Change	Rate of Change	Percent of Total Study Area
Ecocomplex	Frequency	Acres	Frequency	Acres	Change		Acres/Yr	,
High marsh (HM)	6	4.3	4	11.57	+7.27	+169.1%	+0.29	0.52%
Intertidal marsh (IM)	4	9.35	3	11.36	+2.01	+21.5%	+0.08	0.59%
Totals	10	13.65	7	22.93	+9.28	+68%	+0.37	0.54%

Table 31

Old	1974		1999	1	Total Acre	Percent Change	Rate of Change	Percent of Total
PlaceCreek Ecocomplex	Frequency	Acres	Frequency	Acres	Change	Change	Acres/Yr	Study Area
High marsh (HM)	20	180.3	48	213	+32.7	18.1%	+1.31	9.51%
Intertidal marsh (IM)	16	23.92	29	55.82	+31.9	+133.4%	+1.28	2.9%
Totals	36	204.22	77	268.82	+64.6	31.6%	+2.6	6.39%

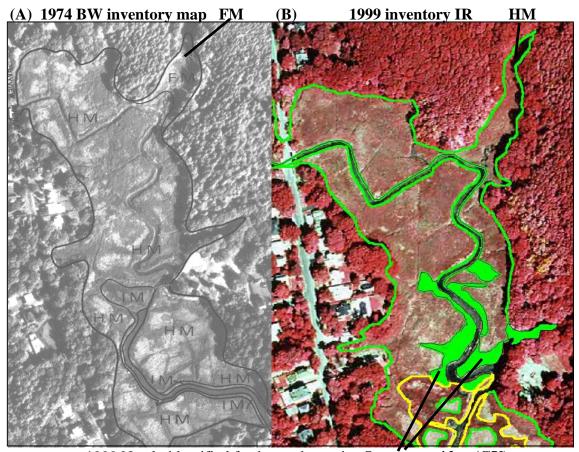
<sup>\*</sup>FC stats (92.25 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Table 32

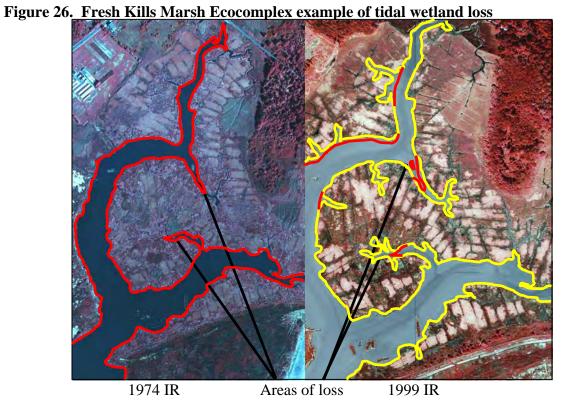
Howland	1974	ļ	1999	)	Total Acre	Percent Change	Rate of Change	Percent of Total
Hook Ecocomplex	Frequency	Acres	Frequency	Acres	Change		Acres/Yr	Study Area
Highmarsh (HM)	3	15.44	8	28.84	+13.4	+86.8%	+0.54	1.29%
Intertidal marsh (IM)	5	4.3	13	20.47	+16.17	+376%	+0.65	1.06%
Totals	8	19.74	21	49.31	+29.57	+149.8%	+1.18	1.17%

<sup>\*</sup>FC stats (1.28 acres) were added to 1974 HM; FC vegetative profile met HM floral characteristics

Figure 25. Lemon Creek, Staten Island. Area of vegetative shift from fresh marsh species to *Phragmites sp.* and newly identified fresh marsh species S. cynosuroides along creek edge.



1999 Newly identified fresh marsh species S. cynosuroides (GV)



Red line represents 1974 TWB; yellow line represents 1999 TWB

Table 33.

Lower Hudson	1974		1999	)	Total Acre Change	Percent Change	Rate of Change	Percent of Study Area	
Ecoregion	Frequency	Acres	Frequency	Acres	&		Acres/Yr.		
High marsh (HM)	7	104.88	7	225.11	+120.23	+114.8%	+4.8	10.05%	
Intertidal marsh (IM)	30	13.41	11	13.9	+0.49	+3.7%	+0.02	0.72%	
Fresh marsh (FM)	6	167	3	39.1	-127.9	-76.6%	-5.12	97.9%	
Totals	43	285.29	21	278.11	-7.18	-2.5%	-0.29	6.61%	

Table 34.

Piermont	1974		1999	9	Total Acre	Percent Change	Rate of Change	Percent of Study	
Ecocomplex	Frequency	Acres	Frequency	Acres	Change	Gillinge	Acres/Yr.	Area	
High marsh (HM)	7	104.88	7	223.49	+118.61	+113.1%	+4.74	9.98%	
Intertidal marsh (IM)	22	12.1	10	13.64	+1.54	+12.7%	+0.066	0.71%	
Fresh marsh (FM)	6	167	3	39.1	-127.9	-76.6%	-5.12	97.9%	
Totals	34	283.98	21	276.23	-7.75	-2.7%	-0.31	6.57%	

Includes Piermont marsh and peninsula

Figure 27. Lower Hudson River Ecoregion, Piermont ecocomplex

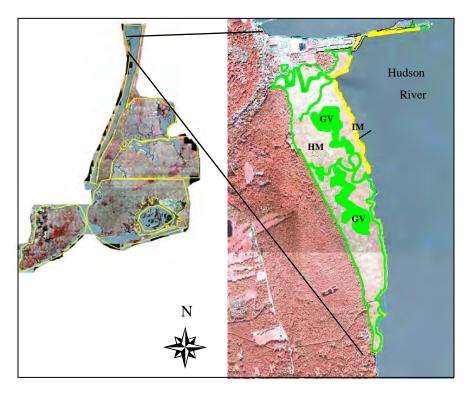
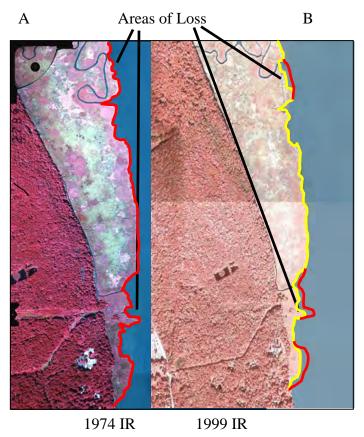


Figure 28. Piermont Marsh Perimeter Loss



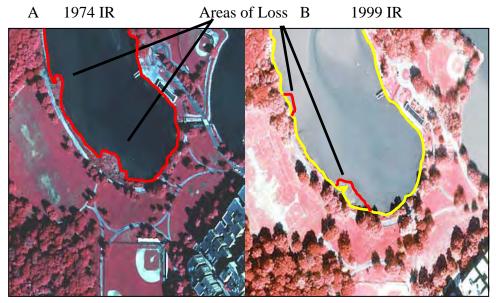
Red line represents 1974 TWB; yellow line represents 1999 TWB

## **Manhattan Ecoregion**

Table 35.

Manhattan ecocomplex	19′	74	19	999	Total Acre Change	Percent Change	Percent of Study Area
	Count	Acres	Count	Acres	Change		
High Marsh HM	0	0	1	0.61	+0.61		0.02%
Intertidal marsh (IM)	1	0.33	7	0.25	+0.43	+30.3%	0.01%

Figure 29. Manhattan (Inwood Hill Park) tidal wetland loss



Red line represents 1974 TWB; yellow line represents 1999 TWB

Figure 30. Mussel Berms and resultant ponding in Jamaica Bay marsh,



Figure 31. Marsh island loss apparently caused by mussel berms, pond coalescence, peat collapse and eventual fragmentation.



Figure 32. Sea lettuce *Ulva sp.* trapped within mussel berm.



Figure 33. Runway extension at John F. Kennedy airport, Queens

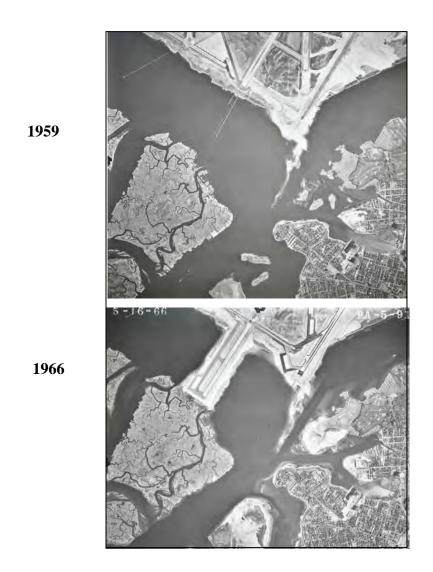
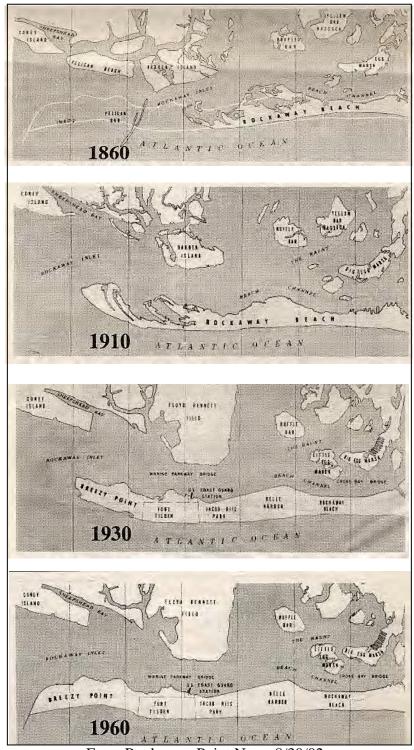


Figure 34. Rockaway peninsula westward migration.



From Rockaway Point News 8/30/02

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## **CD** Contents

The attached CDs contain digital data regarding the trends analysis of the New York metropolitan area and the lower Hudson River from 1974 - 1999. The data can be found on two CDs. CD1 contains ArcView shape files, a 60:1 mosaic infrared aerial photographic map, ArcExplorer (ae2setup.exe file) and an Arc Explorer users manual (arcexplorer.pdf). ArcExplorer is an Environmental Systems Research Institute Inc. (ESRI) freeware software package that allows the sharing of geographic data throughout organizations and elsewhere. Both shapefiles and images can be shared, viewed and data manipulated within this included software. The shapefiles and the image can also be viewed in ArcView 3.x; ArcGIS and other non ESRI products that accept ESRI file formats. Also included on the CDs are the metadata files. Metadata is data about the data.

CD2 contains 244 aerial oblique and ground photos taken during the QA/QC process. The photos are included to help the user assess the character and quality of the subject tidal wetland and give the user a different perspective of the area. A number in the polyn 1 column identifies that polygon with an associated photo. The polyn 1 column only appears in the 1999 shapefile database. The photos are in \*.jpg format and can best be viewed in a photo-processing software such as Adobe Photoshop. They can also be viewed in a web browser, although some photos are multi-photo composites and need to be magnified to view each photo effectively. Any questions, Contact: Fred Mushacke, NYSDEC, voice: (631) 444-0465, e-mail: fmmushac@gw.dec.state.ny.us.