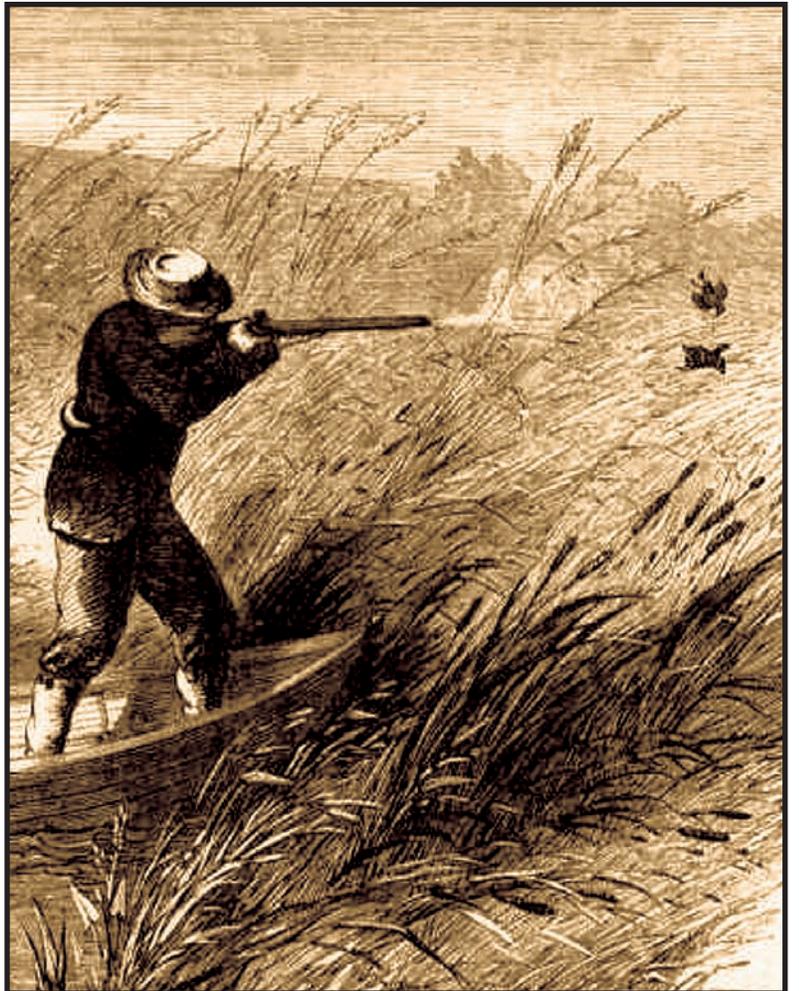


II. Human Use History



Detail from *Our Vanishing Game Birds* (see next page).

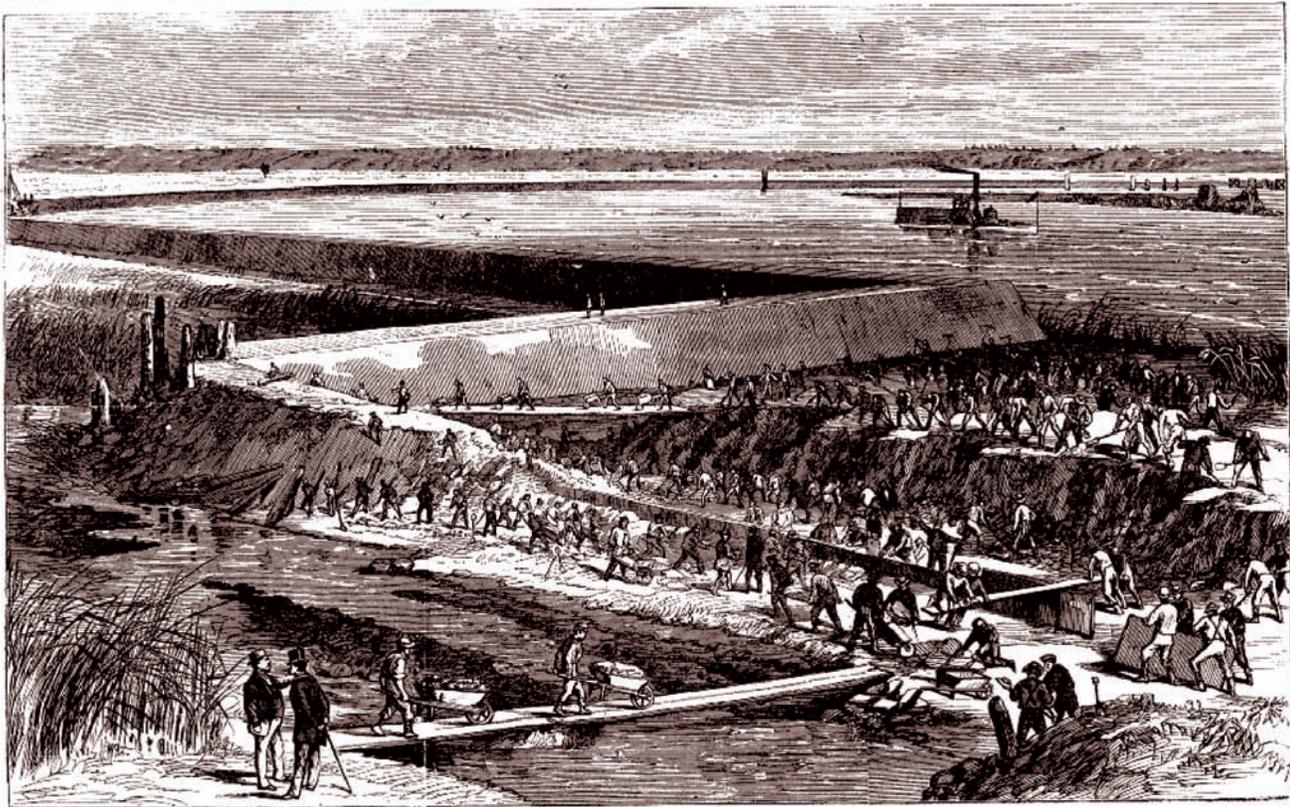
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DIKING AND DRAINING THE NEW JERSEY MEADOWS.



OUR VANISHING GAME-BIRDS.—SHOOTING RAIL ON THE HACKENSACK MEADOWS, NEW JERSEY.—SEE PAGE 56.

Titled *Our Vanishing Game Birds—Shooting Rail on the Hackensack Meadows, New Jersey*, this illustration highlights one problem of over-hunting recognized more than a hundred years ago (Frank Leslie's Monthly, 1885).

Five species of rail still occur in the Meadowlands but remain at risk from contamination and habitat loss.

II. Human Use History

These lithographs (left/below) and accompanying captions (*Scientific American*, 1868; *Frank Leslie's Monthly*, 1885) illustrate how failure to understand the ecological value of wetlands has contributed to human destruction and exploitation of crucial natural resources. The article in *Scientific American* features the labors of the Iron Dike & Land Reclamation Company, founded by Samuel N. Pike, a real estate developer and distiller who had just completed building New York's Grand Opera House. Pike made use of inventor Spencer B. Driggs' designs for "driving iron plates into the soil and joining them end to end, thus presenting an unbroken and impenetrable

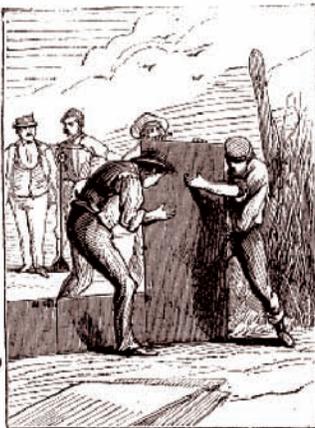
iron wall, which may be extended to any required length, and the durability of which is unquestionable." For some reason, however, the land thus reclaimed grew lush stalks but not a single ear of corn.

Unfortunately, this and other lessons we should have learned were lost on several generations of Americans, who continued to dike, drain, ditch, fill, and otherwise misuse the Meadowlands ecosystem. It was not until a century later that we began to see wetlands as intrinsically valuable for humans as well as fish and wildlife. The many years of abuse have exacted a significant toll. Restoration will take considerable resources,

years of planning, and decades of hard work to return the Meadowlands to a cleaner, more natural ecosystem that sustains diverse communities of healthy, native species.

History is a great teacher. As the coastal population in the United States continues to grow, the Meadowlands, perhaps more than any other urban area, is a harbinger of the Nation's environmental problems. We must learn from the history of the Meadowlands to address its many challenges; more importantly, we must share our solutions to the Meadowlands' problems to improve the future for fish, wildlife, and people everywhere.

DIKING AND DRAINING THE NEW JERSEY MEADOWS.



SETTING A PLATE.

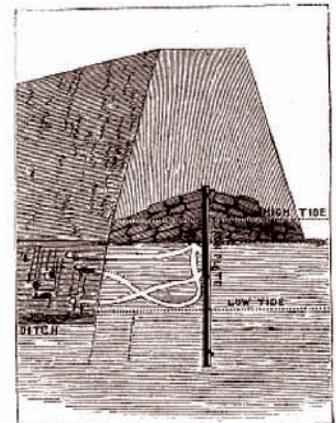
Diking and Draining Salt Marshes.

The draining of swamp lands is not a new idea. Such lands are not only unproductive of anything which can subserve any important purpose, but they are productive of numerous evils. Teeming with miasms, the home of mischievous and annoying insects they are blotches upon the otherwise fair face of nature. To render them fruitful, and productive of good rather than evil, is a problem for which a solution has been anxiously sought, but heretofore only partially obtained. No system applicable to all cases has been discovered, and only three methods have been adopted in the past to any great extent; viz., the slow process of pumping, ditching, and the erection of dikes or levees. These methods are not only expensive at the outset, but inefficient and costly to maintain. The dikes of Holland are embankments made with heavy timbers and filled with stone, the surfaces being covered with bundles of flags and reeds fastened down by stakes. Also piles are driven into



RAISING.

the sand and protected by planking, as well as by earth, turf and stones. In some places wicker work is used to cover and protect slopes, and the willow is cultivated extensively to supply the material for this purpose. In places of great exposure, walls of masonry with piles driven upon the side towards the sea, are used to protect the embankments from the action of the waves



SECTION OF EMBANKMENT.

The fens of Lincolnshire and the Bedford level are examples of the reclaiming of worthless and unproductive swamp lands and transmitting them into fertile and productive fields.

These works are, however, not the results of private enterprise. In order to complete them, it was necessary to seek and obtain governmental aid.

An annual expense of \$30,000 each is required to keep the dikes of Helder and West Cappel, at the western extremity of the island of Walcheren, in repair. The annual expenditure in Holland for maintaining its dikes and

the regulation of its water level is from two to two and one half millions dollars. Watchmen to patrol the dikes and to give the alarm when danger threatens, and engineers to apply the proper means in cases of emergency, are constantly employed.

As we have said, these measures are only partially successful. Water percolates through such artificial embankments.

II. HUMAN USE HISTORY

A. NATIVE AMERICAN HISTORY AND SETTLEMENT

B. EUROPEAN IMMIGRATION, SETTLEMENT, AND RESOURCE EXTRACTION

C. EARLY LANDSCAPE MODIFICATION

D. LARGE-SCALE ENVIRONMENTAL MODIFICATION

E. ENVIRONMENTAL DEGRADATION

F. LAND-USE PLANNING (Late 1960s to Present)

G. DEVELOPMENT AND ENVIRONMENTAL ALTERATION (1970s to Present)

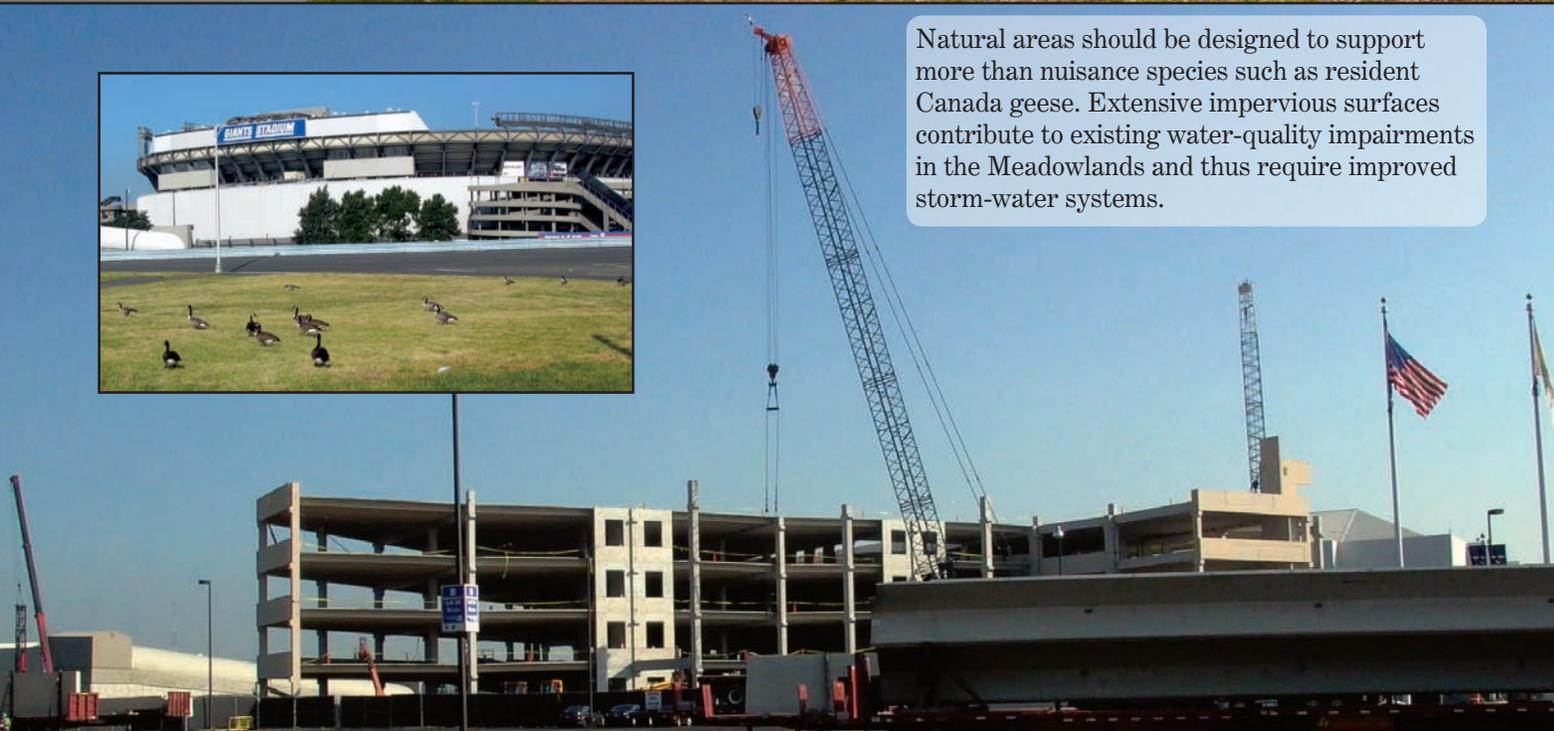
H. STEWARDSHIP AND FUTURE PLANNING

I. SUMMARY

Future redevelopment projects must better address the ecosystem functions of wetlands and the needs of fish, wildlife, and people. Development projects in the Hackensack Meadowlands must be set back from wetlands and waterbodies by vegetated buffers to provide fish and wildlife habitat.



Natural areas should be designed to support more than nuisance species such as resident Canada geese. Extensive impervious surfaces contribute to existing water-quality impairments in the Meadowlands and thus require improved storm-water systems.



II. HUMAN USE HISTORY

The history of human use of the Meadowlands is similar to that of many areas in the United States and the world. Human use history in the Meadowlands begins with a small population of indigenous people living off the land, shifts imperceptibly during initial European settlement, changes more radically as more of the ecosystem's natural resources are extracted or modified by the growing colonial population, then plunges into a period of wholesale modification of an environment that increasingly cannot support the human population (Marshall, 2004). The history of human use becomes an embarrassment as the environment is degraded with refuse and industrial waste from the sprawling human population. Neglect and degradation of the environment continues until enough citizens and public officials recognize that the environment that previously supported the human population in so many ways will likely fail to support a desirable quality of life without direct intervention to remediate and restore the land.

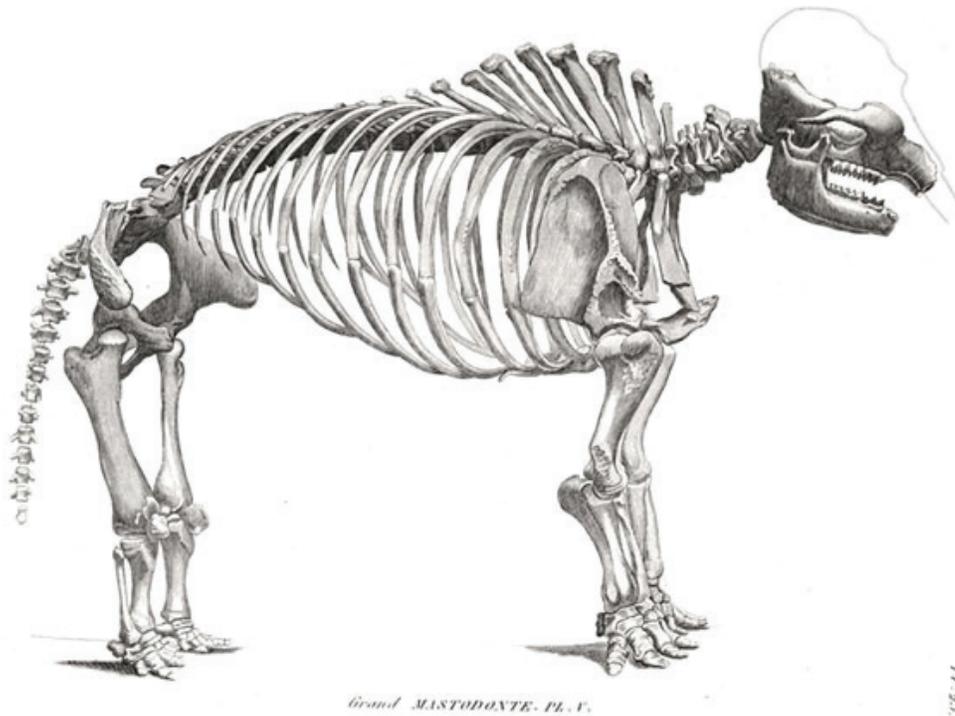
This history of human use in the Meadowlands mandates the purpose for preliminary conservation planning and hence this document: making the Meadowlands a better place for fish, wildlife, and people. History is a great teacher. We must learn from the history of land use in the Meadowlands and share it, not only to prevent past mistakes from being repeated, but to improve the quality of life for future generations.

A. NATIVE AMERICAN HISTORY AND SETTLEMENT

Artifact trails provide evidence that humans first migrated into the northeastern United States along the Allegheny and Ohio valleys, the Susquehanna and Delaware valleys, and the Hudson valley (Kraft, 2001). Radiocarbon dating of archaeological sites in the Delaware and Hudson valleys in Pennsylvania and New York indicates that occupancy of the northeastern United States probably began between 12,580 and 10,190 years ago (Kraft, 1986). Early immigrants undoubtedly consisted of small, nomadic bands of hunter-gatherers that occupied areas seasonally to take advantage of different resources. Just when and where humans first arrived in the HRW is unknown.

At the time of early occupancy by indigenous peoples, the flora and fauna of the HRW were much different from what they are today. The present Meadowlands area was dominated by species of far northern forests and extensively covered with black ash (*Fraxinus nigra*), alder (*Alnus* sp.), tamarack (*Larix laricina*), and black spruce (*Picea mariana*); the animal fauna likely included American mastodon (*Mammuth americanus*, Figure 7), mammoth (*Elephas primigenius*), stag moose (also known as moose-elk, *Cervalces scotti*), caribou (*Rangifer tarandus*), and giant beaver (*Castoroides ohioensis*), which have been reported from other sites in the region (Parris, 1983; Laub *et al.*, 1996; Speiss *et al.*, 1998). Most of those species became extinct over 10,000 years ago, but the cause(s) of the extinctions of those animals (*e.g.*, climate change, human hunting) is much debated (Martin and Wright, 1967; Dunn, 1990). Historical information and other data (*e.g.*, soot layers) suggest that fire became a regular part of the landscape once these early human occupants arrived, and may have been used as a tool in hunting certain animals (Delcourt and Delcourt, 1988; MacCleery, 2004).

Figure 7. Living in the Hackensack Meadowlands during prehistoric times. American mastodon (upper diagram) lived in the Hackensack Meadowlands when humans first immigrated into the region. The diagram below was made of one of the first American mastodon (*Mammot americanus*) skeletons that was ever excavated in North America. The specimen was excavated from the Hudson valley by Charles Willson Peale with the support of Thomas Jefferson (Academy of Natural Sciences in Philadelphia, 2004) and is now on display in Germany. A specimen excavated from the Hackensack Meadowlands is being prepared for display at the Bergen Museum of Art and Science. A fishing-net sinker and a projectile point crafted by native people who inhabited the Meadowlands are shown in the lower photos (artifacts from the Bergen Museum of Art and Science).



By approximately 1,000 A.D., at least three independent cultural-linguistic groups (recognized now as the Munsee, Unalachtigo, and Unami) were established in *Lenapehoking*, the land of the Lenape, an area encompassing present-day New Jersey and portions of nearby states (Kraft, 2001). About that time (the late Woodland period, from 1,000-1,600 A.D.), agriculture (*e.g.*, corn, beans, tobacco) had contributed to establishment of native settlements in the northeastern United States (Hart and Scarry, 1999; Kraft, 2001). Diverse pottery, sometimes decorated, and more sophisticated hunting and fishing implements (stone projectile points and weighted fishing nets) also had appeared (Stewart, 1998; Kraft, 2001; Figure 7). Except for a few year-round settlements, the landscape was little affected or modified by the native groups living in the region.

B. EUROPEAN IMMIGRATION, SETTLEMENT, AND RESOURCE EXTRACTION

In 1524, the Florentine navigator Giovanni da Verrazano and the crew of the French caravel *Dauphine* became the first Europeans to visit Lenapehoking. The area characterized what is presently referred to as true wilderness, indigenous people living in a subsistence mode on the landscape, with large predators and other wildlife. Through the early 1600s, relatively little contact occurred between the native tribes and European explorers in Lenapehoking. By this time, a number of distinct Lenape groups were established, including groups identified as the Carnasees, Esopus, Navasinks, Raritans, Tappans, Kitchtaewanks, Warranawankongs, Wiechquaeskecks, and Hackensacks (Kraft, 1986). These tribes interacted variously with the European groups they encountered, benefiting in some ways (*e.g.*, commerce, especially fur trading) and not in others (*e.g.*, alcohol, infectious diseases). Differences in marriage and family responsibilities, spiritual beliefs, and governance contributed to barriers between native and European cultures. European concepts of land ownership and stewardship also differed from those of native cultures; conflicts continually arose among native and European groups, especially the Dutch who taxed and continually displaced native tribes (Kraft, 1986). Some colonial leaders (*e.g.*, William Penn, Philip Carteret) and Quaker and Presbyterian missionaries treated native groups well, but other colonial leaders' hatred for native peoples was widely recognized (Kraft, 2001).

On February 25, 1643, after several years of increasingly frequent hostilities, more than 80 Hackensack men, women, and children were killed by Dutch settlers (*i.e.*, the Pavonia massacre) under the command of Willem Kieft. On that same night, 40 other natives also were massacred by the Dutch on Manhattan (Corlear's Hook); additional captives from that and subsequent skirmishes were often sold into slavery. Native groups fought back but were generally not well-armed and suffered considerable losses. Over the next hundred years, native peoples increasingly suffered both from armed conflicts and diseases, especially smallpox, which may have killed as many as 90 percent of some native groups during numerous epidemics (*e.g.*, 1654, 1663, 1677, 1688, 1694) originating in European settlements (Kraft, 2001). Census data from 1726 and 1745 clearly reveal the decline in the native population throughout the region. Two regional treaties (Crosswicks and Easton in 1758) eventually ended the hostilities and formalized relocation of native groups (Kraft, 2001). By 1798, all Lenape bands in the region had been relocated to Brotherton, an American Indian reservation established in southern New Jersey (presently Indian Mills, Burlington County), or forced westward to Pennsylvania, and areas now

known as Ohio and Oklahoma (Kraft, 2001). After the presence of indigenous people was erased, settlers increased their focus on resource extraction and exploitation of the Meadowlands.

From 1650 to 1800, the Hackensack region had relatively few European inhabitants, with most settlers scattered among a few towns (*e.g.*, Bergen, Hobuc) or large farms (*e.g.*, John Berry's plantation). Some changes to the natural landscape in the region began with those European settlements, as the region's Dutch and other settlers extensively harvested the region's resources (*e.g.*, timber, game) and burned off the forests and marshes regularly in spring or fall. In the 1700s, salt marshes were considered valuable property, and local laws (74 different statutes from 1697-1783; Quinn, 1997) were established to protect and maintain marshes for salt hay (*Spartina patens*) harvest. Dutch settlers are believed the first to attempt to drain low marsh areas to improve their use for agriculture, as salt hay had many uses in addition to winter fodder for livestock (*e.g.*, roof thatching, improving traction on winter roads, and packing material for produce, glass, and paper). Maps from the mid-to-late 1700s (*e.g.*, Figure 8) show a few communities connected by several roads, some of which clearly traverse the Meadowlands from east to west or north to south. Through the late 1700s, the area's natural character was little impacted by human use of the landscape; however, by the end of that century, most of the Atlantic white-cedar (*Chamaecyparis thyoides*) and other forests had been harvested of their old-growth trees. In addition, marshes and remaining woodland areas were being regularly burned to clear land for various purposes (*e.g.*, agriculture, livestock) to accommodate the growing population.

C. EARLY LANDSCAPE MODIFICATION

In the 1800s, the steadily increasing scale of human activities (*e.g.*, wetlands "reclamation" and major transportation efforts) clearly began to result in substantial changes to the Meadowlands. In 1816, John, Robert, and Samuel Swartout began diking and ditching marshes, eventually "reclaiming" 1,300 acres for growing grains, vegetables, hemp (*Cannabis* spp.), and flax (*Linum* spp.), and supporting a herd of 80 to 90 dairy cattle (*Bos taurus*). Though a major storm in 1820 that breached their dikes and flooded the area ended that business venture, maps in the mid 1800s show an expanding network of roadways and railroads replacing some of the early roadways. In the late 1860s, Spencer Driggs and Samuel Pike installed a canal and levee system to convert 5,000 acres of wetlands into farmland. This was the largest agriculture project ever enacted in the Meadowlands; however, the levee system never worked as anticipated and no crops were ever harvested. Despite these difficulties, the human population in the region continued to grow steadily, as indicated by the growing number of towns, roadways, and railroads in late 19th-century maps (Figure 9). The harvest of the area's Atlantic white-cedar and other forests also continued, with less than six percent of the Meadowlands remaining as forest in the 1890s (Vermeule, 1897). With increasing use and occupation of the Meadowlands came increasing concern about the abundance of mosquitoes.

Figure 8. An early map of New Jersey. In this 1795 map, colonists from Europe have established few settlements in the region, yet roads connecting those communities already cross the Meadowlands.



New Jersey 1795
mapmaker.rutgers.edu

D. LARGE-SCALE ENVIRONMENTAL MODIFICATION

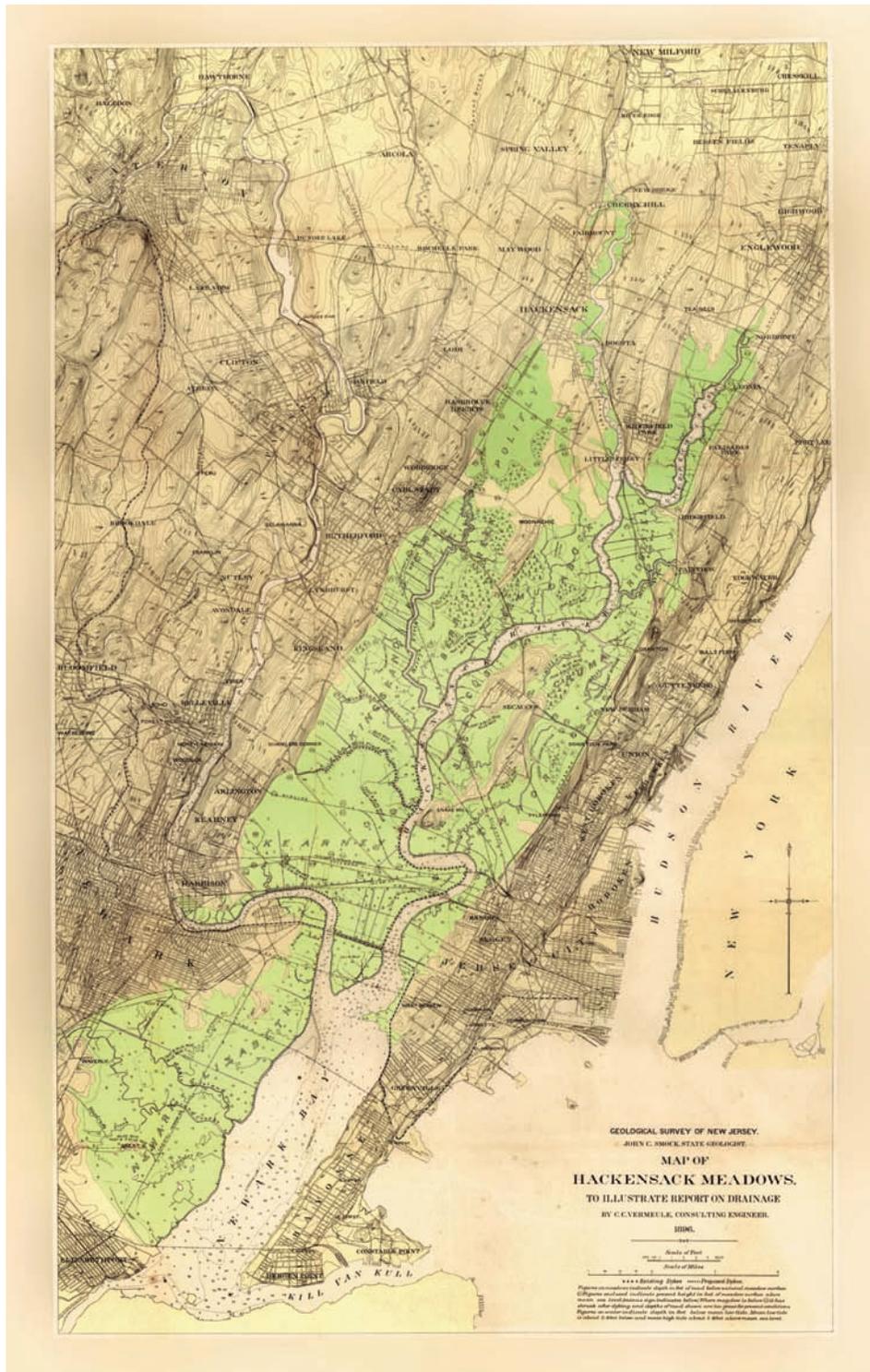
Railroads began to traverse the Meadowlands in the 1830s; this required extensive ditching, diking and filling of wetlands, and also made substantial use of available timber resources (*i.e.*, mostly Atlantic white-cedar). Logs were driven into the Meadowlands' deep muds (deposits 30 feet thick in some places, Figure 9) to support the rail bed. The Meadowlands' hydrology or ecology was not considered in locating these railways, and creek basins within the Meadowlands were increasingly fragmented and isolated by railway and roadway construction (Figure 9). The ditching and diking of marshes, initially begun for agriculture and farming and later for mosquito control (discussed below), made travel across the Meadowlands more pleasant and served to increase demand for rail service, which fueled further regional population growth and industrialization.

Quinn (1997) labeled mosquitoes “the single most important force in the historical coevolution of European humankind and the Meadowlands.” In the 1860s, ditching and diking of the Meadowlands to “control” mosquitoes and to make the “land” more suitable for development became important activities. Kearny, Kingsland, and Berry's Creek marshes on the western side of the Hackensack and Ridgefield and Cromakill marshes along Bellman's and Cromakill Creeks on the eastern side of the Hackensack River were all ditched extensively by hand over the next 30 years. Diking of the lower Hackensack along Kearny and Kingsland marshes was also accomplished entirely by hand in this period (Figure 9).

Shortly after the turn of the century, ditching of the Meadowlands became increasingly mechanized with the development of the Eaton plow, which had separate power plant and ditching equipment, and the later Reilly ditching plow, which was essentially a small tractor (Quinn, 1997). Various mosquito extermination organizations, created by the New Jersey General Health Act in 1904, began extensive marsh-ditching and draining activities. The New Jersey Agricultural Experiment Station joined in the efforts in 1906. By 1924, the Bergen County Mosquito Commission alone is reported to have had one million feet of drainage ditches through salt marshes and over 500,000 feet of upland ditches. The New Jersey Agricultural Experiment Station developed a “swamp tractor” that increased the efficiency of ditching (reducing the cost in 1930 to less than one cent per foot) and shredded the excavated marsh material prior to broadcasting it over the surface of the marsh (Quinn, 1997). By 1945, most salt marsh along the Hackensack River and Newark Bay had been ditched and diked. Common reed became well established in the northern sections of the Meadowlands; bundles and layers of reed were incorporated into dikes throughout the Meadowlands to make them stronger (Headlee, 1945). By 1950, more than 17,000 acres of marshes were ditched and diked for mosquito control in the Meadowlands alone (Quinn, 1997).

About the time of increased mechanized ditching, providing sufficient water supplies for the growing human population became a concern. In 1905, Woodcliff Lake was formed by an earthfill dam on Pascack Brook just north of Hillsdale in Bergen County. In 1907, the New Jersey Water Supply Commission became the first State agency authorized to conduct planning, construction, and operation of surface water projects. The following year, the Commission completed studies for four reservoirs on the upper Passaic River. In 1916, the State established the North Jersey District Water Supply Commission to develop and regulate the public water

Figure 9. The Geological Survey of New Jersey's 1896 Map of the Hackensack Meadows. This map identifies then-existing stands of Atlantic white-cedar and other woody vegetation, the types (peats, blue muds) and thicknesses of sedimentary deposits, natural creeks, dikes, and man-made ditches. Some wetlands are already fragmented extensively by roads and railroads.



supply in twelve counties: Sussex, Warren, Hunterdon, Morris, Passaic, Somerset, Middlesex, Union, Essex, Hudson, Bergen, and Monmouth. In 1922, a hollow concrete dam was constructed on the Hackensack River at Oradell to create a much larger reservoir. It is unclear if construction of this dam was a component of the State-wide plan to divert and store surface waters in reservoirs; however, this dam and reservoir were to have major adverse effects on upstream and downstream areas, including the Meadowlands, which changed from a tidal palustrine to a predominantly estuarine ecosystem (see Section IV.A).

As growth and sprawl of the region's human population increased the demand for municipal water supplies, additional large reservoirs were constructed in upper portions of the HRW. DeForest Lake, currently the largest reservoir in the HRW, was formed after construction of an earthfill dam in 1956 on the main stem of the upper Hackensack River north of West Nyack in Rockland County, New York. Lake Tappan formed after construction of another earthfill dam in 1966 on the main stem of the river north of Old Tappan in Bergen County, New Jersey. The Woodcliff Lake dam was modified in 1984 to increase that reservoir's capacity. Within a few years, the total storage capacity of these reservoirs (13.9 billion gals) was insufficient to provide the water supply for the region, and additional hydrologic alterations were made to supply the region with additional water (see Sections II.G and III.D).

E. ENVIRONMENTAL DEGRADATION

Early in the 20th Century, Meadowlands communities became steadily industrialized, and pollution began to limit recreational and other opportunities on the Hackensack River. By 1900, sewage and pollution already had begun to affect recreation throughout the Hackensack Meadowlands (Iannuzzi *et al.*, 2002). Continued widespread abuse of waters and wetlands throughout the New York harbor area eventually fostered the public perception that the wetlands needed reclaiming (Quinn, 1997). Thus, several large-scale plans were proposed for the Meadowlands and other port areas around New York Harbor. Early plans for the Meadowlands during the mid-1920s included two canals: one connecting the Hackensack River near New Milford to the Hudson River near Piermont, New York, and a second connecting the Hackensack River near Hackensack straight to Newark Bay (Quinn, 1997). The proposed canals were never built. By the mid-1920s, the Hackensack River had become so polluted that several local boards of health had prohibited bathing in the river (Robichaud and Buell, 1973).

Following the establishment of the Meadowlands Reclamation Commission by the New Jersey State Legislature, other plans in the region materialized and contributed to the continuing destruction of the Meadowlands. Several roads (*e.g.*, Lincoln Highway, realigned later as U.S. Rt. 1) soon traversed the Meadowlands in the 1920s (Patrick and Wilson, 2002). The Newark marshes on the west side of Newark Bay and the most southerly portion of the Meadowlands were filled with more than 6 feet of sand pumped out of Newark Bay to establish land for a Newark airport in 1928. Featuring the world's first hard-surface landing strip (*i.e.*, asphalt) at any commercial airport, the Newark Airport quickly became the busiest airport in the world. This success directly resulted in the construction of the Pulaski Skyway connecting Newark to Jersey City in 1932, and led to further wetland filling in the Meadowlands for transportation and

other commercial projects. In the 1930s large tracts of these drained salt marshes were already being overrun by common reed and other invasive species.

Some of these projects were components of various land-use plans for the Meadowlands; however, not all projects or plans were successfully completed. For example, Charles Dyer Norton, together with other influential businessmen, formed the Committee on the Regional Plan in 1922. Incorporating under the name Regional Plan Association (RPA) in 1929, this group developed the nation's first comprehensive, long-range metropolitan plan, the *Regional Plan for New York and Its Environs*. The RPA's first *Regional Plan* proposed filling a "vast 41-acre waste of mosquito-infested New Jersey swampland" with 200 million cubic yards of dirt, dredging and straightening the Hackensack River, and building a city larger than New York was at the time (Popular Science Monthly, 1928). The proposed city would be complete with skyscrapers, seaplane ports, residential neighborhoods, and parks (Figure 10). Despite the influence of the RPA through Frederick Delano (President Franklin D. Roosevelt's uncle and RPA President) and others (e.g., master builders Austin Tobin [then Director of the Port Authority of NY-NJ] and Robert Moses [creator of the Triborough Bridge and Tunnel Authority]), the arrival of the Great Depression undoubtedly terminated the proposed plan for the Meadowlands. As a result, area-wide planning was not a significant component of many projects and activities that soon proliferated in the Meadowlands.

In addition to the draining and diking, vast expanses of land began to be used as dumping grounds for municipal and industrial waste. Landfill dumping began with the intention of turning "unproductive swampland" into tracts of developable land. Land bought or leased from local governments was excavated. Garbage was then dumped into the low areas, sometimes burned at the end of each day to save space, and periodically covered with soil. There were no environmental regulations concerning any aspect of this disposal method. Occasionally, mint-fragrant deodorizers were sprayed over the dumps when the odor became unbearable, though fire was more often employed to eliminate malodorous materials not consumed by invasive scavengers (e.g., Norway rat [*Rattus norvegicus*], German cockroach [*Blattella germanica*]). Dumping in Meadowlands landfills rapidly developed into several commercial enterprises (e.g., trucking, landfill disposal) in the 1940s, and even included disposal of building rubble from London, England that was used as ship ballast during World War II (Sullivan, 1998).

Following World War II, the State of New Jersey recognized that roads in the region were inadequate to accommodate the tremendous increase in traffic volume that had occurred, especially in the corridor between New York and Philadelphia. To address this problem, the New Jersey Turnpike Authority was created by the State legislature in 1948; construction of the New Jersey Turnpike (NJT) from the Delaware Memorial Bridge to the George Washington Bridge began in 1949. The final leg of the initial six-lane roadway, the eastern spur through the Meadowlands, was completed in January 1952. The NJT was one of the first "modern" highways, employing design criteria (e.g., lane width, 3 percent maximum grades, acceleration and deceleration lanes, minimum shoulder widths) that are still used today. While these criteria provided for safety and a high rate of speed, the NJT and similar highways occupy more area with a more extensive "ecological" footprint than other roadways in the United States (Forman and Alexander, 1998). Although the roadway was projected to accommodate increased traffic volume until the mid-1970s, the NJT was widened in 1955 (a third, and for some segments, a

Figure 10. A “Magic City from a Swamp,” which appeared in the October 1928 issue of *Popular Science Monthly*. Note the projects (e.g., waterways, parks) that would have required extensive dredging and filling activities to achieve this vision of the Meadowlands.

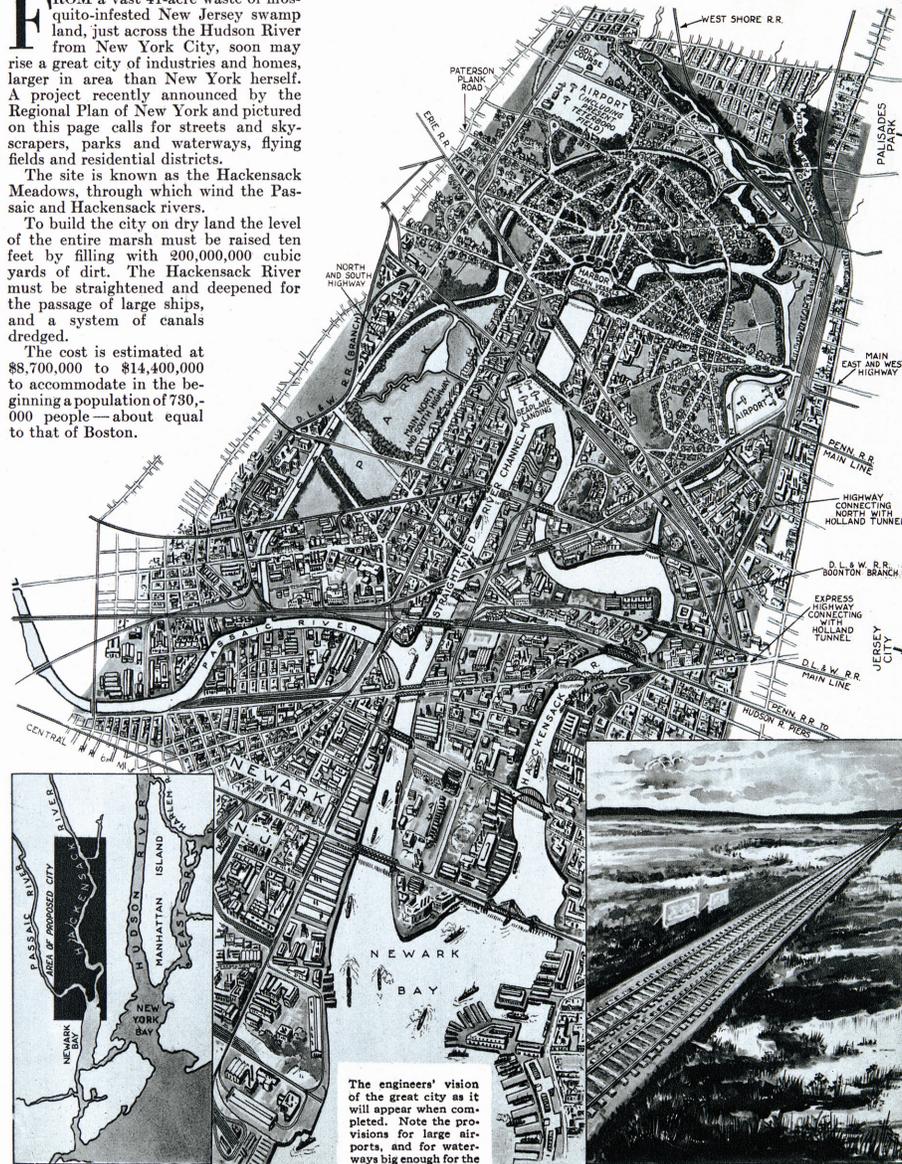
A Magic City from a Swamp

FROM a vast 41-acre waste of mosquito-infested New Jersey swamp land, just across the Hudson River from New York City, soon may rise a great city of industries and homes, larger in area than New York herself. A project recently announced by the Regional Plan of New York and pictured on this page calls for streets and skyscrapers, parks and waterways, flying fields and residential districts.

The site is known as the Hackensack Meadows, through which wind the Passaic and Hackensack rivers.

To build the city on dry land the level of the entire marsh must be raised ten feet by filling with 200,000,000 cubic yards of dirt. The Hackensack River must be straightened and deepened for the passage of large ships, and a system of canals dredged.

The cost is estimated at \$8,700,000 to \$14,400,000 to accommodate in the beginning a population of 730,000 people—about equal to that of Boston.



The black area on the small map indicates proposed site of the new city of the Hackensack Meadows.

The engineers' vision of the great city as it will appear when completed. Note the provisions for large airports, and for waterways big enough for the accommodation of the largest of ocean vessels and seaplanes.

The New Jersey marshes as they appear today. Ten feet of fill will soon turn them into dry land.

fourth lane was added each way) and again in 1966 (six lanes each way throughout). Eventually, a western spur was completed in 1971 that bisected the Meadowlands. Though the NJT's western spur was noted to have some positive impacts on certain fauna for several years following the roadway's construction (e.g., ducks, muskrat [*Ondatra zibethicus*]; Hackensack Meadowlands Development Commission, 1975), more recent studies indicate profound changes (e.g., reduced hydrologic flow) in the wetlands that were cut off from the Hackensack River by the NJT's western spur (Tiner *et al.*, 2005).

Dumping continued virtually uncontrolled throughout the 1950s and most of the 1960s, and turned the Meadowlands into the world's largest landfill at the time (Sullivan, 1998). The amount of garbage that was dumped in the Meadowlands each day, about 10,000 tons, would fill an average-sized football stadium. As they filled with household garbage, most dumps were molded slowly into large hills. Many garbage hills were burned regularly to save space or control wind-strewn debris; others burned accidentally. Methane gas from the decaying refuse and other flammable debris fueled the fires, some of which burned uncontrollably for years (e.g., the Giant stadium-site fire). During the height of the dumping in the 1960s, the Meadowlands received 40 percent of the State of New Jersey's solid waste stream and another 10,000 tons per day from New York City. More than 200 dumps occupied approximately 2,500 acres within the Meadowlands. The garbage and other waste discarded at these sites increasingly degraded ecological processes in the Meadowlands. The air was filled with smoke, the stench of decay, and millions of cubic feet of landfill methane. Landfill leachates and other toxic materials poured into the Hackensack River and its tributaries, combined with heated effluents from power plants and industrial discharges, and made extensive anoxic zones and widespread fish kills a recurring event. At the same time, the landfills' growing hills increasingly dominated the landscape.

F. LAND-USE PLANNING (Late 1960s to Present)

By the late 1960s, many recognized that environmental degradation in the Meadowlands was impacting the quality of human life and compromising the region's ecology and economy; however, residents of the Meadowlands' diverse communities differed as to their preferred solutions. Under increasing political pressure to act, the State legislature created the HMDC in 1969 with three mandates in its governance of the newly designated HMD: manage solid waste, provide for economic development, and protect the environment. Through regional land-use planning, zoning authority, and revenue sharing, the HMDC moved to address the garbage problem. The HMDC took numerous steps to close illegal dumps, prohibit most dumping of out-of-state waste, and more tightly regulate other dumping. Eventually, the HMDC formulated plans to close most dumps and address their diverse impacts to the land, water, and air. Most dumping was halted in the 1970s, but a small number of dumps remained open to accommodate household garbage generated within the HMD. The legacy of the Meadowlands dumping, 2,500 acres of refuse-filled marshes, still impacts the region's landscape (Iannuzzi *et al.*, 2002).

Over the next 30 years, the HMDC directly or indirectly participated in other plans and activities that affected the Meadowlands' environment (Table 1; New Jersey Meadowlands Commission, 2004a). Perhaps most importantly, the HMDC increasingly regulated waste disposal within the

Table 1. Timeline of activities of the Hackensack Meadowlands Development Commission / New Jersey Meadowlands Commission in the Hackensack Meadowlands District (1969 to date).

1969	The Hackensack Meadowlands Development Commission (HMDC) is established by the Hackensack Meadowlands Reclamation and Development Act (N.J.S.A. 13:17-1 <i>et seq.</i>) and begins operations (<i>e.g.</i> , waste management and land-use planning).
1970	The HMDC formulates its first comprehensive land-use plan for the Hackensack Meadowlands District (HMD). This plan imposes certain environmental controls and standards and leads to denial of applications for additional landfills in Lyndhurst and Kearny. Adopted prior to the Clean Water Act (Federal Water Pollution Control Act; see Appendix 1), this plan also calls for the filling and development of more than 2,000 acres of wetlands.
1971	The New Jersey Sports and Exposition Authority (NJSEA) is established to operate sports and entertainment facilities in the Meadowlands.
1973	The HMDC adopts regulations banning disposal of all out-of-state solid waste in HMD landfills.
1974	The HMDC establishes the first tax sharing formula for the HMD.
1975	The New Jersey Department of Environmental Protection (NJDEP) establishes the Sawmill Creek Wildlife Management Area.
1976	Passage of the Solid Waste Management Act (N.J.S.A 13:1E-20) establishes the HMD as the State's 22 nd Solid Waste District and further regulates solid-waste disposal. The NJSEA opens the Meadowlands Stadium for football and the Meadowlands Racetrack for horseracing.
1977	The HMDC and the NJDEP begin their first study of contamination in the Hackensack Meadowlands.
1979	The HMDC begins negotiating with local governments (<i>e.g.</i> , Morris and Union County) to end solid-waste disposal from sources outside of the HMD.
1981	The HMDC begins construction of the Meadowlands Environmental Center with Green Acres funding (\$1 million) from the NJDEP. The NJSEA opens the Meadowlands Arena (now Continental Airlines Arena) for professional basketball and hockey.
1982	The HMDC begins a feasibility study to extract methane from landfills.
1984	The HMDC negotiates and signs an agreement to end disposal of solid waste from Passaic County in the HMD.
1985	The HMDC begins closure of several landfills in Kearny and North Arlington, and protects the Kearny Freshwater with zoning amendments.
1986	The HMDC, the U.S. Army Corps of Engineers, New York District (Corps), and the U.S. Environmental Protection Agency, Region II (EPA) initiate the "Basis for the Advanced Identification of Wetlands" (AVID), a study to identify wetlands in the Hackensack Meadowlands that are suitable for filling. Leachate collection begins at the Kearny 1-A Landfill.
1987	The HMDC closes the Kearny 1-C Landfill and ends disposal of solid waste from Essex and Passaic Counties in HMD landfills.
1988	Prior to the publication of the AVID results, the New Jersey Department of Community Affairs, on behalf of the HMDC, proposes to the Corps and the EPA that a Special Area Management Plan (SAMP) be considered for the HMD. The goal of the SAMP is to "streamline" the federal permitting process to accommodate economic development in the HMD.

- 1989 The HMDC completes closure of the Kearny 1-A Landfill, establishes a recycling program for HMD municipalities, and undertakes its first inventory of the HMD's historic and cultural resources.
- 1991 The HMDC opens its methane recovery plant, the nation's second largest, dedicates the Marshland Discovery Trail and the Losen Slote Creek Park, and establishes the Environmental Improvement Program Trust for remediation.
- 1992 The EPA, Corps, and HMDC publish the findings of their joint AVID study (also conducted with the U.S. Fish and Wildlife Service (Service), National Marine Fisheries Service, and NJDEP): the AVID designates less than 2 percent of wetlands in the HMD as suitable for filling activities.
- 1993 The HMDC signs an agreement with Conrail to accept mitigation funding for wetlands enhancement.
- 1994 The HMDC revises its inventory of cultural and historic resources, and begins wetlands enhancement and its first redevelopment study.
- 1995 The Draft Environmental Impact Statement for the SAMP is published by the EPA and the Corps on behalf of its partners. The HMDC expands its landfill-gas recovery, environmental education, and wetlands enhancement programs.
- 1995 The HMDC proposes establishment of a Meadowlands Conservation Trust, and acquires two wetlands enhancement sites (Mill Creek and Riverbend Marshes). The HMDC participates in discussions regarding a mitigation bank in the HMD.
- 1997 The HMDC ends all household solid-waste disposal in the HMD, establishes an Open-Space Policy, and continues expanding its landfill-gas recovery and environmental education programs.
- 1998 The HMDC establishes the Meadowlands Environmental Research Institute and begins operating: (1) New Jersey's largest leachate-collection system around several HMDC-owned landfills (1-A and 1-E), and (2) two electric-generating stations using landfill gas. The HMDC also receives federal grants to develop a hydrologic model and revise the HMD's flood control.
- 2001 The HMDC withdraws its local sponsorship of the SAMP; the State of New Jersey enacts legislation renaming the HMDC as the New Jersey Meadowlands Commission (NJMC) to reflect its commitment to the restoration and protection of the environment in the HMD.
- 2002 The NJMC, the Corps, and the Service begin the Hackensack Meadowlands Environmental Restoration Project, a component of the Hudson-Raritan Estuary Restoration.
- 2003 The NJMC proposes a revised Master Plan, announces the Encap Redevelopment Project to close and remediate 6 landfills and provide extensive open-space in the form of golf courses and adjoining areas, and reorganizes the Meadowlands Environment Center in partnership with Ramapo College. The NJMC, the Corps, the Service, and Hudsonia, Ltd. co-sponsor The Meadowlands Symposium, a scientific meeting focused on research in the Meadowlands.
- 2004 The NJMC adopts its revised Master Plan.
- 2005 The NJMC, Corps, NJDFW, NFWF, and Service co-sponsor the 4th Stakeholders Work Session for the Hackensack Meadowlands. The NJMC initiates a 3-year study by the NJDEP, the New Jersey Audubon Society, and Ducks Unlimited, Inc. to assess the HMD's fish and wildlife resources and develop a wildlife management plan.
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HMD. The HMDC formulated its first comprehensive land-use plan in 1970. This plan imposed certain environmental controls and standards and led to denial of applications for additional landfills in Lyndhurst and Kearny (New Jersey Meadowlands Commission, 2004a). However, adopted prior to significant federal and State legislation, this plan also called for the filling and development of more than 2,000 acres of wetlands. The HMDC adopted regulations banning disposal of all out-of-state solid waste in 1973 and the HMD's first tax sharing formula in 1974. In 1977, the HMDC and the NJDEP began their first study of contamination in the Hackensack Meadowlands. Two years later, the HMDC began restricting disposal of solid waste from in-state communities outside of the HMD.

Activities by the HMDC affecting the environment slowly grew more diverse during the 1980s. Wetlands filling in the HMD continued but was increasingly opposed by other government-agencies and the public. The HMDC began construction of the Meadowlands Environmental Center and extraction of methane from landfills in 1981 and 1982. The HMDC further restricted disposal of solid waste from in-state sources through the mid-1980s and began closure of large landfills in North Arlington and Kearny a few years later. The NJMC undertook its first inventory of the HMD's historic and cultural resources in the late 1980s.

In 1986, the HMDC, the Corps, and the EPA initiated the AVID study to identify wetlands in the Hackensack Meadowlands that were suitable for filling. The NMFS, Service, and NJDEP also participated in the AVID, which designated slightly less than 2 percent of the Meadowlands (only 122 acres) as suitable for filling activities (U.S. Environmental Protection Agency, 1992). Thus in 1988, prior to publication of the AVID results, the New Jersey Department of Community Affairs, on behalf of the HMDC, proposed that the Corps and the EPA consider a SAMP for the Hackensack Meadowlands District. The goal of the SAMP was to "streamline" the federal permitting process regulating activities in wetlands to accommodate economic development in the HMD. As initially conceived, the SAMP ignored the AVID findings that only 122 wetland acres were suitable for filling, and promoted filling more than 1,200 acres of wetlands for non-water-dependent development. Subsequent revisions to the SAMP reduced the acreage of fill. The HMDC withdrew its local sponsorship of the SAMP in 2001, and soon thereafter, work on the SAMP was discontinued. A short time later, the HMDC changed its name to the New Jersey Meadowlands Commission.

G. DEVELOPMENT AND ENVIRONMENTAL ALTERATION (1970s to Present)

Two years after the HMDC's establishment in 1969, the New Jersey Sports and Exposition Authority (NJSEA) was established in part to build a racetrack and football stadium in the Meadowlands. The Meadowlands Stadium, home initially to the New York Giants, opened in 1976 on the site of one of the largest Meadowlands landfills, where a fire had burned uncontrollably for years. The Meadowlands Arena, now known as the Continental Airlines Arena, was opened 5 years later on an adjoining site as a home for the region's professional basketball and hockey teams. Due to these and other large projects, the landscape in the HRW became increasingly suburban and urban (Hasse and Lathrop, 2001; 2003).

Although the population throughout much of the region declined from the 1970s through the mid-1990s (CensusScope, 2005), natural vegetative cover was declining and becoming increasingly fragmented as suburban sprawl spread throughout the HRW and into the adjoining Passaic River watershed. The increased demand for water in these watersheds was satisfied by extensive alteration of the hydrology of several rivers in northern New Jersey. In the mid-1970s, the North Jersey District Water Supply Commission (a State government agency) and the Hackensack Water Company (privately owned) established a partnership to build the 29.6-billion-gallon Wanaque Reservoir on the Wanaque River, a Passaic River tributary. A few years later, the partnership completed another dam upstream of the Wanaque Reservoir to form the Monksville Reservoir. Both reservoirs in the Passaic River watershed are connected by 102-inch aqueducts to the Oradell Reservoir to allow for regular diversions of water from the Passaic River reservoirs into the Oradell Reservoir. The storage capacity of Woodcliff Lake on the upper Hackensack River basin also was increased by construction of a new dam. Other aqueducts were constructed to transfer water from the Saddle River in the Passaic River watershed and Sparkill Creek in the Hudson River watershed. While satisfying the demand of local municipalities for water, the reservoirs cause additional losses of riparian areas and further fragmentation of riverine habitats in the upper watershed. The increased water supply also promoted additional development throughout the upper Passaic and Hackensack watersheds. Though outside the Meadowlands, development of the landscape and subsequent hydrologic alterations throughout the watershed have long contributed to: (1) further isolation of the Meadowlands, (2) additional deterioration in water quality and other adverse hydrologic impacts on the Meadowlands, and (3) greater vulnerability of the Meadowlands to other disturbances, such as invasive species.

Although original enabling legislation granted the HMDC broad powers for brownfield redevelopment, the HMDC did not undertake its first redevelopment project until 1994. The HMDC adopted an Open Space Plan in 1997. Since that time, several other redevelopment projects (*e.g.*, Vincent Place in Teterboro, 16th Street in North Bergen) have been initiated. One of the latest redevelopment projects in the HMD, the Encap Project, will convert six common reed-covered landfills into golf courses and a mix of other land uses, including open space (New Jersey Meadowlands Commission, 2005a). The NJMC is pursuing redevelopment of several other brownfields within the HMD. More recently, a new retail-entertainment complex, known as Xanadu, has received federal and State permits to redevelop a portion of the NJSEA site. As has occurred with other projects in the HMD, upland grasslands and wetlands are being converted to other uses for this project. Most recently, the State has proposed limited gambling (*i.e.*, slot machines) at the Meadowlands Racetrack; the NJSEA has announced possible modifications to and/or an expansion of the Meadowlands Stadium and a minor league baseball stadium as part of the Xanadu project. At this writing, the Service has not received detailed information regarding the proposed activities; therefore, any potential environmental impacts of these projects are unknown.

H. STEWARDSHIP AND FUTURE PLANNING

By the late 1990s, public attitudes toward the Meadowlands had changed considerably. Many NGOs were vocal in their opposition to what is now considered an unacceptable use (*e.g.*,

wetlands filling for non-water-dependent projects) of the Meadowlands and became increasingly effective in engaging government agencies regarding protection of the Meadowlands. Government agencies also became active. The Service's (1996a) Southern New England – New York Bight Coastal Ecosystems Program completed a comprehensive study, *Significant Habitats and Habitat Complexes of the New York Bight*, which identified the importance of the Meadowlands' open space to fish and wildlife populations and further promoted protective efforts. In response to NGO advocacy and a Congressional inquiry, the Service's Northeast Regional Land Acquisition Review Committee requested a briefing on the feasibility of establishing a National Wildlife Refuge in the Meadowlands. In reply, the NJFO prepared a 1999 presentation entitled *The Hackensack Meadowlands National Wildlife Refuge: A Proposal for a New Refuge Establishment*. At the time, the Northeast Regional Office decided not to pursue establishment of the Meadowlands as part of the refuge system, largely due to contaminant concerns and other higher-priority land acquisitions. However, the Service continued to pursue partnering in stewardship efforts.

The next few years represented a turning point in the focus of activities regarding the Meadowlands. Beginning in 1999, several of New Jersey's Congressional members as well as the Secretary of Interior toured the Meadowlands. In 2000, the Corps initiated the Reconnaissance Phase for the Hudson-Raritan Estuary Restoration Project: the Meadowlands was identified as one of several potential restoration areas that warranted priority consideration. Later that year, the Service and other agencies co-authored a *Wildlife Management Plan for the Hackensack Meadowlands* (U.S. Fish and Wildlife Service *et al.*, 2000). Although intended as a document to supplement the SAMP, which was still being developed at the time, the management plan advocated protection of large, undeveloped wetland tracts. In response to the NGO constituency, the Service also hosted the first of several stakeholder work sessions later that year. In May 2001, the second stakeholder session included the NJDFW and addressed expectations of the NGOs, the NJDFW, and the Service. Later that year the SAMP was discontinued and a third stakeholders work session, attended by representatives from NGOs, government agencies, and elected officials, was held. Stakeholders reached a consensus that environmental restoration and protection were their shared objectives for the Meadowlands.

With strong support from local organizations, federal and State agencies expanded their activities to protect the Meadowlands. The Corps, NJMC, and the Service initiated their joint planning (*i.e.*, the Project Management Plan) for the Meadowlands as a component of the HRE Ecosystem Restoration Project in spring 2002. The NJFO and the NJDFW hosted the Service's Director and District Congressman Steve Rothman (NJ 9th) on a Meadowlands tour in August 2002. In the fall, the Service's Northeast Regional Directorate Team toured the Meadowlands. In December 2002, the NJFO promoted the Hackensack Meadowlands via 18 articles authored by various stakeholders in its newsletter *Field Notes*. Also in 2002, the Service and the NJDFW developed a *Vision Plan* for the Meadowlands (Appendix 2). The Service's National Wetlands Inventory (Tiner *et al.*, 2002) published *Wetland Status and Trends for the Hackensack Meadowlands* to identify cumulative losses of wetlands and other land-use trends within the HMD. In 2003, the Service, Corps, Meadowlands Environmental Research Institute (MERI), and Hudsonia, Ltd. (a local NGO) sponsored *The Meadowlands Symposium*, a research symposium to showcase scientific research in the Meadowlands. Eight papers from the symposium were published in the online journal of the Brooklyn Botanic Garden (2004a), *Urban Habitats*. Also in 2003, the

NJMC's Meadowlands Environmental Center began re-organization through a partnership with Ramapo College. In 2004, the Service declared the Meadowlands a "Regional Resource Priority." In June 2005, the Service, Corps, NJDFW, NJMC, and NFWF co-sponsored the fourth stakeholders' work session to update stakeholders regarding ongoing restoration, planning, and other activities (e.g., outreach, research). All of these activities increased the public visibility of the Meadowlands and promoted additional and ongoing efforts to protect and restore the Meadowlands.

Presentations at the June 2005 stakeholders' work session identified several restoration efforts that are currently underway or in planning stages. The Service, Corps, and NJMC are partners in the Feasibility Study that is currently focused on the restoration of the 53-acre Anderson Creek Marsh (e.g., U.S. Army Corps of Engineers, 2004b). These same three partners are not only planning the restoration of that site but also investigating restoration (and the potential need for prior remediation) of other sites (e.g., ENSR, International, 2004; U.S. Fish and Wildlife Service, 2005a). Additionally, the NJMC (2004b) has received funding from the EPA to investigate use of *in situ* barrier materials for capping the heavily contaminated Kearny Marsh site. The NJDFW has been funded by the NJMC (2004c) to develop a detailed wildlife management plan for the HMD; this plan will take the form of a wildlife action plan and focus on protection of State-listed species inhabiting the Meadowlands. During the June 2005 stakeholders' works session, the Service presented an overview of four ongoing Meadowlands activities: (1) *The Hackensack Meadowlands Initiative: Preliminary Conservation Planning* (this effort), (2) an overview of its contaminant concerns as a partner in the Feasibility Study (U.S. Fish and Wildlife Service, 2005b), (3) updating and expanding its wetlands status and trends assessment for the entire HRW (Tiner and Bergquist, 2005), and (4) outreach and education. The presentations at the work session identified many different efforts to move forward the restoration of the Meadowlands and made clear the need for regular collaboration among stakeholders, especially those federal and State agencies partnered in diverse efforts to remediate and restore numerous sites throughout the Meadowlands.

I. SUMMARY

Humans have lived in the Meadowlands for roughly 10,000-12,000 years. For most of that time, the human population, comprised of ancestral Lenape groups, had minimal impacts upon the landscape and largely subsisted off the area's abundant natural resources, including wildlife species that no longer exist today. Upon the arrival of European colonists, exploitation of the natural resources of the Meadowlands increased, slowly at first, and then rapidly as the colonial population expanded, displaced the native Lenape from their settlements, and spread across the landscape. About 200 years ago, as the region's timber resources were harvested, humans began large-scale modification of the Meadowlands. Wetlands were ditched and diked for agricultural and other purposes (e.g., mosquito eradication) and altered to improve transportation throughout the region. Landscape alterations promoted further development and contributed to a faster growing human population. Around the turn of the century, the natural water supply in the Meadowlands watershed was no longer adequate to meet human demands. As a result, the landscape of several watersheds (e.g., adjacent Passaic River basin) was increasingly altered to store water, thus disrupting natural hydrology. Flow alterations hastened further changes in the

landscape, and dramatically changed the Meadowlands from a tidal palustrine to a predominantly estuarine ecosystem (see Section V). With further population growth, waters and wetlands in the Meadowlands became increasingly neglected and degraded. Much of the wetlands were used as landfills, and human refuse and industrial contamination became widespread. As the environmental consequences were slowly recognized, the need to address them became apparent. However, short-term needs outweighed concerns as the human population continued to alter the landscape and hydrology throughout the HRW. Since the turn of this century, diverse stakeholders, including NGOs and State and federal agencies, have joined together in efforts to protect and restore the Meadowlands. These organizations and agencies now have many ongoing projects addressing restoration of specific sites, management of fish and wildlife resources, and public outreach and education. Such activities are moving environmental restoration forward but make clear the need for, and importance of, more and improved stakeholder collaboration in future efforts to restore the Meadowlands and protect its fish and wildlife populations.