This PDF file is a digital version of a chapter in the 2005 GWS Conference Proceedings. Please cite as follows:

Harmon, David, ed. 2006. *People, Places, and Parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites.* Hancock, Michigan: The George Wright Society.

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Big Egg Marsh Experimental Restoration in Jamaica Bay, New York

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Saltmarsh loss in an urban national park

At Jamaica Bay, in the New York City harbor area, centuries of urbanization destroyed 90% of the wetlands. The remaining 400 ha of saltmarsh islands are disappearing at an accelerating rate. Currently, about 16 to 20 ha of saltmarsh islands are being lost every year, through internal decay and erosion (Gateway National Recreation Area 2001). The grassy interiors of the islands are transforming into mosaics of soft mud and isolated grass tussocks. Investigations are underway to identify the causes of these losses and to find effective ways of restoring saltmarshes (Gateway National Recreation Area 2004).

To address the question of what is an effective and long-lasting method for saltmarsh restoration, Gateway National Recreation Area undertook the Big Egg Marsh experimental restoration. The project area comprises approximately 1 ha of restored saltmarsh and an adjacent 1 ha of control (or reference) marsh in the southern side of Jamaica Bay. This site was selected because the saltmarsh is well along in transforming to a bare mudflat. It also is conveniently located adjacent to Broad Channel village, where there is easy access for interpretive activities and for the public's participation in the Volunteers-in-Parks (VIP) program.

The Big Egg Marsh experimental restoration project is funded by the National Park Service, and is being carried out by Gateway NRA. The project location, Jamaica Bay, is at the southwestern end of Long Island. Jamaica Bay lies within the boroughs of Brooklyn and Queens. Jamaica Bay and its saltmarshes today measure about 6 km north to south, and 13 km east to west. Most of Jamaica Bay's estuarine waters, wetlands, and artificial uplands lie within the Jamaica Bay Wildlife Refuge, now included within the national recreation area.

Gateway was established as the nation's first urban national park over three decades ago (U.S. Congress 1972). The park includes historic forts that defended New York harbor. It also includes natural resources that are important habitats for migratory birds and fishes. Several federal-listed threatened and endangered birds and plants occur within Gateway. The New York portion of the park includes most of Jamaica Bay, large portions of the Rockaway barrier island, and parts of Staten Island. In New Jersey, most of Sandy Hook barrier island is included in the park. Overall, Gateway includes over 10,500 ha of ocean water, saltmarshes, beaches, and adjacent uplands. Most of the fringing freshwater wetlands, however, are lost to urban development.

Planning the experimental restoration

An environmental assessment was prepared to recapitulate the issues, present alternative actions, and review the resources and impacts (Gateway National Recreation Area 2003). The "no action" alternative would allow the gradual transformation of the remnant saltmarsh into bare mudflats. Six "action" alternatives were considered, but four were immediately rejected because they were based on barging in sand from a distant source; such action would have necessitated dredging an access channel, which was prohibitively expensive, time-consuming, and destructive. The remaining two "action" alternatives that were considered further depended on excavating sand from a trench in the adjacent tidal creek. One of these alternatives was to dredge a thin layer off the entire creek bottom, and the other was to dredge a deep narrow trench. The latter, the ecologically preferred alternative, was chosen because it was expected to provide the purest sand for the marsh surface while having the least impacts on the local fauna.

The selected method for applying sand to the experimental restoration site is by means of a small barge with a swing-ladder dredge and a high-pressure spray (Figure 1). The intake end is the swing ladder, which moves side-to-side across a swath 6.7 m wide with a maximum depth of 1.8 m. The intake pipe has a rotating cutting head at its distal end. The slurry that enters is pumped through a 20-cm diameter pipe, and then reduced to a 10-cm diameter nozzle that sits 3 m above the stern. The slurry spray is supposed to deliver to a distance of around 60 m.

This spray technique was chosen because it was expected to be less destructive to the remnant marsh than conventional dredging. The plan was to add layers of sand to elevate the treatment site generally a minimum of 20 cm above the plane of the highest existing remnant

Figure 1. A swing-ladder dredge with high-pressure spray extracted 6,000 cu^3 of sand from a trench in the adjacent creek and sprayed it over the surface of Big Egg Marsh.

tussocks of smooth cordgrass *(Spartina alterniflora).* Prescribed places within the site were to receive an additional layer of sand up to 23 cm thick, to attain a maximum elevation of 43 cm above the reference plane. The lowest-lying mudflats and drainages (which cut below the reference plane) were, therefore, to receive up to 100 cm of fill. The design was to place most of the sand in an L-shaped ridge, paralleling a bend in the adjacent creek. The total volume of sand needed was estimated at 5,000 to 6,000 cu m. Sand was to be dredged from a trench along the deepest part of the creek bottom, and sprayed throughout the fill site. The dredging and spraying were planned to start in summer 2003, immediately after the environmental compliance was completed.

The finished fill elevation was designed so that most of the marsh would be covered by the daily high tide. The highest parts of the filled site are the same elevation as the lower edge of nearby common reed *(Phragmites australis).* If the fill were any higher, the treatment marsh would be at risk of invasion by the unwanted alien genotype of common reed.

Ecological Monitoring

Before beginning the restoration, one year of ecological monitoring was done. It was accomplished collaboratively through a cooperative agreement between the National Park Service (NPS) and the Aquatic Resources and Environmental Assessment Center (AREAC) at Brooklyn College, City University of New York. Coordination and carrying out the fieldwork was done by Gateway natural resources staff, assisted by AREAC student interns and by volunteers (local and international). Technical supervision and support were provided through the NPS Cooperative Ecosystem Studies Unit at the University of Rhode Island, and through the NPS Boston Support Office.

Monitoring of the control site and treatment site began in autumn 2002, one year before the sand was applied—thus, we have comparisons of the control and treatment sites both before and after. Monitoring is focused on physical and chemical changes of the marsh surface and creek bottom, changes in plant cover, and changes in animal occurrence. Each site has three surface elevation tables (SETs), more than 100 grid markers (many with elevations), and 30 permanent 1-m^2 vegetation plots. Also, on the treatment site there are sixteen 2-m^2 unplanted plots to monitor regrowth of the original vegetation and colonization by seedlings. There are ten places on each site where the water table is monitored, and where soil particle size and sulfides are monitored. The occurrence of birds, mammals, insects, and spiders are surveyed, as are the macroinvertebrates in the soil and water. Water quality (12 parameters) and fishes are sampled in the adjacent creek. Recovery of the excavated trenches that supplied the sand is being monitored, too. The monitoring in large part follows the guidelines specific to saltmarshes elsewhere (e.g. Niedowski 2000; Raposa et al. 2001; Roman et al. 2001).

A SET is installed at three locations in the treatment site and another three in the control site. Each SET consists of a steel rod driven at least 15 m deep into the marsh; the rod is capped with a movable arm that holds nine sampling pins (Cahoon et al. 2000). Plots of either sand or bentonite are placed nearby. The SETs provide information on subsidence, upward expansion, erosion, and accretion. Before-and-after and control-and-treatment monitoring was accomplished by installing SETs in the treatment site and in the control site, with readings beginning one year before the dredging and continuing indefinitely thereafter.

Doing the experimental restoration

Before dredging and spraying sand on the marsh, a silt fence was installed around the low-lying portions of the perimeter. About 240 hay bales, held in place by more than 1,000 wooden stakes and 2,000 m of sisal twine, provided the primary containment (Figure 2). Where silt runoff became apparent, supplemental containment was provided by installing 100 m of black plastic construction fence for silt control.

The swing-ladder dredge with high-pressure spray was contracted to pump for 200 hours. During this time, over 6,000 cu^3 of sand were placed on the 1-ha treatment site. The spray was effectively delivered to a distance of only 40 m. To gain additional distance, some slurry was streamed farther into the marsh interior by directing the nozzle horizontally across the surface of the fresh fill, causing the slurry to flow further inland. The placement of the fill was guided by white polyvinylchloride (PVC) pipes arranged in a grid pattern. Each pipe contained an elevation target marked with red duct tape and plastic flagging. Dredging was completed by the beginning of October 2003.

Figure 2. Before spraying sand on the Big Egg Marsh restoration site, 240 hay bales were staked across the drainages to contain the runoff of silt and organics.

Planting began on 3 October of that year. Over 20,000 peat pots of smooth cordgrass were planted by the volunteers and by park staff. These plants were grown on contract with the Native Plant Center, which is operated by the New York City Department of Parks & Recreation. Their seed sources were two locations on Staten Island, about 10–30 km from Jamaica Bay, but within the New York City harbor. Volunteers continued the planting for about six weeks, ending in late November 2003.

Simultaneously with the planting, green plastic fence was erected to keep geese from devouring the new plants. Geese regularly dig out smooth cordgrass by the roots during the winter, and graze the fresh green growth throughout the growing season. To prevent this on the restoration site, volunteers and NPS staff installed about 700 m of fence on 260 wooden posts. The fences were arranged in cells of about 20 m diameter, to make it difficult for geese to land or take off within the fences. Additionally, mason's woven string with surveyor's plastic flagging were stretched overhead to further subdivide the cells. Repairs had to be done repeatedly during the winter, due to damage from floating debris (wrack, wood debris, and ice), wind, and waves.

Results

The U.S. Geological Survey is reading the SETs at approximately three-month intervals. On the restoration site their SETs recorded dredge-filled sand 40 to 50 cm thick. In the year since placement of the sand, the ground surface at the SETs fell by several centimeters due to settling and surface erosion. The northwest edge of the filled area was impacted by wind-driven waves, resulting in an erosion belt 60 m long by 3–5 m wide that lost 20–40 cm of elevation. Another place of long-fetch is in the southeast, where eroding waves created another erosion belt 20 m long by 5 m wide that lost at least 20 cm of elevation.

In the first spring after planting, the smooth cordgrass in peat pots, spaced 50 cm apart, showed nearly 100% survival and regrowth. The only significant mortality of potted plants was from erosion along the marsh edge, where pots washed away. Plastic fencing kept the geese out of the planted area during spring and summer 2004, but since then the geese have become an ever-increasing problem. They seem habituated to the fences, and at high tide they swim freely through breaks in the fences to feed. Snow geese *(Chen caerulescens),* brants *(Branta bernicla),* and Canada geese *(Branta canadensis)* graze upon and dig out the smooth cordgrass. The migratory snow geese were present only during February and March, and the brants from October to May. Canada geese, however, were present all year round.

Most of the treatment marsh also experienced germination of smooth cordgrass seeds, which washed naturally onto the sandy surface during the winter. During the last week in March 2004, there seemed to be more than 2,000,000 seedlings on the treatment site. By 20 April, there were still at least 300,000 seedlings on the treatment site; in some places, particularly in wet depressions, seedling density was up to 800 seedlings/m^2. These seedlings filled in the spaces between the potted plants, at an average density of 35 seedlings/m^2 surviving in June 2004 (the range was 1 seedling/m^2 to 230 seedlings/m^2) in the plots that were unplanted. By September, the periphery of the treatment site outside the goose-excluding fence was nearly 100% reworked by the geese, resulting in the loss of most plants (both the potted plants and the seedlings that germinated on site). Inside the fence, however, most plants were surviving, except where in May and June 2004, hundreds of horseshoe crabs *(Limulus polyphemus)* passed under the fences and laid eggs in the sand of the restoration site. In doing so, they dislodged many thousands of tiny seedlings.

One of the expected advantages of thin-layer spray was that the original scattered clumps of smooth cordgrass would rebound and continue growing through the thin layer of sand. In the first year after the treatment, however, we observed that the smooth cordgrass survived only when it received 20 cm or less of sand cover. The thinner the layer, the greater the survival.

The treatment marsh after one full growing season had silt accumulating on the sand. All but the highest places had a cover of algae. The grass was entirely smooth cordgrass (Figure 3). By October 2004, in most of the permanent vegetation plots the stems from seedlings were no longer distinguishable from the stems that arose from rhizomes of the potted plants—their combined density averaged 151 stems/m^2, with a maximum of nearly 600 stems/sq m. The average stem density was nearly double that of the pretreatment plots and the control plots, due to more of the treatment plots having vegetation in them, i.e., there were fewer bare areas after restoration. The restored marsh already was being colonized by fiddler crabs (*Uca* sp.), eastern mud nassa *(Ilyanassa obsoleta),* common periwinkle *(Littorina littorea),* as well as fishes, worms, and insects.

Figure 3. By the end of the first growing season, Big Egg Marsh regained a good carpet of smooth cordgrass *(Spartina alterniflora).* The sandy soil already was accumulating silt, algae, and macroinvertebrates.

Stakeholder participation

The Big Egg Marsh experimental restoration is a collaborative effort that includes NPS permanent staff at Gateway and from the Cooperative Ecosystem Studies Unit at the University of Rhode Island. Other collaborators are AREAC, the Marine Sciences Institute at Rutgers University, Department of Oceanography and Marine Sciences at Dowling College, U.S. Geological Survey, Environmental Protection Agency, Natural Resources Conservation Service, New York State Department of Environmental Conservation, New York City Department of Parks & Recreation, and three contractors.

NPS's Jamaica Bay Institute is located at Floyd Bennett Field, a historic airfield at the west side of Jamaica Bay. The institute's mission is to lead the way toward improved stewardship of the Jamaica Bay ecosystem by creating a bridge between science and decision-making through research and education on the natural and cultural heritages of Jamaica Bay. The institute endeavors to connect people with the environmental consequences of their actions. During the past three years, the Jamaica Bay Institute has disseminated research results through publications and workshops, assisted new researchers, and fostered appreciation and accountability for the Jamaica Bay ecosystem in the urban community. The institute is participating in the experimental restoration of Big Egg Marsh.

In 2002–2003, more than 80 volunteers from local community groups, universities, and government agencies assisted in the pretreatment monitoring, site preparation, and planting (Figure 4). Since then, an additional 60-plus volunteers assisted with the maintenance and monitoring of the site. Overall, the participants in the Big Egg Marsh experimental restoration number over 200 individuals, comprising volunteers, student interns, collaborators from government agencies, contractors, and NPS staff. Many of the volunteers came from local conservation groups such as the EcoWatchers, the American Littoral Society, the Audubon Society, and the Jamaica Bay Task Force. Others came from local businesses, colleges, schools, and community organizations. To all these stakeholders, we owe many thanks.

Conclusions

The Big Egg Marsh experimental restoration is technically successful insofar as the sand is transforming into a silty and organic saltmarsh soil, there is a dense cover of smooth cordgrass, and an appropriate animal community is becoming established on the treatment site. Geese grazing and rooting increased in intensity inside the fenced treatment site after the first

Figure 4. Approximately 80 stakeholders volunteered in 2002–2003 to prepare the Big Egg Marsh restoration site, replant the Smooth Cordgrass, and assist with the monitoring. Since then, additional volunteers and other stakeholders bring the total to 200 participants.

ten months, apparently due to habituation. Consequently the goose-deterring fence will need to be rigorously maintained in place for an additional year, or alternative goose-scaring methods will be needed. Although the results are good to date, it remains to be seen how many decades the restored site will last.

The experimental restoration also was successful in a nontechnical way, by providing the opportunity for about 200 local stakeholders to become involved first-hand in protecting wetlands.

Gateway currently is collaborating with the Army Corps of Engineers to restore at least 12 ha of saltmarsh at Elder's Point, in the north side of Jamaica Bay. The findings from Big Egg Marsh will be useful for designing and monitoring the Elder's Point restoration.

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