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Plant biodiversity in an urban wildlife refuge of New York City

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Abstract

Jamaica Bay Wildlife Refuge, comprising 3,705 hectares, is part of a large National Park Unit, Gateway National Recreation Area, New York, New Jersey, USA. Gateway National Recreation Area was created by an act of Congress in 1972, to preserve the science, beauty, flora, fauna, and recreational opportunities of the estuaries and beaches in the New York City metropolitan area. Gateway is the United States' first urban national park. Urban and industrial developments have modified the natural environment by grading and filling, construction, pollution from biological and chemical contaminants and over harvesting or eradication of native plant species. Despite these impacts, the natural environment and many native plants have been remarkably preserved. Within the wildlife refuge are a variety of habitats including salt marsh, successional old fields, shrublands, woodlands, freshwater wetlands dominated by Phragmites australis, fresh and brackish-water impoundments, and several old landfill sites. Here we report on an aspect of a large comprehensive study dealing with the restoration of the Jamaica Bay ecosystem. We present information on enhancing and maintaining plant biodiversity in an urban wildlife refuge. Our initial objective has been to prepare a complete floristic inventory of the refuge, involving vegetation sampling, herbarium work, and voucher specimen deposition. Identified to date are 330 species of vascular plants. Once the plants have been completely inventoried, we will suggest recommendations to maintain and/or increase plant biodiversity at the refuge. The creation of new habitats such as freshwater impoundments, the introduction of native species, arresting community development by selectively cutting, mowing or burning will provide habitat supporting a more diverse number of species.

1 Introduction

Jamaica Bay Wildlife Refuge, comprising 3,705 hectares, is part of Gateway National Recreation Area, New York, New Jersey. The region of the refuge used in this study is located between Shore Parkway on the north, the Rockaway Peninsula on the south, between J.F. Kennedy Airport on the east and Floyd Bennett Field on the west at 40 ° 35' Latitude, 72° 52' Longitude.

The primary objective of this study is to inventory the vascular flora of Jamaica Bay Wildlife Refuge. The second objective is to address the problem of maintaining botanical biodiversity and rare plant populations at the refuge.

The area was first settled by the Dutch at Flatlands in 1636. Nearby Flatbush, also known by the Indian name Midwout, was settled in 1651. When the English conquered the Dutch in 1664, newly appointed Governor Nicholl granted patent confirmation to landholders of Jamaica, Long Island, in 1665. The landowners exploited the extensive salt marshes surrounding the bay as a source of hay, which was collected by early residents. Shellfishing was also an important industry of Jamaica Bay in the 17th, 18th and especially the latter part of the 19th century. Pollution rendered shellfish unfit for consumption in the early 20th century [1].

A letter by Commissioner Robert Moses to Mayor Fiorello La Guardia, July 18, 1938 provides land use history for Jamaica Bay [2]. In 1908, a plan to develop Jamaica Bay into an industrial park and ship terminal was proposed by the Jamaica Bay improvement Commission. Nothing came of this plan but in 1922, New York City adopted a plan to replace the bay's marshlands by constructing two large islands and a series of navigation canals bordered by kilometers of industrial piers and wharves. Industrial and commercial activity began in the vicinity of Mill Basin and on the mainland near avenue U, but the other projects never reached fruition. In 1938 Moses stated, "over 95% of the entire Jamaica Bay area, as far as industrial development is concerned, has not advanced a step toward the grandiose scheme of 1922" (Moses 1938). Further development of Jamaica Bay was prevented in 1950 by the transfer of the bay and surrounding land to the New York City Department of Parks. In 1951, Herbert Johnson was appointed supervisor, a position he would hold for 30 years.

Notes from the October-November 1965 magazine, "The Conservationist" report that Jamaica Bay had become a marshy "trash disposal" area populated by "an ill assorted clan of squatters," [2]. The bay was to be used as a sewage disposal area. As this paper goes to press, the waste treatment facility now dumps three hundred twenty million gallons of partially treated sewage into Jamaica Bay each day.

A significant aspect of the refuge's history is that it is largely not a natural landscape. Superintendent Johnson, a horticulturist, was responsible for numerous plantings in the refuge. Many of the plantings were non-native species such as *Elaeagnus* sp., Autumn Olive, *Rosa rugosa*, Rugose rose, *Rosa multiflora*, Multiflora Rose, *Pyracantha* sp., Pyracantha, *Pinus nigra*, Japanese Black Pine, wheat, oats and rye. The seed producing grasses were planted to

attract grain-eating birds. Johnson also planted native species including *Myrica pensylvanica*, Bayberry, and *Aronia* spp. Chokeberry. An additional list of non-native trees growing at the refuge reported by Johnson appears in Table 2. Non-native shrubs planted at the refuge by Johnson are in Table 3.

The floristic inventory of Jamaica Bay Wildlife Refuge has been based upon more than 15 years of observations by the senior author, collections by various National Park personnel, and by examination of voucher specimens collected at the refuge and housed in the Gateway National Park herbarium. During the past 15 years, human disturbances and natural processes such as plant succession and storms have modified the environment and changed the flora. The plant life in any natural or artificial setting is dynamic and ever changing. Populations of various species may increase or decrease from year to year. Yearly changes in annual precipitation and temperature may favor certain species at the expense of others. For instance the cool moist summer of 2000 may have been responsible for the abundance of Spiranthes cernuua, Twisted Stalk Orchid.

2 Methods

Collecting trips were made to the refuge beginning on June 20, and proceeding approximately every two weeks until October 20, 2000. Additional collecting trips will be made during spring, 2001 at two-week intervals beginning March 20 and terminating July 1, 2001. Objectives for each trip included collecting voucher specimens and accumulating information on abundance and habitat preference of each species.

More than 500 specimens form the basis of this preliminary study. An additional 300 specimens may be collected before the project is completed. Taxonomically problematic specimens have been sent to botanical experts for annotation. These scientists will be acknowledged when the final paper is prepared and submitted to a botanical journal. Plant specimens mailed to the botanical experts will be retained by them and housed in their herbaria. Accession numbers of plant specimens are assigned by the National Park Service, Gateway National Wildlife Refuge.

Nomenclature follows Gleason and Cronquist [3]. When nomenclature differs from Kartesz [4], a broader nomenclature reference, synonyms are provided in brackets. Non-native plants as defined by Gleason and Cronquist [3] are designated by an asterisk.

3 Results and Discussion

A preliminary list of the vascular flora of Jamaica Bay Wildlife Refuge consists of 330 species within 208 genera and 77 families. One hundred thirty eight species or 41.8% of the flora are not native to the region. A preliminary summary of the flora is presented in Table 1.

Table 2 provides the frequencies of native versus non-native plants for four urban sites including Jamaica Bay Wildlife Refuge. There is homogeneity

among these four sites in the distribution of non-native versus native taxa (G = 2.22, P = 0.53, 3 df) [5]. The frequency of non-native plants at two coastal sites, Liberty State Park, and Sandy Hook, NJ is remarkably similar, 44.1% and 44.2% respectively. The percentage of non-native plants at coastal Jamaica Bay Wildlife Refuge, and Wave Hill, an inland urban site, is 41.8% and 47.8% respectively. The average percentage of non-native taxa at the three coastal sites is 43.5%.

The Poaceae (24 species) and Asteraceae (21 species) have the largest number of non-native species (Table 5). The Brassicaceae and Fabaceae have the highest percentage of non-native species, each with 79 percent, followed by the Caryophyllaceae with 75%. The Cyperaceae family, by comparison is comprised exclusively of native species. The Brassicaceae and Caryophyllaceae favor disturbed sites; all non-native species of both families are annuals. Annual plants are well adapted to disturbed sites and complete their life cycles during a single growing season. Many species of Cyperaceae, by contrast, occupy undisturbed sites. None of the Cyperaceae are alien taxa at our site.

Three lianas (vines), Celastrus orbiculatus, Oriental Bittersweet, Ampelopsis arborea Porcelin Berry, and Lonicera japonica, Japanese Honeysuckle are among the most common non-native vines and pose the greatest threat to native species at the refuge. These lianas climb over native shrubs and trees smothering them. Oriental Bittersweet and Porcelain Berry are more aggressive then Japanese Honeysuckle though all have the potential to displace native species. Polygonum cuspitadum, Japanese Knotweed, a forb, grows in aggressive colonies, and once established at a site, will out compete other forbs and grasses. A second non-native forb, Lythrum salicaria, Purple Loostrife, while common elsewhere in our region at moist sites, is uncommon at the refuge at the present time. Phragmites australis, Tall Reed is another plant of concern. This taxon is native to the United States, and may have hybridized with European and/or Asiatic varieties. Once established at wet sites, Phragmites may grow in dense pure stands, three to four meters tall. The pond at the east side of the refuge is bordered by an extensive stand of Phragmites that effectively excludes most other species.

Two non-native shrubs, Rosa multiflora, Multiflora Rose and Elaeagnus spp., Russian Olive are common at the refuge. If these species were eradicated from the refuge, both could easily reestablish themselves. Seeds of Multiflora Rose and Russian Olive are continually deposited in the refuge by birds who have fed on their fruit. Ailanthus altissima, Tree of Heaven, an Asian exotic is common at the refuge. Ailanthus may be eradicated from the refuge by selective cutting and uprooting.

Ten New York State rare plants have been identified at the refuge (Table 5). One species on the list, Aster tenuifolius, Perennial Salt Marsh Aster, has been removed from the state's rare plant list and placed on the state's watch list. The senior author has observed Perennial Salt Marsh Aster at several additional salt marsh sites bordering Jamaica Bay. Aster tenuifolius may be more common than officially recognized.

Quercus phellos, Willow Oak, has been planted at the refuge, and is reproducing. Quercus phellos was probably not part of the natural flora at this site. The other rare plants on this list live in special habitats. Annual Salt Marsh Aster, Aster subulatus is very common at slightly saline meadows. Two sedges, Cyperus polystachyos var. texensis and Cyperus schweinitzii are locally abundant on sandy soils. Populus heterophylla, Cottonwood, thrives on old landfill sites within the refuge. Two populations of Plantathera lacera, Ragged Fringed Orchid have been observed on the east and west side of the refuge associated with Phragmites australis, Tall Reed. Both populations are small and may become extinct in the future. Solidago ampervirens var. mexicana, Seaside Goldenrod, is common on dry sands throughout the refuge. Tradescantia ohiensis, Spiderwort, is locally abundant on disturbed soils while Cuscuta pentagona, Dodder, is a common plant parasite on several plant species throughout the refuge.

One of the major threats to biodiversity of native plant populations at the refuge is the introduction and establishment of non-native plants. Many non-native plants were deliberately introduced to the refuge [2]. Some were planted by the refuge's first superintendent, Herbert Johnson (Tables 3 and 4). Many more non-native plants have been accidentally introduced to the refuge, though most of these species were well established in New York City by the end of last century [7, 9]. Some non-native plants arrived at New York City in dry and wet ballast; others may have journeyed to the United States in colonial times as weed seeds in commercial grains. Still other alien plants have been inadvertently brought to the refuge as seeds on visitor's clothing. It is also quite probable that non-native plants were brought to the refuge in the seed bank of fill soil when salt marshes were covered to create high land.

Habitat creation and maintenance is important in maintaining populations of rare plants and enhancing species diversity. Habitats may be maintained or created by selective mowing or burning which arrests community development (plant succession). Herbicides are most effective if they are applied to invading single individuals. Herbicides are also effective when applied to populations of individuals that occupy small areas. Herbicides should never be used on vines that climb over native vegetation because an application of herbicide will kill the host plant as well. Selective cutting of woody vegetation may be effective but only if the offending plants are not numerous. Young woody vines, trees and shrubs may be pulled out by hand, but only after an expert has identified the undesirable vegetation.

It is always desirable to have an expert botanist walk an area and identify both rare and undesirable plants before any treatment of vegetation occurs. The expert can mark undesirable plants with red or orange ribbon or spray paint; only these species will be treated with herbicide, cut or pulled from the ground. Extensive disturbance such as plowing under alien annuals or digging up unwanted plants may alter the habitat making the environment unsuitable for desirable native species that thrive in a more mature stable environment.

Biodiversity may be enhanced by transplanting or seeding species into appropriate habitats. For example Sorhastrum nutans, Indian Grass and

Androgpogon gerardii, Big Blue Stem, two native tall grass prairie grasses have been successfully planted at Bayswater State Park, a few kilometers from the refuge. These grasses were planted four years ago, and are thriving in 2001. They will continue to thrive as long as woody species are prevented from invading the park. Big Blue Stem and Indian Grass are found at nearby isolated locations, e.g. Hempstead Plains [6] but they are probably not native to any community type today within New York City.

National state and city park personnel should determine the type of community they wish to maintain or create within their parks. The best communities are those comprised of native species, particularly species that are indigenous to the area. Once established, mature communities of native vegetation will thrive and require little or no maintenance (and cost) as long as the community is little disturbed.

The cost of creating and maintaining species diversity is important. When in doubt, use native plants that are part of the normal flora for a specific community within the soil and climate regime. Moreover, plant communities are dynamic and ever-changing; a young community such as a successional grassland, may change culminating in a community dominated by woody vegetation.

Diversity at aquatic communities may be enhanced and/or maintained by periodic raising and lowering the water table. A high water table will kill most shoreline plants that thrive in moist soil but cannot tolerate inundation, while lowering the water table provides open habitat for annual herbaceous plants. Some grasses and sedges, e.g., Psilocarya, produce seeds that lie dormant in waterlogged soil for years. The seeds of Psilocarya germinate during years of exceptional dryness when the pond bottoms are dry.

Maintaining desired levels of salinity at ponds, meadows and marshes at the refuge also will enhance plant diversity. At the present time there are several slightly saline meadows that support large populations of a New York State endangered plant, Annual Salt Marsh Aster, Aster subulatus. If these meadows become too saline or too fresh, this endangered Aster may be extirpated.

Preservation of special habitats is important in maintaining species diversity and maintaining rare plants. Plants may be rare for one or more of the reasons listed in Table 7. Rarity of plant species exists at many levels: local (within special habitats at a particular park) and at regional, state, national and global levels. Scientists have designated criteria to quantify rareness. Those searching additional information on "rare" plants are directed to the Young unpublished reference at the end of this paper [11].

When possible, the public should be involved in biodiversity projects. Many laypeople are knowledgeable botanists, and would welcome the opportunity to share their knowledge with park professionals. Moreover, these same individuals might volunteer their labor to rid plant communities of undesirable alien plants.

To insure continuity of vegetation management in federal, state and city owned parks, exchangeable databases should be established. People may not work at a particular park forever; few resource managers stay at the same site for

more than a few years. Therefore, it is important for park scientists to keep detailed records and to share their work and knowledge with others.

Table 1. A preliminary summary of the vascular flora of Jamaica Bay Wildlife Refuge, New York.

	Lycopods	Ferns	Conifers	Dicots	Monocots	Total
Families	1	3	2	63	8	77
Genera	1	3	2	161	41	208
Species	1	3	3	245	78	330
Native Species	1	3	2	135	51	192
Introduced Species	0	0	1	110	27	138

Table 2. Frequencies of native vs. non-native plants at Jamaica Bay Wildlife refuge, NY; Liberty State Park, NJ; [1], Sandy Hook, NJ [8]; and Wave Hill, NY [10]. All are urban habitats.

	Jamaica Bay Wildlife Refuge	Liberty State Park	Sandy Hook	Wave Hill
Native	192	185	269	144
Non-native	138	145	213	132
% Non-native	41.8	44.1	44.2	47.8
Total species	330	331	482	276

Table 3. A list of non-native trees planted by Superintendent Johnson at Jamaica Bay Wildlife Refuge. Native plants introduced to the refuge are indicated by an asterisk.

Betula fontinalis	Gray Birch
Malus spp.	Crabapple
Pinus thunbergii	Japanese Black Pine
Quercus phellos*	Willow Oak
Salix spp.	Willow species
Sorbus aucuparia	European Mountainash

Table 4. A list of non-native shrubs planted by Superintendent Johnson at Jamaica Bay Wildlife Refuge. Native plants introduced to the refuge are indicated by an asterisk.

Aronia arbutifolia*	Chokeberry-Red
Aronia melanocarpa*	Chokeberry-Black
Celastrus scandens*	American Bittersweet
Cornus amomum*	Silky Dogwood
Cornus mas	Corneliancherry Dogwood
Cornus racemosa*	Gray Dogwood
Cornus stolonifera*	Redosier
Crataegus spp.	Hawthorn
Elaeagnus pungens	Thorny Elaeagnus
Ilex glabra*	Inkberry
Lonicera maackii	Amur Honeysuckle
Lonicera tatarica	Tatarian Honeysuckle
Myrica cerifera*	Bayberry
Pyracantha coccinea	Firethorn
Sambucus canadensis*	American Elder
Symphoricarpos albus*	Common Snowberry
Viburnum trilobum*	American Cranberry bush
Weigela sp.	Weigela

Table 5. Floristically dominant families, Jamaica Bay Wildlife Refuge, New York.

Family	Total species	Native species	Non-native species	Percent non-native species
Asteraceae	62	41	21	34
Poaceae	54	30	24	44
Rosaceae	25	15	10	40
Fabaceae	19	4	15	79
Brassicaceae	14	3	11	79
Cyperaceae	14	14	0	0
Caryophyllaceae	12	3	9	75

Table 6. New York State rare plants at Jamaica Bay Wildlife Refuge.

Aster subulatus
Aster tenuifolius (state watch list)
Cyperus polystachyos var. texensis
Cyperus schweinitzii
Populus heterophylla

Bidens laevis
Quercus phellos
Solidago sempervirens var. mexicana
Tradescantia ohiensis
Cuscuta pentagona

Table 7. Some contributing factors and forces to plant rarity.

- Some exist at the edge of their normal range
- Some plants have narrow habitat requirements
- Natural biological events may contribute to plant rarity
- Plant succession
- Drought
- Hurricane
- Severe cold
- Erosion
- Accretion, e.g., Sand deposition during severe storms (hurricanes, nor'easter)
- Debris deposition- Debris may include soil, vegetation, building debris and more deposited as a result of the storm surge during hurricanes or usually high tides during severe nor'easters

4 Conclusions

There are multiplicity of ways that species diversity may be maintained at an urban park environment. These have been described to counter the effect of the introduction of non-native plants, modification of the natural environment by grading and filling, and to arrest or retard the natural process of plant succession/community development, when desired.

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