Welikia West Bronx:

An analysis of the historical streams and wetlands between the Harlem and Hudson Rivers and the Bronx River, New York City, with recommendations for restoration

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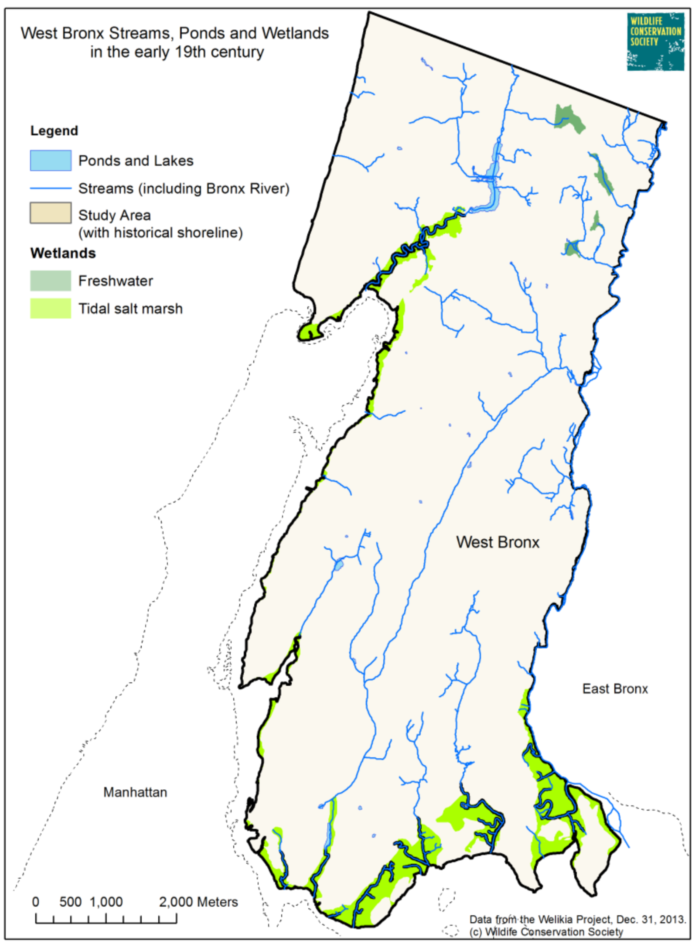

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Abstract

To inform stream and wetland restoration opportunities in the Bronx west of the Bronx River, we studied the historical ecology of the area. Through synthesis of historical maps and accounts, we determined that this part of New York City once had over 307 ha of wetlands and 94 km of streams and rivers in the early 19th century. Given the heavy urbanization of this area since the incorporation of this area into the city in 1874, it is not surprising that 99% of the wetlands have been lost and 84% of the streams filled or sewered during the last 200 years. Despite these remarkable changes to the natural hydrology of this part of the city, active restoration efforts are on-going along the Bronx River and Tibbett's Brook and new possibilities may exist to bring back long lost features like Mill Creek, Bungay Creek, and Cromwell's Creek and the associated wetland complexes of the Bronx River, Hunts Point, and Spuyten Duyvil, thus enhancing the environmental quality, livability and coastal resilience of this part of the city.

Introduction

Urban restoration is challenging on many levels, not the least of which is determining what is possible (Sanderson & Huron 2011). What we do know about cities is that change will happen and that the primary agent of change is people: our ideas, decisions and actions. Those ideas, decisions, and actions change over time. Though at any given moment, the city can seem monumental and unmovable given the amount of concrete, cement, and steel used to construct homes, businesses and roadways, in fact over historical times, we see that the city – the now urban landscape – is constantly in flux. 150 years ago the Bronx was mostly farmland; 400 years ago it was a wilderness inhabited by the Lenape and Siwanoy native American cultures. These people lived in the area that would someday be New York for more than four times longer than the current city has existed without exhausting it, arguably improving it for themselves and the species that lived with them (Sanderson 2009). Understanding these changes in ecosystems, physical structure, and human culture over time, and how these changes influence the environment, may open new possibilities for restoration and imagination over the next 400 years.

The discipline of historical ecology synthesizes diverse historical records to learn how historical ecosystems and habitats were distributed in the past and have changed (Egan and Howell 2005). Understanding how streams, wetlands, and woodlands were organized in past times helps scientists and conservation managers develop new strategies for integrated and functional landscape management, even in highly urbanized settings. By looking closely, we can see signs the natural landscape in the city around us today.

Given the dramatic changes to the New York City landscape over the past four centuries, most people have only a rudimentary understanding of the systems we seek to protect and enhance through conservation and restoration efforts (Grossinger et al. 2007). Researchers and managers are increasingly recognizing that restoration and conservation strategies often fail because of a lack of understanding, or a misunderstanding, of historical conditions (e.g. Montgomery 2008; Grossinger 1999; Swetnam et al. 1999). In New York City the "odd" coincidence of coastal flooding associated with Hurricane Sandy in 2011 with the former extent of tidal marsh wetlands of the city is only one of many indications that the environment of the city is here to stay (Sanderson 2005; Sanderson and Brown 2008).

Understanding past environments requires pulling together information from historical, cartographical, and archaeological sources. Standard historical treatments of the Bronx (formerly part of Westchester County) include Bolton (1848), Scharf (1886), Bolton (1881), Jenkins (1912), McNamara (1989, 1991), Ultan (2009), Ultan and Bronx County Historical Society (2009), and Ultan & Hermalyn (2000). Past efforts to understand the historical ecology of New York City include the Mannahatta Project (Sanderson 2009) and a study of the Bronx River watershed (Sanderson and LaBruna 2005). As part of the Wildlife Conservation Society's Welikia Project (welikia.org), historical ecology studies like this one are also on-going for the Newtown Creek watershed and the Jamaica Bay watershed, with the goal of a city-wide synthesis by 2016 (Eric Sanderson, personal communication). "Welikia" means "my good home" in Lenape. Here with funding from a WCS-NOAA regional partnership grant and in cooperation with the City of New York's Department of Parks & Recreation Natural Resources Group, we present the results of an investigation into the historical ecology of the West Bronx, with implications for wetland and stream restoration opportunities in the future. Our goal is to not only help support on-going restoration efforts, but to encourage new thinking about future places, opportunities, and our collective sense of what environmental quality, coastal resilience and sustainability mean for the west Bronx.

Methods

Study area

The study area is bounded on the west by the Hudson and Harlem Rivers, on the south by the East River, on the east by the Bronx River, and on the north by the boundary between the City of New York and Westchester County, New York.

Historic map identification and georeferencing

We searched archives in the United States and the United Kingdom for maps indicative of the historic state of the west Bronx, eventually locating and obtaining the eleven maps listed in Table 1 for this project. Each map or "spatial data resource" or SDR was given a unique SDR code and held in a SDR on-line database constructed for the Welikia Project. We georeferenced each map listed in Table 1 to the modern city using at least 20 control points. We sought a root-mean-squared error (RMSE) of less than 50 m using a first order rectification procedure in ArcGIS (version 10.1, ESRI, Redlands, CA). Although we considered several eighteenth century maps, we were unable to georeference these maps to meet the quality standards set out for this project. Thus all of the maps digitized from the project are from the nineteenth century, so the resulting synthesized historic layers are indicative of the early 19th century. Since relatively little development other than agriculture occurred in the Bronx prior to the early 19th century, we believe that these synthesized layers are reliable indicators of past conditions related to topography, streams, and wetlands.

Digitization

After georeferencing the maps, we digitized each map at a scale of 1:5,000. In general this digitized scale is larger than the original scale of the maps, ensuring that we captured all the details the maps were intended to show. We digitized the following features: shoreline, streams, ponds, wetlands, and topographic indications like point elevations and contour lines. Details of which features were obtained from which SDR are shown on Table 1.

Synthesis

We synthesized the each feature type using a modification of the method given in Grossinger et al. (2007). For each feature we identified the most detailed and/or earliest version of the feature. We then compared that version of the feature to all the other maps being used, noting the overlap using the following system of codes in the attribute table of the synthesized feature.

For polygonal features (e.g. ponds, wetlands, shoreline)

- 3 = Polygon mapped directly from this SDR
- 2 = Polygon shown, with majority overlapping the feature used
- 1 = Polygon shown, but not/barely overlapping the feature used
- 0 = Feature not shown

For linear features (e.g. streams, rivers):

- 3 = Polyline mapped directly from this SDR
- 2 = Polyline shown within 50m of the feature used
- 1 = Polyline shown, but outside of 50m from the feature used
- 0 = Feature not shown

Finally all features were clipped to the study area as defined by the historic shoreline and the current northern boundary of the city. All area and length calculations were made based on the Universal Transverse Mercator (UTM) projection for zone 18 north, which covers New York City.

Shoreline

Upon comparing the oldest SDRs in the study (428 and 425, both from 1837) to the next oldest SDR, 429 (1857), it looks as if the shorelines from 428 & 425 match with of the shoreline of SDR 429 within 20 meters in most cases. SDR 429 (RMSE: 20.2) depicts a continuous shoreline from Fort Morris in the South Bronx to Riverdale and will thus be used as the starting point for the shoreline synthesis.

For the shoreline east of Randall's Island SDR_ 47 (1874, RMSE: 23.3) was used. The shoreline for the Harlem River is shown consistently within 50 m of that of SDR 429, and in general it shows greater detail than the map nearest in age, SDR 278 (1863). SDR 147 also follows the Bronx River further up its course than SDR 278.

For the northern bank of the Hudson River, SDR 278 (1863, RMSE: 32.9) was used. Although it has a higher RMS error than SDR 138 (1891), it is a coastal survey map, whereas SDR 138 is a Civic Planning Atlas. It seems reasonable that the coastal survey personnel would have paid greater attention to the coastline and it is 30 years older. It remains unclear however to what extent the railroad line along the Hudson River changed the shoreline given the sharp declivity in this area.

Wetlands

Wetlands were synthesized in cases where at least three maps depicted wetlands, using SDRs 147 and 429 as the primary documents. SDR 147 from 1872 shows meticulous attention given to topography and other terrestrial features where new parks and the new extension of the city would be made. We used data from this SDR primarily where it showed the least development, primarily around the mouth of the Bronx River outlet and around Tibbets Brook. SDR 429 is a coastal survey map from 1857, which shows more detail and has a lower RMSE than other coastal surveys from the same time period. While some developed areas exist in this map, the attention to detail devoted to wetlands and differentiating between wetlands and tidal mudflats leads me to believe that this is the earliest, most reliable inventory of wetlands that exists for the Bronx side of the Harlem River. SDR 278 was also employed due to the level of detail given to tidal wetlands along the East River/Long Island Sound. While the RMSE at 32.9 m is higher than we would generally like, the overall extent, shape, and location of wetlands depicted here match several other SDRs and are extensive enough to merit using them as a basis for synthesis. Wetlands that were contiguous with the shoreline were coded as “tidal salt marshes;” all other wetlands were coded as “freshwater wetlands.”

Streams and rivres

As with the synthesis of wetlands, SDRs 147 and 429 served as the foundations for synthesizing streams and the Bronx River due to their low RMS error, SDR 429's date and its overall correspondence with older maps, and the detail depicted on SDR_147 . Ass with wetlands, in most cases only streams that were depicted on at least three maps were included in the final synthesis. There are many streams represented on SDR 147 that were not included in the final synthesis, even though this map seems reliable, for that reason. In some cases we added small connecting pieces to ensure connectivity between stream courses.

Digital elevation model

We created a digital elevation model of the historic topography using contour information from SDR 147 primarily. SDR 278 and 429 provided bathymetric information. SDRs 429, 430, 432, 428, and 425 provided supporting features and information. We digitized the contour lines and treated the historic shoreline as a 0 foot contour and the upper boundary of tidal salt marshes as 6 feet above sea level. These data, along with the stream layer, were analyzed using the Topo to Raster function in ArcGIS (ArcGIS Toolbox> Spatial Analyst> Interpolation> Topo to Raster). The resulting digital elevation model is expressed as a 10 m horizontal resolution; vertical elevations are expressed in feet above sea level.

Comparison to current condition

We obtained ArcGIS shapefiles of the current shoreline, hydrography, street centerlines, ownership patterns, and building footprints from the New York City Open Data portal (https://nycopendata.socrata.com/). (See the list of references for the complete weblinks, below.) We digitized some additional streams and tidal salt marshes that are not shown on these datasets, particularly within the New York Botanical Garden, Bronx Zoo, and Concrete Plant Park. We also obtained ArcGIS shapefiles of current Bronx River wetland priorities from the Department of Parks and Recreation (Sarah Tobing, personal communication.)

Although somewhat incidental to the main thrust of this study, we examined three different geographic descriptions of the modern wetlands of the west Bronx. We obtained the New York State wetlands from the National Wetland Inventory maintained by the U.S. Fish and Wildlife Service and freshwater wetlands from the New York State Department of Environmental Conservation (full citations with weblinks are provided in the reference list). These were compared to the City of New York's hydrographic features, referenced above. Each of these geographic descriptions uses a slightly different classification system, so we attempted to "cross-walk" the datasets by assigning them to three main classes that seem particularly relevant to wetland restoration in the Bronx: tidal salt marshes, freshwater wetlands, and open water. We know that these broad classes hide further underlying variation (c.f. Sanderson 2009), however they provide a simple framework to try to make sense of what different government authorities actually think the wetlands of the west Bronx actually are.

We analyzed the historic and current data to measure the amount of areal or linear length change in features between the early 19th century (as represented by the synthesized historical datasets) and the current condition (Table 2). We also analyzed the current ownership patterns of lands where historic wetlands have been buried under landfill to identify possible future restoration opportunities, particularly on public land (Table 3). To help with the interpretation of the change condition we searched the historical literature for descriptions of the features, creating a placename database. Although this effort remains incomplete, we did find selected descriptions (excerpted in Table 4.) Finally we compared the current Bronx river wetlands (according to different government geographic descriptions) (Table 5) and priority areas (Table 6; Figure 3) in the west Bronx to the historical condition and suggest other speculative opportunities for wetland and stream restoration between the Harlem and Bronx Rivers.

Data access

The synthesized shapefiles are available via welikia.org/downloads.

Results and Discussion

Figure 1 and Table 2 shows the change in hydrographic and wetland features since the early 19th century in west Bronx. Our synthesis dataset indicates that the western Bronx once was watered by at least 94 km (58.4 miles) of streams (including the Bronx River). Major historical streams, heading west from the Bronx River to the Harlem / Hudson Rivers, were Leggett's Creek, Bungay Creek, Mill Creek, Cromwell's Creek, and Tibbett's Brook, each nestled in its own generally north to south trending river valley. Of these, only the Bronx River and Tibbett's Brook still run above ground, though even in these cases the tributaries are almost entirely built over. Particularly notable in stream losses is the complete sewerage of Mill Creek, which was once almost nearly as long as the Bronx River and a feature of primary importance to the early urban development in the Bronx. Today the West Bronx retains approximately 16% of its original length of streams and rivers.

The West Bronx also had an extensive set of tidal salt marshes, particularly along the East River and at the mouths of the aforementioned streams and rivers (Figure 1a). We also documented four freshwater wetlands in the precincts of what is now Woodlawn Cemetery and van Cortlandt Park. There may have been additional wetlands in the Fordham section of the study area, though these are not included in the reported totals, as they are shown only on 18th century maps like SDR 191 and the British Headquarters

Map (Sanderson 2009). Of the original 307 ha wetlands of wetland in the study area less than 1% remain, and these are largely constructed wetlands in the confines of the Bronx Zoo and New York Botanical Garden. Some restoration has also restored some of the Bronx River tidal wetlands, for example, at Concrete Plant Park. Note that we have not attempted in this study to estimate stream or river associated floodplain forests, which in general are not indicated clearly on the SDRs used for this study (though see SDR 166).

In terms of land area, the West Bronx has gained about 5% in area over the last 200 years, mostly through land filling of tidal wetlands and adjacent shallow estuary waters. Also included among the additions is the land mass of Marble Hill, which was once a near island at the mouth of Tibbett's Brook, but which has subsequently been welded to the rest of the Bronx through landfill, though the Marble Hill neighborhood remains politically part of Manhattan.

There is no doubt that the West Bronx has lost streams and wetlands over the last 200 years; exactly how much depends on which version of the modern wetlands and waterway data one compares to. We located wetland maps for the Bronx mapped at the Federal, state, and local (city) government levels, and compare them in Table 5. Making the comparison is more difficult than it should be because each description uses different classification systems and different approaches to include or not include open water areas (i.e. ponds and lakes/reservoirs) and tidal marshes and/or estuarine waters. Also it seems that some wetlands mapped in some of these data layers may no longer exist. For example, the National Wetland Inventory maps several small freshwater emergent wetland areas in Hunts Point which no longer appear to exist on examination by Google Maps. Since there are relatively few areas, and since they have the possibility to still be extant, we recommend some field work to assess the wetlands mapped on these data layers within the west Bronx study area.

Critical to any future restoration projects is the willingness and capability of land owners. The City and other government agencies, and non-profit entities like the Wildlife Conservation Society, New York Botanical Garden and Woodlawn, are significant land owners/managers of filled and new wetlands within the study area (Table 2). Areas of landfilled wetlands currently managed by the city government include the Concrete Plant Park, the Hunts Point industrial area, scattered areas in the extreme south Bronx, in the areas around Yankee Stadium, and in the Tibbett's Brook watershed within and south of van Cortland Park. Several significant blocks of land are unbuilt as shown in Figure 2.

The City of New York's Department of Parks and Recreation has identified 76 individual areas as wetland priorities in the west Bronx, which collectively total 17.86 ha (Table 6; Figure 3). If all these areas were successfully restored and added to the approximate 3.04 ha of existing wetlands, then the city would have succeeded in bringing back approximately 7% of the historical wetland distribution. These priority areas fall mainly along the Bronx River corridor, Tibbett's Brook, and the Harlem and Hudson River shorelines. It is interesting, and not surprising, that most of the areas considered for restoration are described along the extant waterways (mainly the Bronx River, but also Tibbetts Brook), as opposed to waterways completely lost like Mill Brook or Leggett's Creek. In terms of addressing the needs of nature-impoverished people in the Bronx, the city may want to consider additional sites along Mill Brook, Leggett's Creek, Bungay Creek and/or Cromwell's Creek, all important waterways in the past. The city should consider additional wetland sites that were formerly major wetland complexes at Hunts Point; the cluster of parks around Brook Park, Peoples Park and Saw Mill Playground in Mott Haven and along Bronx Kill; around Yankee Stadium (especially River Avenue Park and East 161st Park); the freshwater wetland areas of Woodlawn Cemetery and in van Cortlandt Park (in addition to the Tibbetts Brook wetland); and the Department of Education property at 3350 Johnson Ave in Spuyten Duyvil.

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Tables and Figures

Table 1. Spatial data resources (SDRs) used in this study of the historical ecology of the West Bronx

SDR	Reference	# of control points	RMS Error	Digitized features
138	Bien & Vermeule, 1891. Long Island Sound, Westchester north to Mt. Vernon, Queens south to Jamaica.	42	13.2	Forests, ponds, shoreline, streams, wetlands
147	New York (N. Y.). Dept. of Parks. Topographical Division -- Author, 1873. Topographical map made from surveys by the commissioners of the Department of Public Parks of the City of New York of that part of Westchester County adjacent to the City and County of New York embraced by chapter 534 of laws of 1871 as amended by chapter 878 of laws of 1872.	100	23.3	Ponds, shoreline, streams, topography, wetlands
166	Viele, E.L. & Quakenbush, C., 1874. Topographical Atlas Of The City Of New York Including The Annexed Territory. V. (Northernmost portion). Showing original water courses and made land.	102	13.4	Ponds, shoreline, streams, wetlands
278	Bache, A.D., 1863. Hudson River from New York to Haverstraw [Sheet No. 1].	42	32.9	Forests, ponds, shoreline, streams, wetlands, bathymetry
425	Renard, C., 1837. Harlem River and Throg's Neck (in two parts).	20	46.5	Forests, shoreline, streams, topography, wetlands
428	Renard, C., 1837. Manhattan Island, northern part of New York City to West Farms.	40	21.6	Forests, shoreline, streams, wetlands
429	Mechan, J., 1857. Manhattan, Shores of Harlem River and Spuyten Duyvel Creek with adjacent topography.	105	20.2	Forests, ponds, shoreline, streams, topography, bathymetry
430	Rockwell, C., 1859. Manhattan, Harlem River, east side, from High Bridge to Kingsbridge.	36	14.9	Forests, shoreline, streams, topography, wetlands
432	Gerdes, F.H., 1853. Manhattan, Hudson River, from Spuyten Duyvel Creek to Sounding Point.	28	33.4	Forests, shoreline, streams, topography, wetlands
191	Skinner, A., Taylor, G., n.d. A map of the country adjacent to Kings-bridge surveyed by order of His Excellency General Sir Henry Clinton … 1781. Surveyd & drawn by And[re]w Skinner and George Taylor.	45	>50	Not used for synthesis
70	Beers, F.W., 1868. West Farms and Morrisania.	45	>50	Not used for synthesis

Table 2. Estimated changes in land, wetland and open water areas, and stream length in the West Bronx from the early 19th century to 2013. Land areas are in hectares and lengths in meters. Historical data was developed as explained in the methods section; the 2013 figures are based on the hydrographic data from the New York City Department of Information Technology and Telecommunications (DOITT). Also see Table 5.

Feature	**Early 19th century**	**2013**	**Absolute Change**
Area of land (ha)	4,791.0	5,005.6	+214.6
- Land fill (includes Marble Hill from Manhattan) (ha)	-	-	+232.5
- Land loss (ha)	-	-	-17.9
Area of wetlands (ha)	307.0	3.4	-303.6
- Area of tidal salt marsh (ha)	284.3	0.5	-283.8
- Area of freshwater marsh (ha)	22.7	2.9	-19.8
Area of open freshwater (ha)	20.6	52.2	+31.6
- Van Cortlandt Lake (ha)	13.0	7.0	-6.0
- Jerome Reservoir (ha)	0	36.8	+36.8
- All other ponds (ha)	7.6	8.4	+0.8
Length of streams (m)	94,572	15,838	-78,734
- Bronx River (m)	15,150	12,922*	-2,228
- Mill Brook (m)	13,634	0	-13,634
- Leggett's Creek (m)	8,302	0	-8,302
- Tibbett's Brook (m)	5,799	1,774	-4,052
- Bungay Brook (m)	4,949	0	-4,949
- Cromwell's Creek (m)	2,715	0	-2,715
- All other streams (m)	44,022	1,142	-42,880

* Estimated as half the perimeter from the DOITT shoreline polygon for the Bronx River

Table 3. Summary of current ownership of historical wetland areas that have been landfilled in the West Bronx

Ownership (according to MapPLUTO v13v2)	**Historic tidal salt marsh (ha)**	**Historic freshwater wetlands (ha)**
City Ownership	62.7	8.9
Mixed City & Private Ownership	0	0
Other Public Authority, State or Federal Ownership	11.7	0
Tax Exempt Property (city, state, federal government; public authority; or private institution)	6.5	0
Private Ownership	70.8	11.4
Not given (presumed private)	132.6	2.4

Table 4. Selected descriptions of historical features in the West Bronx study area.

Name	Feature type	Alternate Names	Description
Hunts Point	General topography	Quinnahung *Lenape* (Jenkins 1912, McNamara 1991)	"This was a Siwanoy Indian name for Hunts Point, although ordinarily the Siwanoys did not cross to the west bank of the Bronx River. It meant 'The Planting Neck.'" (McNamara 1991, 374)
		Planting Neck *English* (Jenkins 1912)	
		Corne Field Neck *English* (Jenkins 1912)	"Beyond Lafayette Avenue, the neck still remains a meadow land, though some of the streets are laid out and are being graded (Jenkins 1912, 381)
		Hunt's Point *English* (Jenkins 1912)	
Mill Brook	Stream	Mill Brook *English* (McNamara 1991, 15)	"The valley between Fordham Ridge and the ridge on the easterly side of the Bronx valley is wide at its southern part, allowing of several minor ridges forming the valley of Mill Brook." (Jenkins 1912, 15)
		Mill Creek *English* (Hyde & Co. 1900)	
		Morris Mill Brook *English* (Beers et al. 1867)	"In the improvements in the decade before 1900, the stream disappeared within a great sewer under Brook Avenue, which follows approximately the bed of the old stream." (Jenkins 1912, 16)
		Morrisena Creek *English* (Kitchin 1788)	
Spuyten Duyvil	Stream	Muscoota *Lenape*(Jenkins 1912, 178)	"Nature had placed in the middle of Spuyten Duyvil Creek a reef which was bare at low tide, and which had been from time immemorial a ford, or wading place, to and from the mainland." (Jenkins 1912, 182)
		Paparinemo *Lenape* (Cook 1913, 7)	
		Shorackkappock *Lenape* (Cook 1913, 6)	
		Speijt den Duyvel *Dutch* (Cook 1913, 7)	"Many will no doubt recall Washington Irving's legend on the origin of Spuyten Duyvil - how trumpter Anthony Van Corlaer arrived at the creek one stormy day to summon the Dutch farmers of the mainland to the defence of New Amsterdam, and found no ferryman daring enough to venture across. The wind was blowing a

Spuyten Duyvil (con't.)		Spikendevil *English* (Cook 1913, 7)	perfect hurricane, which sent the waters swirling like a maelstrom. For a short time Anthony [Van Corlaer, of New Amsterdam] vapored like an impatient ghost upon the brink, and then bethinking himself of the urgency of his errand, took a hearty embrace of his stone bottle, swore most valorously that he would swim across 'in spite of the devil' (en spijt den Duyvil), and daringly plunged into the stream. Luckless Anthony! Scarce had he been buffeted half way across the stream, when he was observed to struggle violently as if battling with the spirit of the waters - instinctively he put his trumpet to his mouth, and giving a vehement blast, sank forever to the bottom." (Cook 1913, 8)
		Spiking Devil *English* (Cook 1913, 7)	
		Spitting Devil *English* (Cook 1913, 7)	
		Spouting Devil *English*(Cook 1913, 7)	"The mile-long stretch of the river that divides the two boroughs at 218th Street had three crossings. That stretch is also known as Spuyten Duyvil Creek, although today it is a deep channel connecting the Harlem River to the Hudson." (Pritchard 2002, 95)
		Spouting Devil Creek *English* (Cook 1913, 6)	
		The Fresh Spring *English* (Cook 1913, 7)	
Tibbetts Brook	Stream	Mosholu *Lenape* (Cook 1913, 61)	"The name is an Indian one, referring to the small stream called by them 'Mosholu,' but known today as Tibbett's Brook. Professor Tooker, and authority on the tribal tongue, believed it meant 'smooth stones' or 'small stones.'" (McNamara 1991, 145)

Tibbets Brook (con't.)		Tibbet's Brook *English* (Pritchard 2002, 97)	"On an 1897 Bromley Atlas, Tibbett Avenue is laid out though not yet opened. Between Tibbett and Johnson,South of 230th Street There is a frame building shown for the first time." (Historical Perspectives, 1987, 20)
		Tippett's Brook *English* (Ultan 2009, 2)	
		Uncas River *English* (Cook 1913, 59)	"Besides the deer, the wild turkey existed in great numbers on the verge of the forest. It is said that flocks of them used to fly from the ridge west of Van Cortlandt Park across Tippet's Brook to a hill east of this little stream. The flight was always begun by a large black cock, and was made at sunset. The leader gave the note and the flock were at once on the wing." (Cook 1913, 59)
		Yonkers River *English* (Jenkins 1912, 178)	

Table 5. Comparison of modern wetland inventories for the West Bronx.

Project wetland categories:	Area (ha)			Notes
	Tidal salt marshes	Freshwater wetlands	Open Water	
U.S. Fish & Wildlife Service (2013) National Wetland Inventory				
Estuarine and Marine Deepwater	?		12.2	Very thin strip along tidal Bronx River and Harlem River; may include some salt marsh as well as estuarine waters
Freshwater Emergent Wetland		5.9		Associated with Tibbetts Brook north of van Cortlandt Lake and several areas in Hunts Point that no longer appear to have ponds or wetlands
Freshwater Forested/Shrub Wetland		10.7		Discrete areas within Bronx Zoo, Woodlawn Cemetery, van Cortlandt Park, and north of the New York Botanical Gardens near the Bronx River
Riverine		0.9		Riparian buffers along portions of Tibbetts Brook and the Bronx River
Freshwater Pond			11.7	Includes van Cortlandt Lake
Lake			37.9	Jerome Reservoir
New York State Department of Environmental Conservation (1999) Freshwater wetlands				
Class I		29.0		Includes van Cortlandt Lake
City of New York Department of Information Technology & Telecommunications (2009) Hydrographic features				
Lake/Reservoir			43.8	Includes Jerome Reservoir and van Cortlandt Lake
Pond			8.4	Mainly in the Bronx Zoo, New York Botanical Garden, and Woodlawn Cemetery
Stream wider than 8 ft			1.1	Tibbett's Brook
Wetlands	0.5	2.9		Separated by the Welikia Project; includes some additional areas not in the DOITT layer as described in the text

Table 6. Summary of City of New York Department of Parks and Recreation Natural Resources Group Wetland Priority Areas in the West Bronx (Jamie Ong and Sarah Tobing, personal communication)

NRG West Bronx Wetland Restoration Priority Sites	Waterway	Area (ha)
Bridge Park	Harlem River	1.48
Bronx River Park 179th to 181st & 182nd St Dam	Bronx River	0.61
Bronx Zoo and Dam (WCS)	Bronx River	2.08
Concrete Plant Park	Bronx River	0.12
Depot Place	Harlem River	0.50
Muskrat Cove	Bronx River	1.94
Mill Pond Park - Pier 5	Harlem River	0.09
Riverdale Park	Hudson River	0.87
Shoelace Park	Bronx River	4.19
Snuff Mill Dam (NYBG)	Bronx River	0.48
Tibbetts Brook Daylighting	Tibbetts Brook	3.43
Tibbetts Brook Riparian Restoration	Tibbetts Brook	2.08
Total		**17.86**

Figure 1. Comparison of land area and hydrographical features (open water, wetlands, and streams) in the West Bronx from (a) the early 19th century, (b) 2013. Figure 1c shows the current features with the street center lines.

Figure 1a.

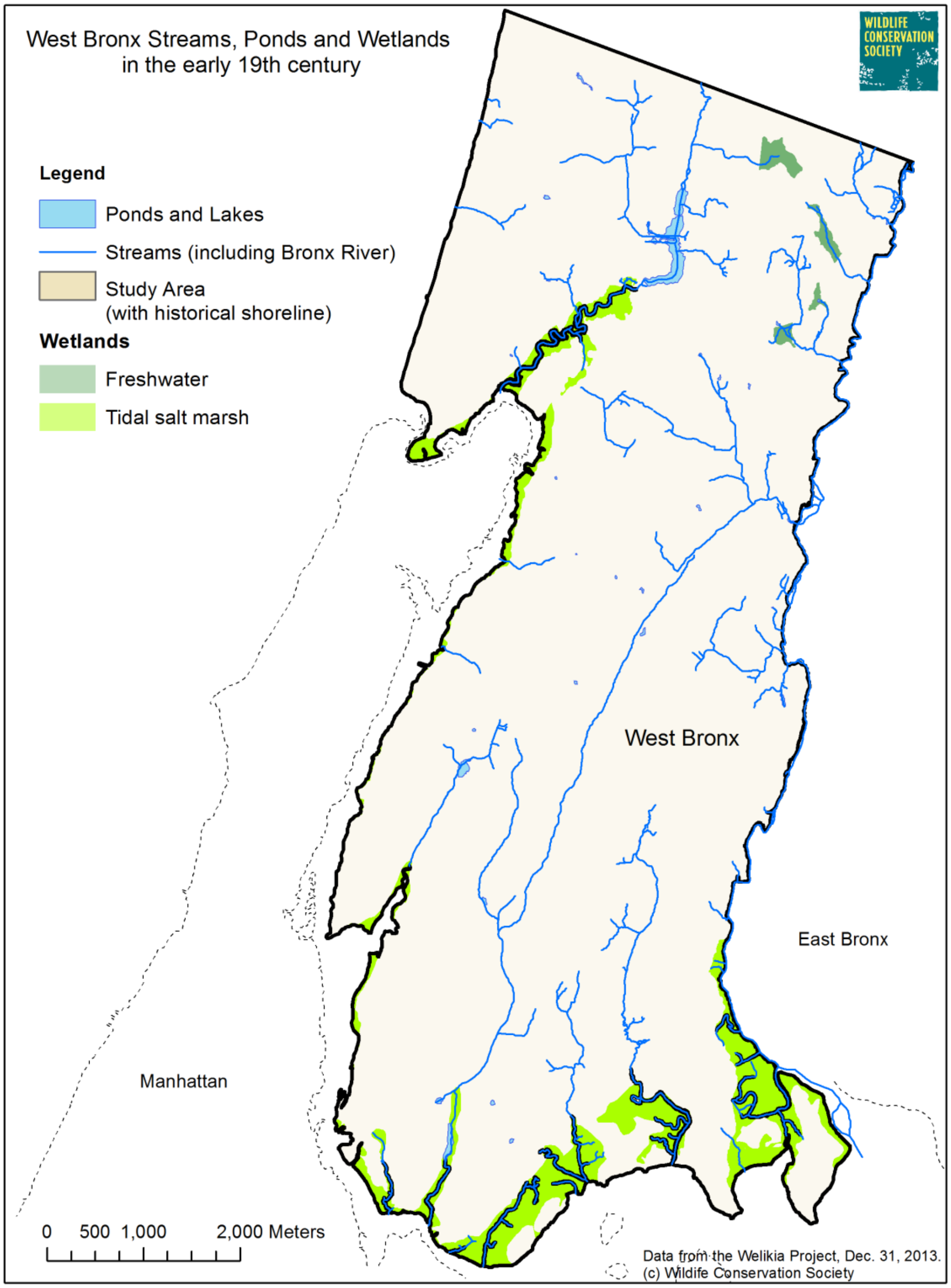


Figure 1b.

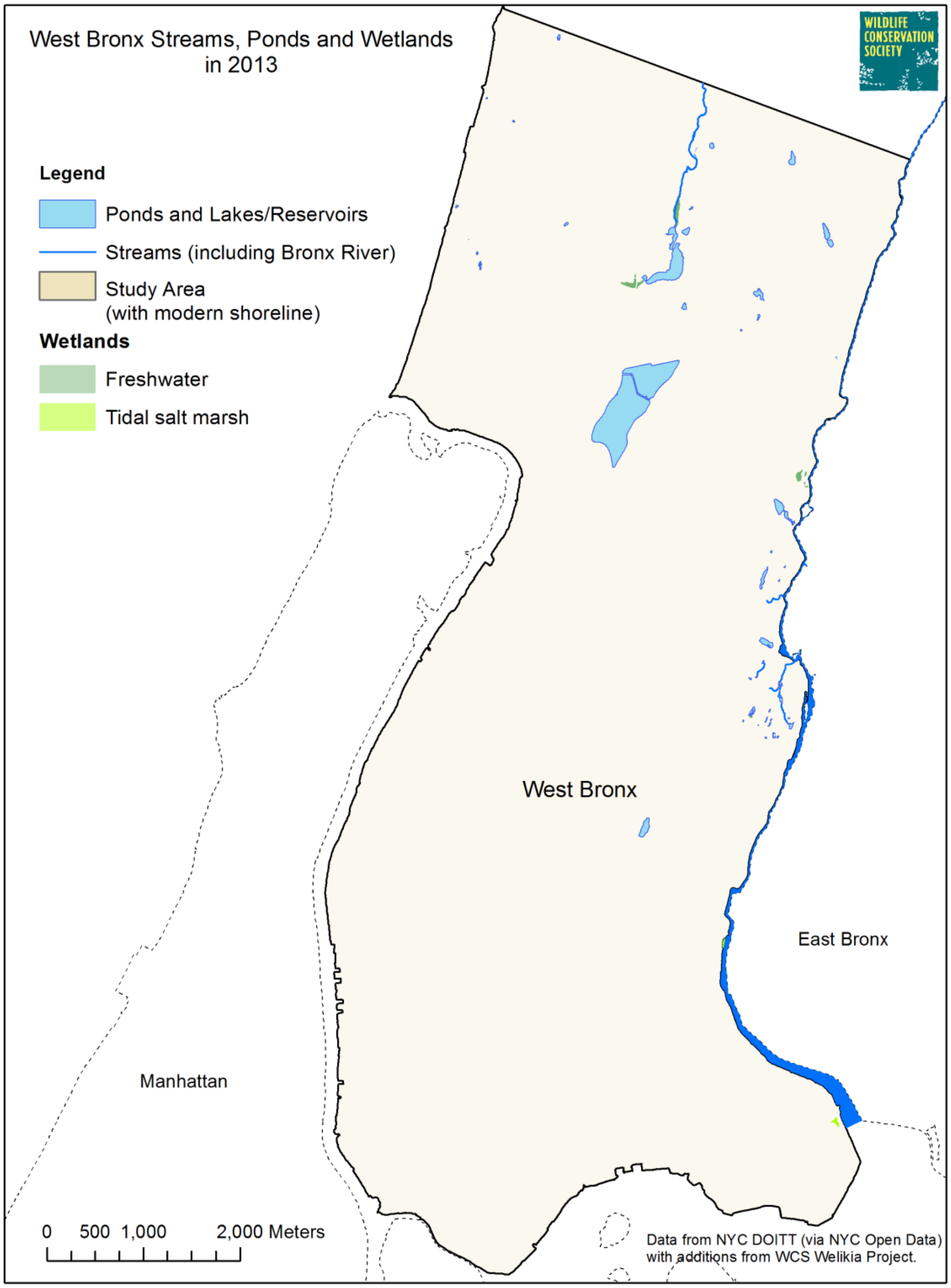

West Bronx Streams, Ponds and Wetlands
in 2013
WILDLIFE CONSERVATION SOCIETY
Legend
Ponds and Lakes/Reservoirs
Streams (including Bronx River)
Study Area
(with modern shoreline)
Wetlands
Freshwater
Tidal salt marsh
West Bronx
East Bronx
Manhattan
0 500 1,000 2,000 Meters
Data from NYC DOITT (via NYC Open Data)
with additions from WCS Welikia Project.

Figure 1c.

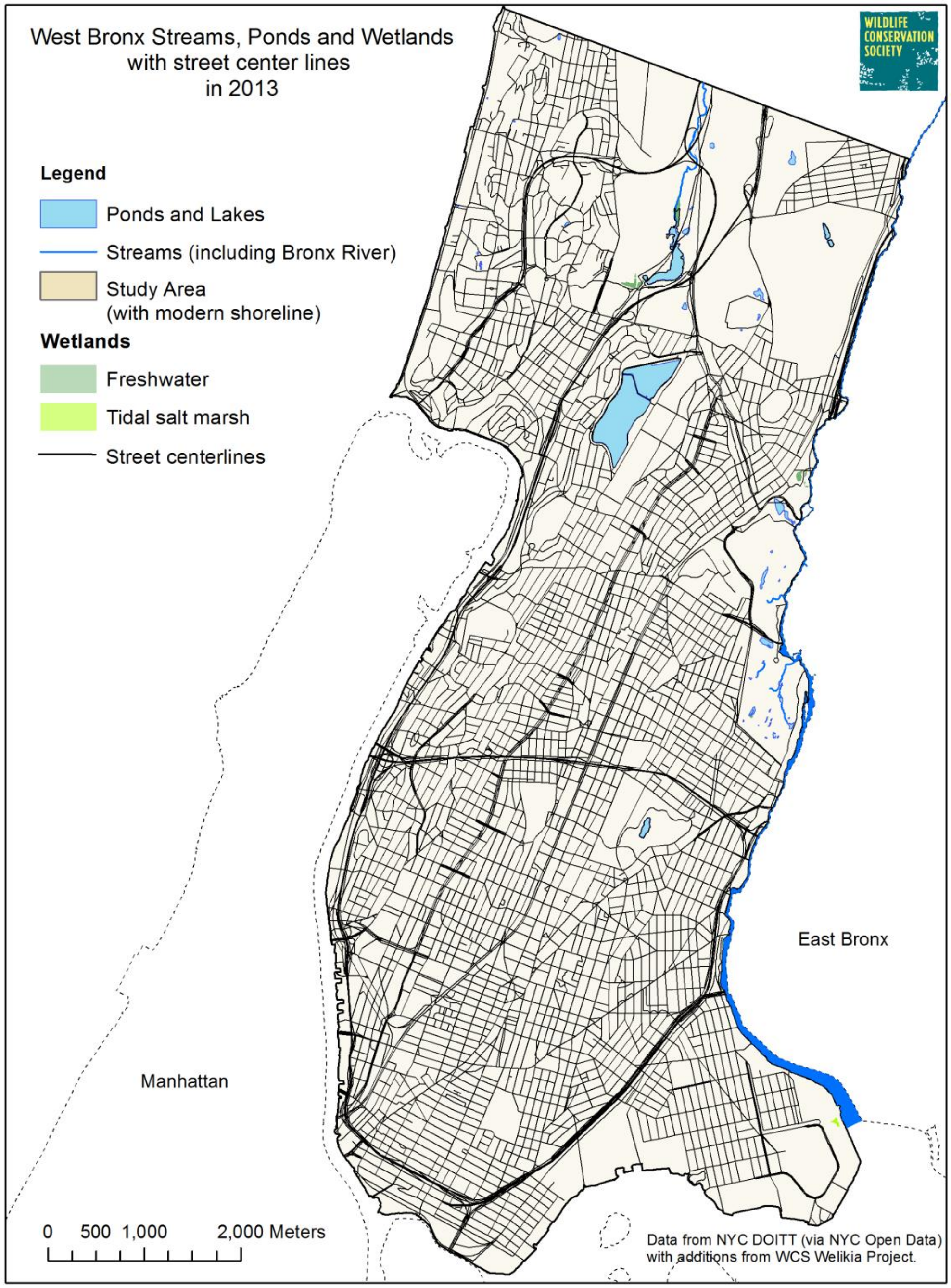

West Bronx Streams, Ponds and Wetlands
with street center lines
in 2013
WILDLIFE CONSERVATION SOCIETY
Legend
Ponds and Lakes
Streams (including Bronx River)
Study Area
(with modern shoreline)
Wetlands
Freshwater
Tidal salt marsh
Street centerlines
East Bronx
Manhattan
0 500 1,000 2,000 Meters
Data from NYC DOITT (via NYC Open Data)
with additions from WCS Welikia Project.

Figure 2. Comparison of the distribution of early 19th century streams and wetlands and the 2013 pattern of ownership in (a) the west Bronx.   Detail maps show (b) Hunts Point, (c) South Bronx, (d) Spuyten Duyvil, and (e) Woodlawn Cemetery and New York Botanical Garden.

Figure 2a.

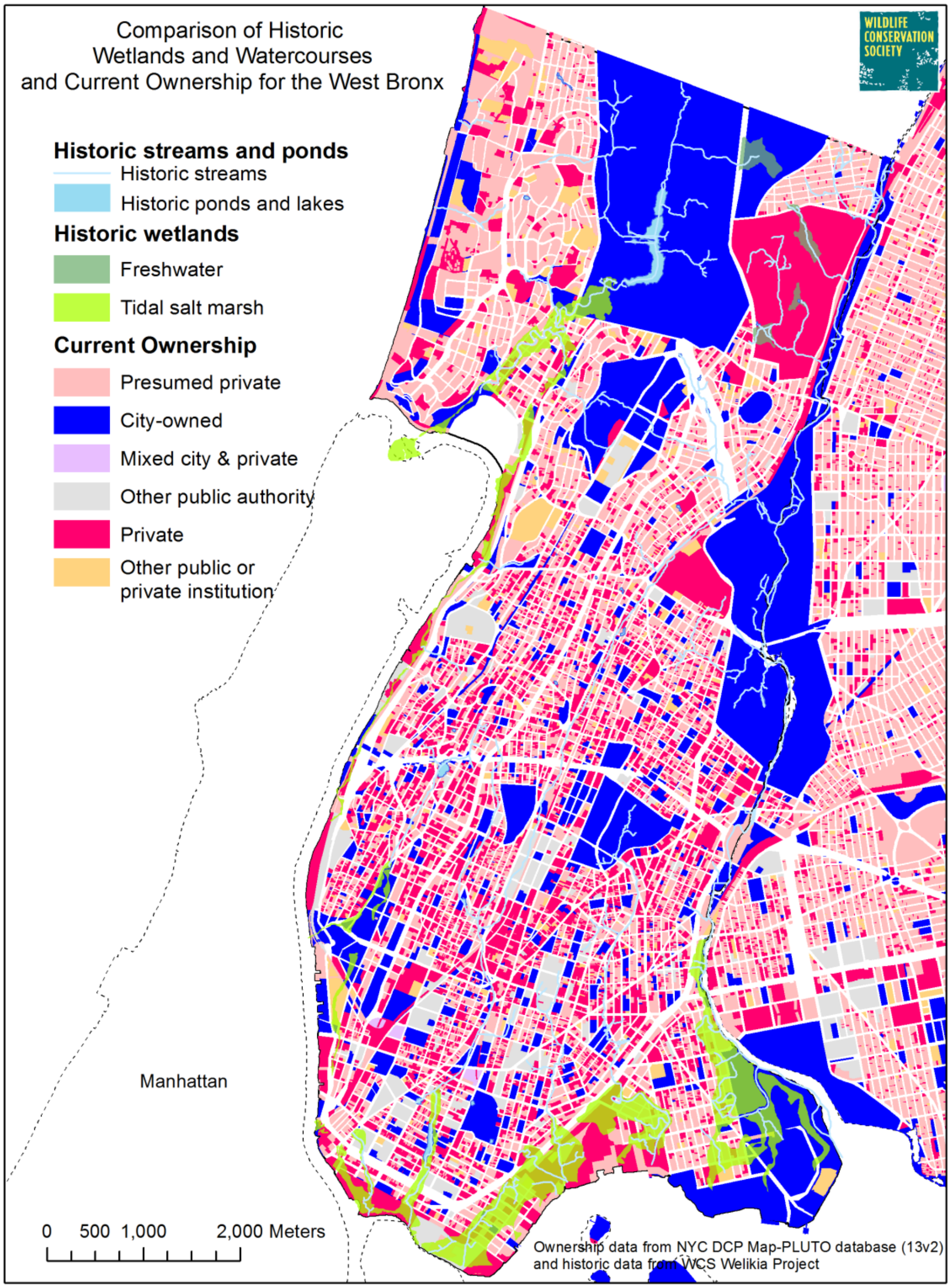


Figure 2b.

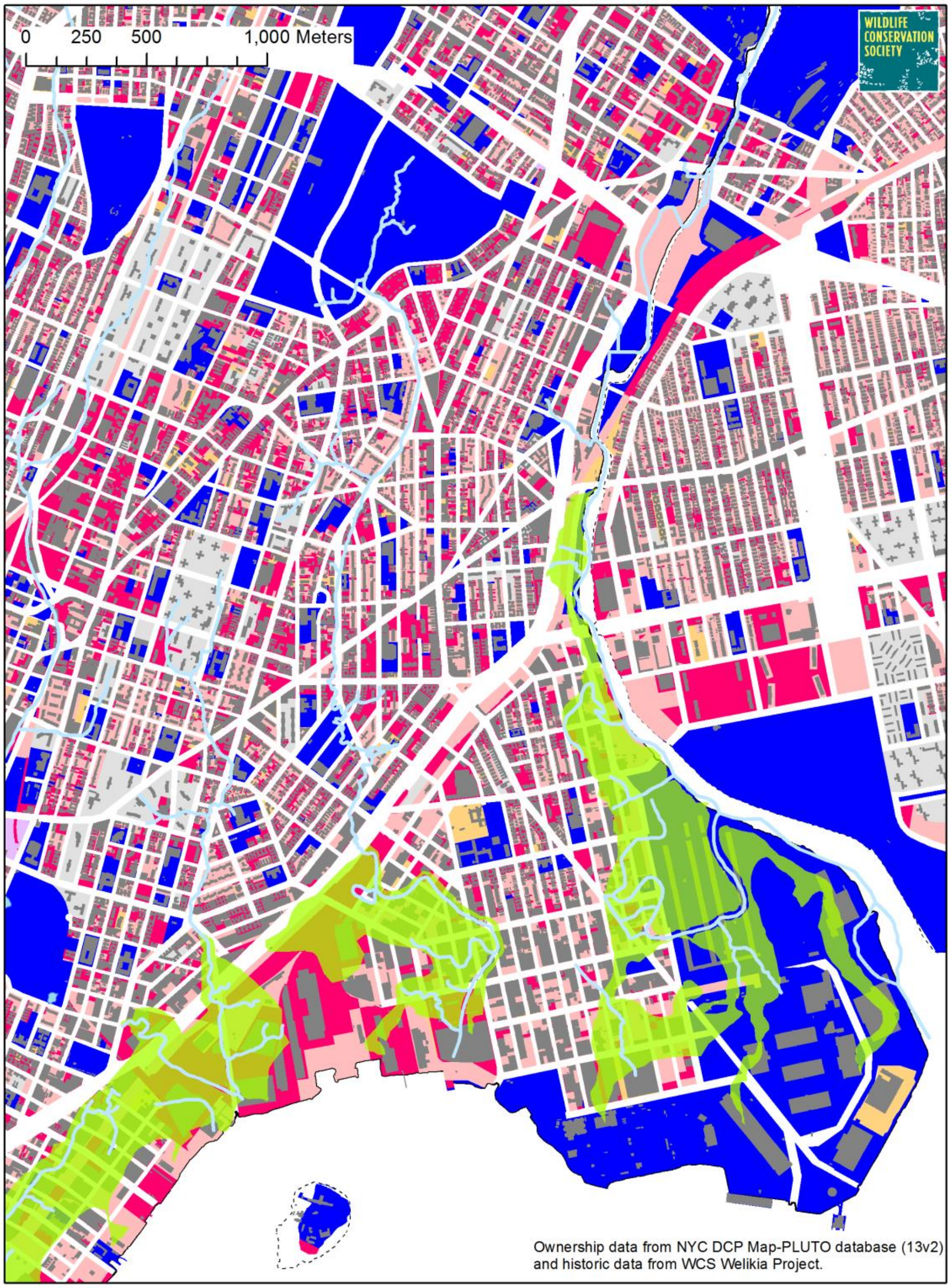
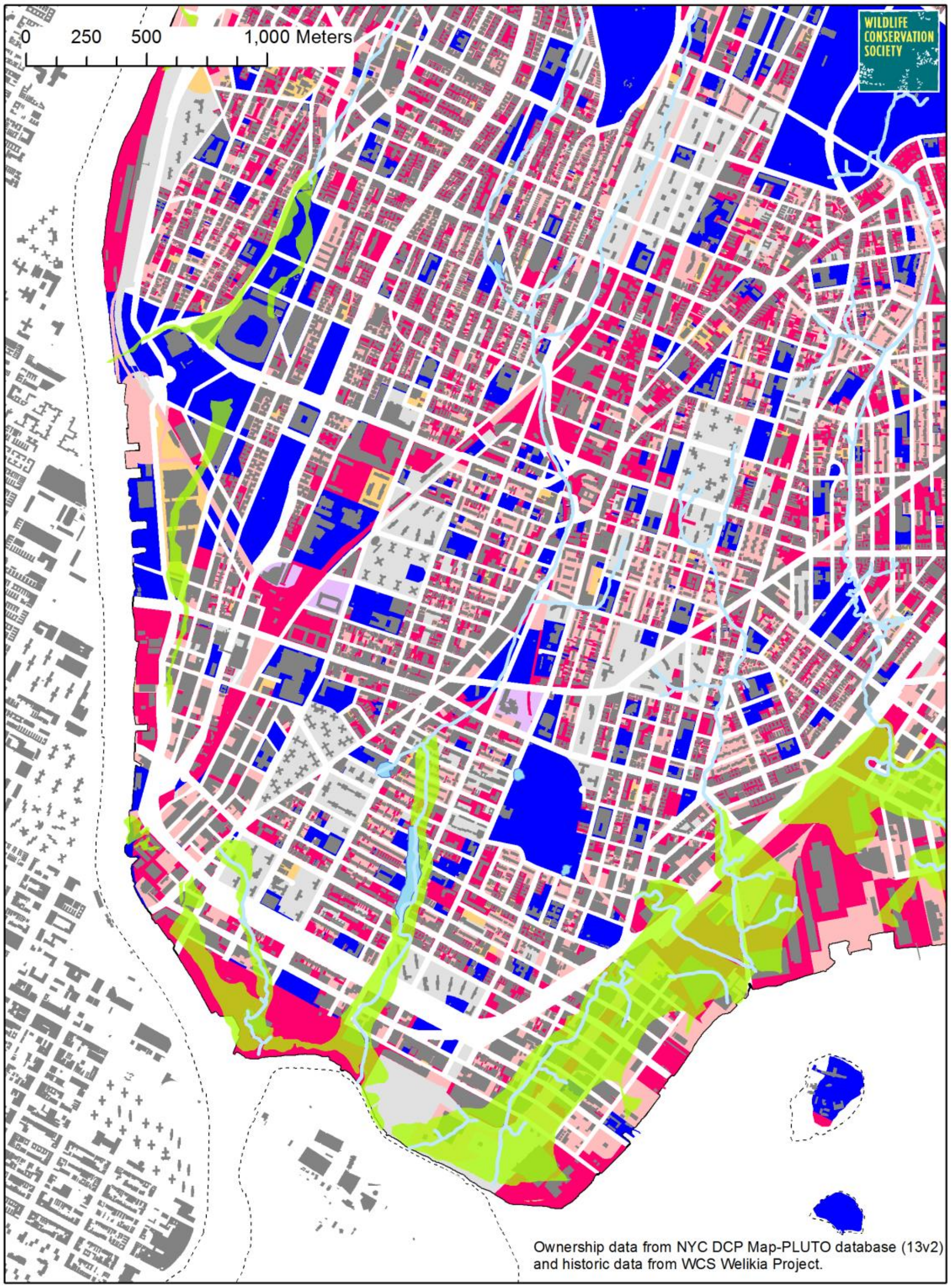
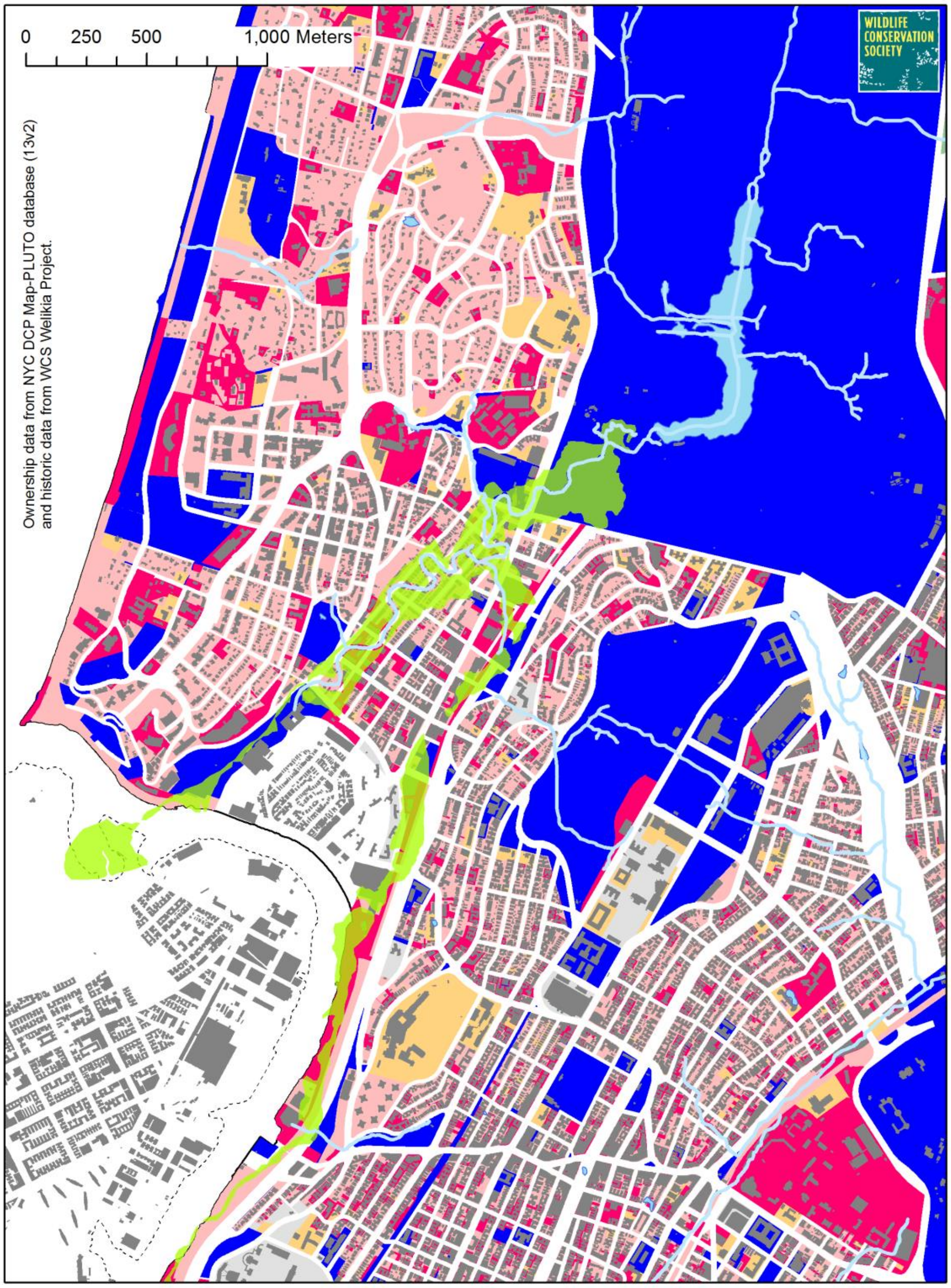

0 250 500 1,000 Meters
WILDLIFE CONSERVATION SOCIETY
Ownership data from NYC DCP Map-PLUTO database (13v2)
and historic data from WCS Welikia Project.

Figure 2c.



0 250 500 1,000 Meters
WILDLIFE CONSERVATION SOCIETY
Ownership data from NYC DCP Map-PLUTO database (13v2) and historic data from WCS Welikia Project.

Figure 2d.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WILDLIFE CONSERVATION SOCIETY
Ownership data from NYC DCP Map-PLUTO database (13v2) and historic data from WCS Welikia Project.

Figure 2e.

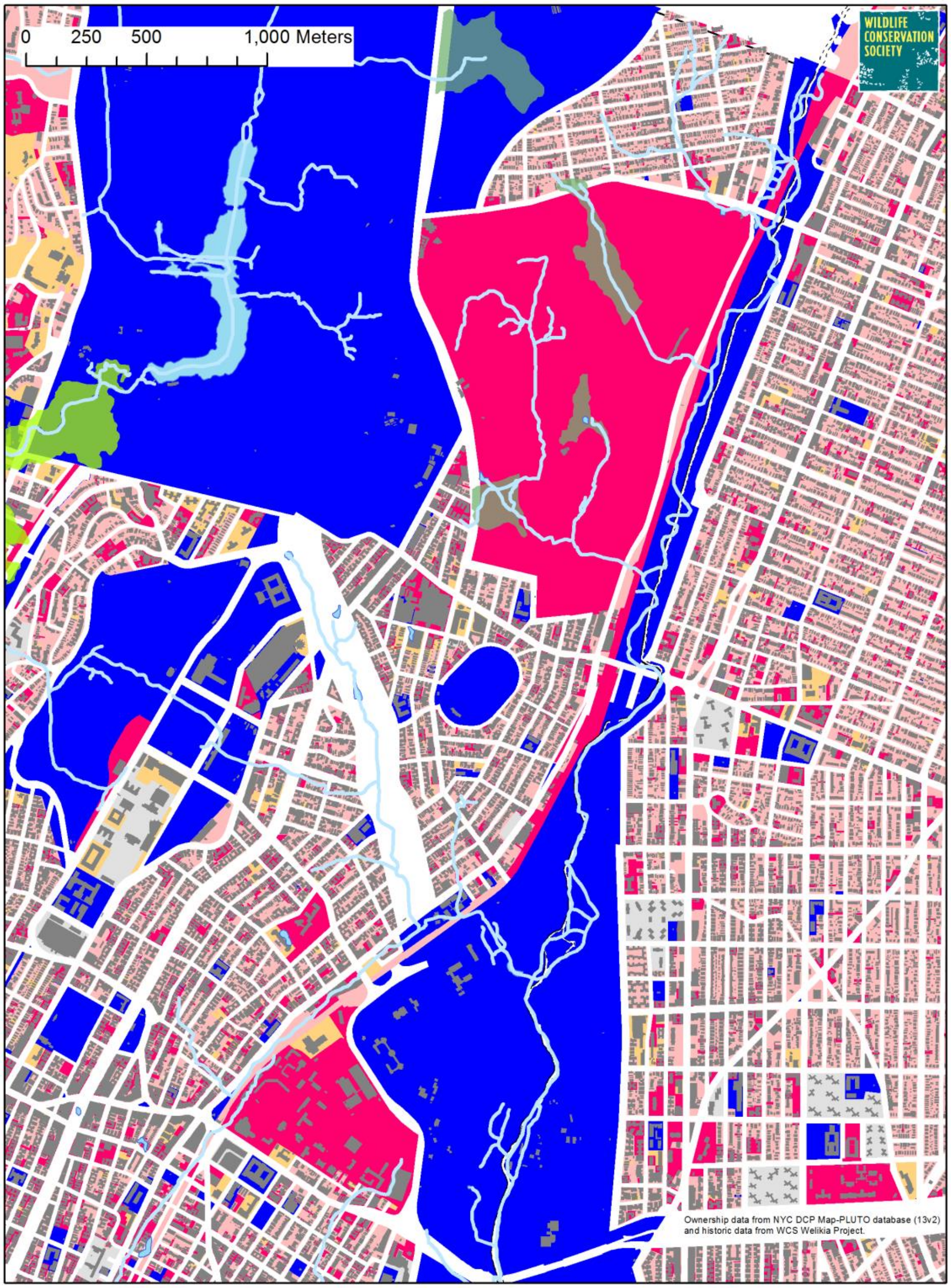
0 250 500 1,000 Meters
WILDLIFE CONSERVATION SOCIETY
Ownership data from NYC DCP Map-PLUTO database (13v2)
and historic data from WCS Welikia Project.

Figure 3. Comparison of current Bronx River wetland restoration priorities from the Department of Parks and Recreation's Natural Resource Group (NRG) and historic streams and wetlands of the West Bronx.