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Advancing urban ecosystem governance in New York City: Shifting towards a unified perspective for conservation management

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ABSTRACT

New York City's extensive municipal park system is home to forests, wetlands, and grasslands that provide important ecological and social benefits to the city's population. While efforts and programs exist to restore and protect these spaces, management recommendations are complex due to variable conditions in urban natural areas. To advance the management of urban natural areas, the first comprehensive ecological assessment was conducted through a collaborative effort across 4000 ha of natural areas within New York City parkland. Field and spatial data were collected and analyzed to identify the extent of forests, the types of forests, and their conditions. This approach will help guide decision-making and prioritization of natural area management at the regional level by developing unique quantitative targets for urban forests. This project serves as an example of collaboration between private and public institutions advancing the governance of urban natural areas to achieve citywide conservation and policy goals.

1. Introduction

New York City (NYC) is the most populous city in the United States (United States Census Bureau, 2014) and is recognized for its highly diverse ethnic and social makeup (New York City Department of City Planning, 2013) as well as its extensive park system (Trust For Public Land, 2014). Situated on three islands and the adjacent mainland of the Atlantic Coast of the United States (40.7127° N, 74.0059° W), NYC is home to more than 8.3 million residents living in the five boroughs of Manhattan, Queens, Bronx, Brooklyn, and Staten Island (United States Census Bureau, 2014). Within the five boroughs there is 117 km^2 of city-owned parkland – nearly 35 percent of which is managed as natural area parkland – including freshwater wetlands, salt marshes, rocky shorelines, beaches, meadows and forests (New York City Department of Parks and Recreation, 2015a). NYC's position straddling three physiographic provinces of the United States results in exceptional biodiversity (Kiviat and Johnson, 2013) which contributes to the critical ecosystem services that forests and wetlands provide to the city's residents (Flores et al., 1998; McPhearson et al., 2013, 2014; Nowak et al., 2007; City of New York, 2012). The confluence of geologic processes also contributes a range of unique habitats, from serpentine grasslands in Staten Island to vernal ponds in Alley Pond Park in Queens (Parisio, 1981; Greller, 1975).

Beginning in the 1980s, there was a systematic effort by the New York City Department of Parks (NYC Parks), a municipal agency, to inventory park natural areas and use these inventories as the basis for conservation and management of these 4000 ha (over 2000 ha of forest) (Sisinni and Anderson, 1993; Sisinni and Emmerich, 1995). These inventory efforts were conducted between 1984 and 2010 and primarily focused on qualitative inventories describing the spatial extent of broad categories of vegetation covertypes such as closed canopy forest, vineland and shrubland cataloging the dominant species within each covertype (see example: New York City Department of Parks and Recreation, 1987). Over the intervening decades, forest management became focused on reducing the cover of invasive plants and closing the forest canopy by planting native tree seedlings (New York City Department of Parks and Recreation, 2015b). These efforts were conducted by municipal contracts, NYC Park's staff, and volunteers, and was most notably funded by the MillionTreesNYC program (City of New York, 2011) which started in 2007 with the goal to plant one million trees citywide within a 10-year timeframe. Half of the million trees were designated to be planted as part of reforestation efforts in natural areas (as of 2015 over 95% have been planted). During the implementation of the MillionTreesNYC program the short-comings of using the qualitative, park-specific

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inventories to inform and prioritize work at the citywide scale were identified. The inventories failed to (1) reliably characterize vegetation assemblages in detail across all NYC Parks natural forests (2) provide data associated with management targets that could be summarized to compare the condition between and across forests in NYC's natural areas, and (3) identify goals and targets useful for site level work and long-term restoration and management. The inability of past inventory methods to address these goals highlighted the need to provide new scientific studies to understand the range of ecolgoical conditions in the urban context in order to identify realistic, quantitative targets, and link regional (across all NYC) and site-level (within a park) efforts for management actions. To help address this need, the Natural Areas Conservancy (NAC), New York City's only citywide parks conservancy, was created in 2012 to work in direct partnership with NYC Parks.

The first initiative of NAC was to conduct a citywide assessment of natural area parkland in NYC based on ecological metrics in 2013–2014. The goal of this assessment was to provide quantitative baseline data to enable categorization of the extent and condition of NYC's natural areas that would be used to set citywide and site-specific targets that are informed by the range of existing conditions. Field assessments were conducted across three main ecological systems: salt marshes, freshwater wetlands, and upland forests with data collection protocols unique to each system. In this publication we focus on the results and applications of the forest assessment. The forest assessment included two types of data (1) an in-depth field study of 1124 fixed area research plots in more than 50 parks, including data on key forest health and threat metrics (Table 1); and (2) a remotely-sensed mapping project defining the spatial distribution of all vegetation associations across New York City.

2. Concepts and theories in urban ecosystem governance

Urban forests exist in a unique mosaic surrounded by the built environment and human influenced features (Dale et al., 2000) and are impacted by the consequences of previous disturbances and current urban stressors (McDonnell and Pickett, 1993). These factors have been shown to lead to altered ecosystem function and process, including differences in flora and fauna assemblages, and air, soil, and water quality (McDonnell et al., 1997; Pouyat et al., 1995, 1996; White et al., 2004). Theories and approaches for management and restoration of urban and other human-altered ecological systems have been identified at multiple scales (Flores et al., 1998; Zipperer et al., 1997; Hobbs, 2007, 2010; but see Murcia et al., 2014) yet there is little work cited that translates theory to applied urban woodland management.

In multiple cities in the United States (i.e., Chicago, Seattle, and San Francisco), data from baseline condition assessments of urban natural areas has been used to create citywide prioritization structures to direct long term management (Prairie Research Institute, 2014; GreenSeattle, 2004; City of San Francisco, 2006). These data-based, prioritization frameworks for forest management are useful in urban areas to maximize limited municipal budgets while conducting conservation and restoration efforts that address urban pressures such as encroachment, invasive species and fragmentation. In Chicago, IL (USA) a comprehensive master plan for Cook County (Prairie Research Institute 2014) was released which summarizes the ecological and cultural values and threats across the 28,000 ha forest preserve. This plan outlines the distribution of different vegetation types and management threats such as invasive species, fragmentation, vandalism and the absence of wildfire. This plan also describes a five-tiered condition rating for land parcels based on factors including the rarity, sensitivity, and potential for restoration of their significant features. Similarly in 2004, the City of Seattle, WA (USA) produced a 20 year strategic forest plan (GreenSeattle, 2004) written in partnership with private and public organizations that categorized the condition of their city's forests into nine groups based on a field assessment that simplified forest value as percent canopy closure and threat as percent invasive species composition. Using this plan as a framework, Seattle has been able to communicate the resources needed for management and recruit a large volunteer stewardship effort. Citywide prioritization frameworks help managers faced with resource allocation decisions and also serve as important tools for communicating the range of conditions found in urban forests and the efforts needed to address them.

Table 1
Key ecological attributes, indicators, and data collected during the citywide forest assessment in New York City. All field data was collected in New York City during May-October 2013 and 2014.

Key ecological attributes of healthy urban forests	Indicators	Field measurement (10 m radius plot, 4 1 × 1 m subplots)
Forest canopy dominated by native species	Relative basal area (m^2/ha) of native tree species	All trees > 10 cm DBH (diameter at 1.37 m): Species and DBH
Canopy closure >50%	Percent canopy closure	Analysis of canopy photo and visual estimate of percent canopy closure in fixed-area plot (4 photos/plot)
Healthy forest canopy	Proportion of trees with a healthy canopy	Dieback, discoloration of foliage, defoliation, and vigor class estimations of trees > 10 cm DBH
Complex vertical structure present	Vegetation lifeforms in the understory, midstory, and overstory	Abundance and size class for woody plants (<2 cm DBH sampled in 1 m × 1 m subplots)
Forest understory dominated by native species	Diversity and relative cover of native herbaceous species	Percent cover of all herbaceous plants and woody plants <2 cm DBH (1 m × 1 m subplots)
Soil quality and chemistry suitable for supporting native plants	Range of pH, organic matter, macro- and micro-nutrients, heavy metals	Soil sample collected at each 10 m radius plot
Structure present on forest floor	Leaf litter and downed woody material present on the forest floor	Leaf litter and duff depth measurements, percent cover forest floor substrate, volume of fine, medium and coarse woody material, and decay class of coarse woody material
Limited herbivory damage to vegetation	Browse on vegetation (deer), missing leaf tissue (insect defoliation)	Percent herbivory classes for understory plants and trees/shrubs (2–10 cm DBH)
Native tree regeneration present	Tree seedlings present in the understory	Woody seedling percent cover and individual count (1 m × 1 m subplot)
Limited encroachment and anthropogenic alternations	Dumping, desire lines, vandalism, trash	Percent cover of any infrastructure, evident environmental modification or trash by category
No invasive vines overtaking the forest canopy	Species and stage class of invasive vines in the understory, tree trunk and in the tree canopy	Vine presence on trees and stage class (1, 2, or 3)

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