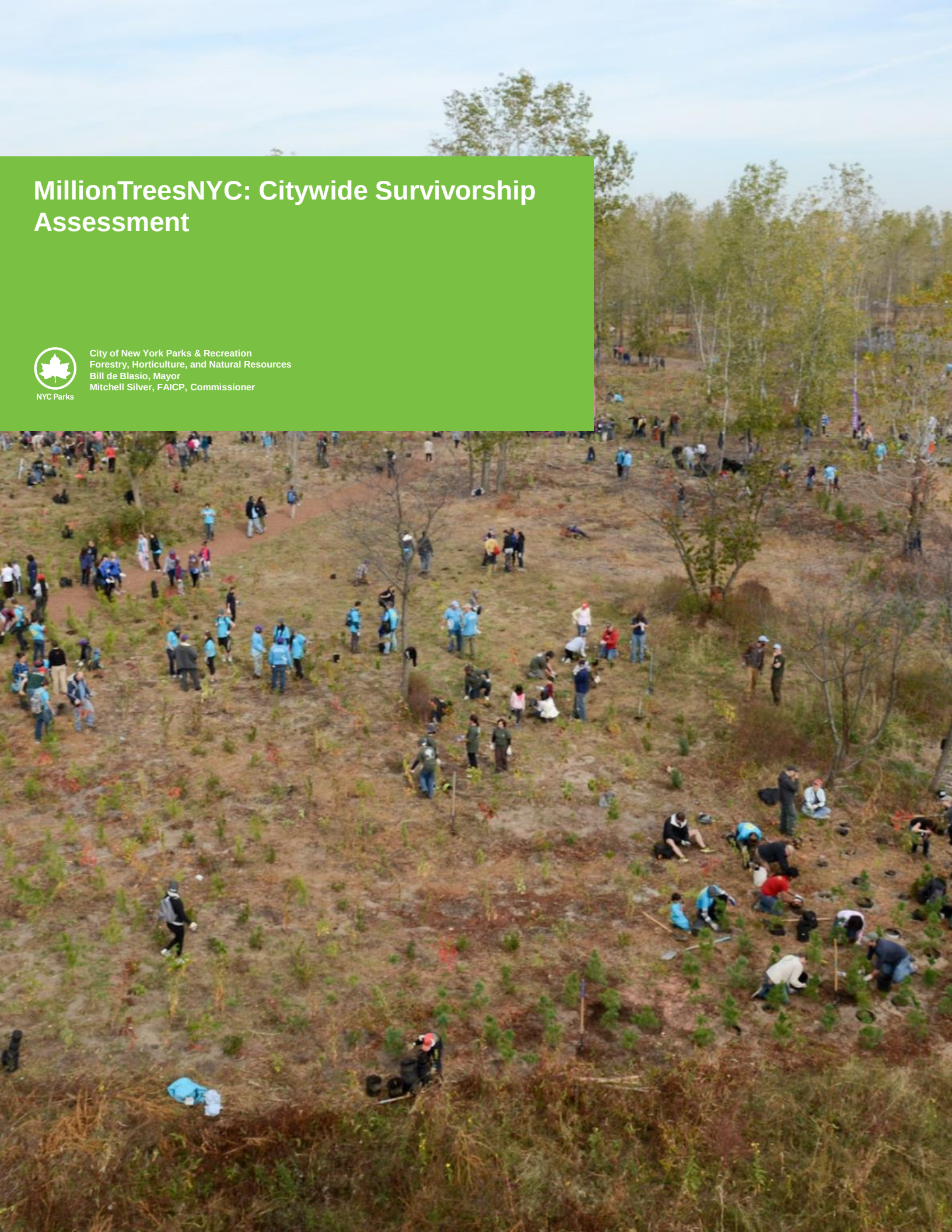
MillionTreesNYC: Citywide Survivorship Assessment



NYC Parks

City of New York Parks & Recreation
Forestry, Horticulture, and Natural Resources
Bill de Blasio, Mayor
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Cover photo: MillionTreesNYC volunteer tree planting event at Rockaway Community Park in 2013

Introduction

PlaNYC, Mayor Bloomberg's initiative to make NYC sustainable by 2030, included a number of groundbreaking greening initiatives and dedicated over $390 million over ten years. In addition, the Mayor funded 156 additional New York City Department of Parks & Recreation (NYC Parks) staff and provided $4.6 million in new maintenance funds to support these greening efforts. In 2007, as a part of PlaNYC, NYC Parks and the New York Restoration Project launched the MillionTreesNYC (MTNYC) program. One million trees were planted between 2007 and 2015, with intended benefits that included improvements to air quality, increases in neighborhood value, lower summer temperatures, reduced energy costs, benefits to the city's water systems, and carbon sequestration (PlaNYC 2007).

As a part of the MTNYC initiative, NYC Parks' Natural Resources Group (NRG) led a combined reforestation and afforestation program to plant 584,007 trees in parkland across the city, from mature forest (closed canopy) to road-sides. Before planting, sites were prepared by NRG in-house staff and/or contractors. Site preparation typically included the removal of debris and invasive plant species. The program utilized containerized trees and shrubs grown from native seed, in 1 - 3 gallon pots, around 1 meter tall (based on the American Standard for Nursery Stock, Quinn 2014). Planting was accomplished largely through volunteer efforts as well as supplemental planting from NRG in-house staff and contractors (NYC Parks, 2014).

To evaluate the success of these planting efforts, NRG ecologists developed a study to monitor the health and survival of trees at the planting sites. Data related to tree species, survivorship, and condition were collected on trees one and two years after planting during their root establishment periods. The goal was to determine:

1) What is the two-year survival rate of trees planted as part of the reforestation and afforestation program?
2) What are some of the major causes of tree mortality?
3) How do survival rates vary across planting strategies and site characteristics?

Methods

Plot establishment

Permanent 5 x 5 meter plots were established within planting area boundaries. Plots were randomly selected using ArcGIS v. 9.3 and Hawth Tools v. 3.27. Sampling occurred in 165 out of 579 planting polygons in 53 out of 75 planted parks (Figure 2). Three percent of each planting area (totaling 462 plots) was sampled, according to recommendations by Emmerich et al 1999. The planting sites were established seasonally, fall and spring, leading to similar plot grouping. The sample reflected the season and year planted (Table 1). The plots were established one growing season after the trees were planted, and then re-sampled in the second growing season. Sampling captured all species planted for the program.

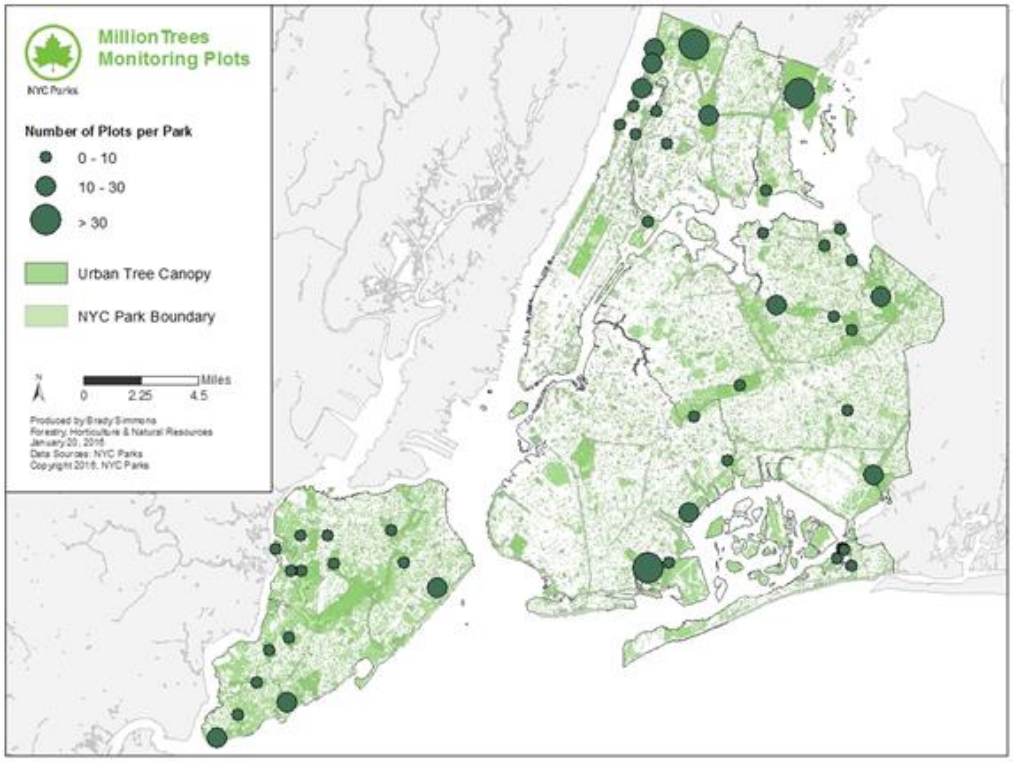

Figure 2. Citywide locations of all plots per park

Table 1. Years that trees from each planting date were sampled

	Year Sampled				
Season & Year Planted	2009	2010	2011	2012	2013
Fall 2007	√	√			√
Spring 2008	√	√			
Fall 2008	√		√		
Spring 2009		√	√		
Fall 2009			√	√	
Spring 2010			√	√	
Fall 2010				√	√
Spring 2011				√	√
Fall 2011					√
Spring 2012					√
Total Number of Plots Established in Each Year	222	53	82	88	17

Data collection

The locations of the 5 x 5 meter plots were determined using GPS, and their boundaries were demarcated using five meter lengths of rope affixed to stakes. 6,337 trees were sampled for the monitoring program from 2009 to 2013. Species, alive/dead status, and height were recorded for each tree. For the dead trees, cause of death was recorded as uprooted, broken stem, mammal damage (added in 2010), or unknown cause. For the live trees, various health metrics were recorded: herbivory damage (insect/mammal), leaf discoloration, stem damage, and dieback (recorded as more than or less than 50% dead). Dieback is a typical stress response that can be triggered by transplant shock, drought, lack of core nutrients in soil, and other environmental stressors.

For each plot, percent ground cover was recorded for the three most dominant herbaceous species, along with the presence or absence of canopy cover based on a desktop analysis of aerial photography in ArcGIS (Figure 3). Starting in 2011, the presence or absence of vines attached to saplings and the species of those vines were recorded. Soil characteristics were also assessed for each plot: pH was analyzed and recorded *in situ* at time of collection. Multiple surface soil samples (0-10cm depth) were collected from within the plot and sent to the Brooklyn College Environmental Sciences Analytical Center for analysis of soil texture, organic content, bulk density, and plant available nutrients.

Figure 3. Photo on left, CC (canopy cover) with planted trees under existing mature canopy. Photo on right, No CC (full sun) with planting on the side of an existing ball field. Varying colors in polygons denote different planting years.

Major Findings

1) Overall Survival Rates

Across all planting sites, the average survival rate for newly planted trees was 88% in the first year. Of the trees that lived past the first year, there was a 90% chance of survival through the second year (Figure 4). The percentages reflect all of the trees planted in the years fall 2007 to spring 2012. Although there are differences in survival rates between planting sites and two of the planting sites had extremely low survival rates, that variation proved negligible to overall program success, given the scale of the MillionTrees program.

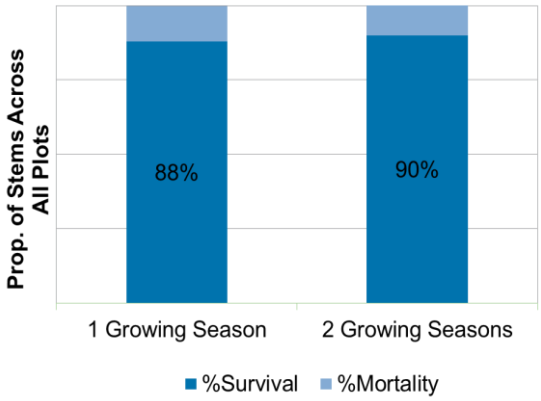

Figure 4. Survivorship across growing seasons

2) Causes of Mortality

For the vast majority of trees that died (86%), cause of death was not determined (Figure 5**)**. Some trees died of causes related to vandalism (7%) – they had broken stems or were uprooted. Although many of the trees were planted in highly urbanized parks with millions of people visiting throughout the year, vandalism appeared to contribute very little to overall citywide mortality. Death from mammal damage (7%) was added in 2010 in response to a planting in Staten Island that suffered major losses from meadow voles. At the time this study was initiated, deer herbivory was not a large component of mammal herbivory.

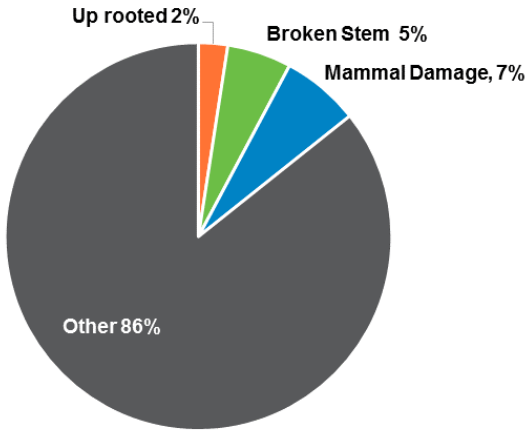

Figure 5. Causes of tree mortality (n = 572)

3) Variations in Survival Rates Across Planting Strategies

Volunteer-planted trees and trees planted by professional staff (i.e., contractors and Parks in-house staff) have similar two-year survival rates (Figure 6). Tree planting events rely heavily upon volunteer efforts. Out of all trees planted on parkland, 58% were planted during volunteer events compared to 42% by professional staff. Most volunteers have limited experience with tree planting and only received a quick demonstration on the day of the event. With investment in event planning, close volunteer supervision, and quality control by in-house staff, trees planted by volunteers are just as likely to survive as those planted by professionals.

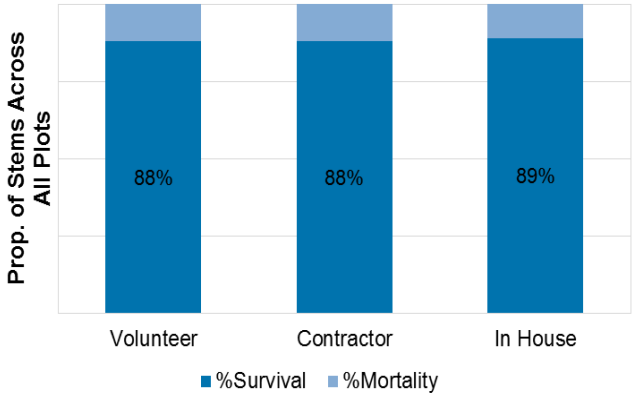

Figure 6. Survivorship across planting strategies

To better understand what factors contribute to tree mortality in addition to vandalism and mammal damage, the next two findings are from analyses of trees that died of "other" causes.

There is no measurable difference between survivorship of trees planted in the fall versus those planted in the spring (Figure 7). To maximize the number of trees planted in a given year, planting occurred in both spring and fall of every year. Although some research suggests a competitive advantage to planting in the fall because trees have a longer period to establish root systems without summer stresses (Miller 1999), this study does not support that finding.

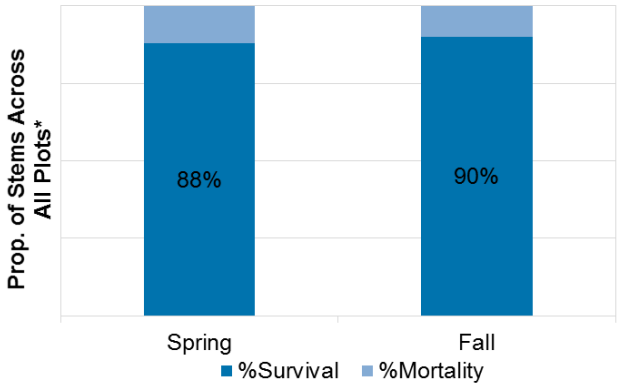

Figure 7. Survivorship comparing season planted. *Survival rates only reflect trees that died of "other" causes.

Trees have higher survival rates when planted in areas with existing canopy cover than in areas with no canopy cover (Figure 8). Exposure to sunlight differs among the planting areas: some trees were planted around ball fields or adjacent to existing stands of trees (no canopy cover, or "No CC", plots) while some trees were planted to close gaps in existing canopy (canopy cover, or "CC" plots). Plantings in full sun have a slightly lower survival rate than those planted within existing forest.

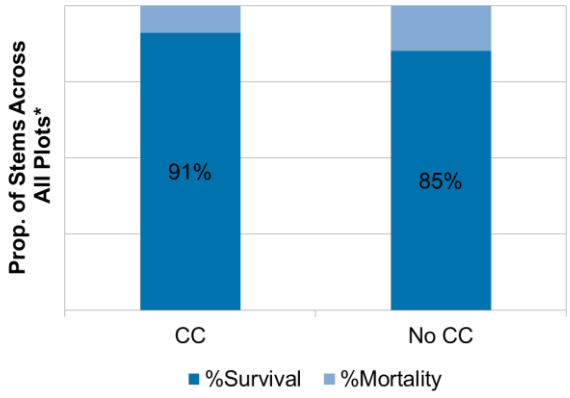

Figure 8. Survivorship across canopy cover. *Survival rates only reflect trees that died of "unknown" causes.

Conclusion & Recommendations

This study shows that after two years, tree survival rates are high and generally consistent across planting strategies. Based on this study, we have the following recommendations:

Involve volunteers in reforestation efforts. Trees have the same chance of survival whether they were planted by a professional arborist or forester, a volunteer from a school group, or a neighborhood stewardship effort. With diligent planning, training, supervision, and quality control, well-organized volunteer planting events can contribute

significantly to restoration in addition to creating opportunities for environmental education and community engagement.

When selecting a planting site, existing canopy cover should be taken into account. There was little variation in survival rates due to planting season and year, but planted trees had slightly lower survival rates when placed in full sun. This may be due to drier soils and exposure to higher temperatures. These results should not be used to discourage planting in specific situations, such as areas outside mature canopy cover, but to understand the pressures underlying certain planting conditions and to encourage appropriate interventions, such as increased watering or planting drought-tolerant trees.

Data on tree health and other site conditions are needed to better understand causes of decline in tree health and eventual mortality. The methods for this study were created for a quick and scalable monitoring program that could be implemented by other municipalities or NGOs that have limited resources and/or skill sets. While some metrics were collected in order to provide insight into tree health, the results were inconclusive, and more detailed information may be required to tease apart subtle differences in health. For example, the USDA Forest Service developed a tree stress index that has been used in a number of studies (Pontius & Hallett 2014) and could be leveraged for an evaluation of a sub-set of the original sample. Further analysis could also examine variation in tree survival with regards to soil characteristics and previous land use history.

Additional monitoring on mammal damage is needed, especially in light of the range expansion of white-tailed deer in the Bronx and Staten Island. Mammal damage was recorded as either a cause of tree mortality or a cause of decline in tree health (for trees that survived) – though no distinction was made between herbivory by vole, deer, or rabbit. Although mammal damage was relatively high in specific Parks and planting sites, it was not a major contributor to mortality citywide. However, it was an important factor when considering tree health. For trees that survived, mammal damage increased 69% between 2010 and 2011 across all sites and leveled off in subsequent years. It is unclear if this is due to an increase in mammal population size, range expansion, or the result of planting in areas already occupied by mammals. The data from this study could be cross-referenced with inspection data collected by Parks Forestry staff to assess mammal-specific impacts on tree health. Overall, there is a clear need for additional monitoring on mammal damage, especially in light of the range expansion of white-tailed deer in the Bronx and Staten Island.

Further analysis is needed to needed to determine the longer term survival of trees at these restoration planting sites and to inform management strategies. This study only focused on the two growing seasons immediately following planting. Although this root establishment period is of critical importance, the data collected by this study cannot be used to draw conclusions about long-term results. As stated earlier, this study is only one tool to evaluate a large-scale planting program. These preliminary results show that reforestation and afforestation efforts have been successful thus far, and additional monitoring of the planting sites over the long-term can help better

understand which factors are vital to planted tree survivorship and which factors have little impact (see Next Steps).

Next Steps

Short-term (within the next year)

- The monitoring data has been paired with the 2013 Natural Resources Conservation Service's NYC Soil Survey data, and further analysis will look at survivorship on native versus anthropogenic soils.
- Analyze plot-level soils data for trends among planting areas, leader stem dieback and invasive presence/absence. Evaluate efficacy of tests for future monitoring.
- Examine whether management actions (documented in NRG Tracking Database) differ across plots. If possible, examine whether different management actions result in different mortality rates, including site preparation and site maintenance.
- Determine goals for revisiting plots to examine long-term success of tree planting efforts.

Long-term (within 2-5 years)

- Revisit a subset of the plots to determine long-term success of tree planting efforts.

Literature Cited

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