New York City Parks Internship Project
Brooklyn Borough Forestry
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Management Strategies for Street Trees Along Historic Parkways

Executive Summary

Street trees in New York City face a number of environmental hazards that can limit their growth and impact their mortality. The care and stewardship of these trees is the responsibility of the New York City Department of Parks and Recreation. The unique history, geography, and urban form associated with Eastern Parkway and Ocean Parkway in Brooklyn presents a number of challenges and opportunities for managers. A summary of potential hazards is presented below, and best practices for mitigation and remediation are discussed. Finally, recommendations are provided for potential management strategies.

Selected Highlights

- Eastern and Ocean Parkways are distinct from other streets in the borough because of, among other things, their designation status by the LPC, the variety of recreational amenities along each parkway, their length, their cultural significance, and the unique urban form which allows for large, connected tree and plant beds, all of which warrant them being managed separately from other street tree operations.
- Street tree health and mortality are impacted by environmental hazards such as: heavy metal and other soil and air pollutants because of nearby traffic; salt spray effecting leaves as well as impacting soil chemistry; compaction effects from foot and vehicle traffic; direct impact from vehicles and construction equipment; litter and refuse in the tree bed; among other factors.
- Of the above negative health hazards, soil salt content, the proximity of trees to vehicle traffic and construction sites, size of the tree bed, and the presence and quality of stewardship/maintenance activities were all found to be important predictors of street tree health/mortality.
- While parkways like Eastern and Ocean should receive special attention for their unique urban form and ecosystem benefits, few examples exist of municipal management strategies that are specific to parkways or roadways like them.
- Assessing current conditions through the appropriate allocation of staff time is the highest priority recommendation of this report. Many of the potential tree mortality hazards cannot be successfully mitigated or mediated without sufficient study of current conditions.
- Alternative governance models may be necessary to provide the quantity and quality of care necessary to ensure effective Parkway Management. Buffalo's Olmstead Parks Conservancy and the Boston-based Emerald Necklace Conservancy may serve as effective models in this regard.

1. Why Parkway Management?

Trees in urban areas have long been known to provide a wide variety of social and environmental benefits. Urban green spaces and the urban forest can provide ecosystem services such as stormwater runoff mitigation (Kuehler et al. 2017), street trees can help to mitigate the urban heat island effect (Marando et al. 2019), and urban green spaces have been shown to boost property values and physical and mental wellbeing among residents (Dwyer et al. 1992; James et al. 2020). Urban greenspaces can provide important nature contact opportunities for urban residents, and the prevalence of recreation amenities is positively linked to mental wellbeing among those who participate and live nearby. As a result, protecting and maintaining urban street trees can have many positive impacts on residents and the neighborhood writ large, far beyond the direct costs of stewardship and maintenance activities (Dwyer et al 1992; Vogt et al. 2015). Despite this, municipal urban forestry budgets are often limited, which in turn limits the ability of practitioners to effectively manage urban greenspaces (Kronenberg et al. 2015; Vogt et al. 2015; Wirtz et al. 2021). Poor investment has been found to reduce the overall quantity and quality of urban tree health and the ecosystem benefits provided by the urban forest.

The costs and benefits of urban forest management are particularly acute along roadways such as Eastern and Ocean Parkways. The parkways are each between four and five miles, both of which host large streetside trees along their entire length. Trees along these parkways enjoy unusually large and interconnected tree beds which create unique opportunities and challenges for management. Increased soil space for tree growth has been linked to decreased tree mortality and shorter establishment periods (Berrang 1985; Koeser et al. 2013; Sanders and Grabosky 2014). By the same token, the parkway trees are in close proximity to the road, as the tree beds line the parkways for their entire length. Proximity to traffic has been found to be correlated with higher mortality rates and reduced canopy growth due to increased traffic and collision incidents, higher levels of air and soil pollution, and compaction effects (Berrang 1985; Bignal et al. 2007; Cekstere and Osvalde 2013; Gregory et al. 2002; Quigley 2004). The branches of the trees overhang busy road and pedestrian throughfares, including benches and recreation spaces, which increases the potential hazards associated with limb or tree failure (NYC Parks). Eastern Parkway and Ocean Parkway also both contain many mature and well-established trees, which provide the fullest amount of ecosystem benefits (Sanders and Grabosky 2014). However, both parkways lie within areas of the city with high Heat Vulnerability Index scores, which makes the proper mitigation of heat effects through urban greening a top priority (NYC DOH). The unique social and environmental benefits provided by the parkway trees necessitate dedicated maintenance strategies.

Furthermore, the parkway's greenspaces play an important role in the city's history and its present. The parkways' construction dates to the 1870s, when famed landscape architects Frederick Law Olmsted and Calvert Vaux extended the shaded "pleasure" drives along Prospect Park into what was then suburban Brooklyn (Landmarks Preservation Commission, 1975). The two coined the word "parkway," and designed the roadways to be enjoyable, rather than purely utilitarian. They also provided that the parkways should be "bordered by a small belt of shrubbery," with trees and plants lining either side (LPC, 1975). These two parkways were the first of their kind, and the first of this type of roadway in the United States. For their historic significance, the New York City Landmarks Preservation Commission designated the two as Scenic Landmarks, affording them special protection and status among the city's

urban form (LPC, 1975; LPC, 1978). Today, the parkways are enjoyed by many New Yorkers who use the bike and pedestrian pathways and enjoy the trees and green spaces along the streets. As part of the Grand Army Plaza Monuments system, trees along Eastern Parkway bear plaques commemorating soldiers who fell in World War 1. Eastern Parkway also hosts the annual West Indian American Day Parade, and Ocean Parkway critically connects the heart of Brooklyn to Coney Island (NYC Parks). In order to ensure the continued ecological, social, and historic value of Eastern Parkway and Ocean Parkway, specific maintenance strategies should be designed to meet the needs of their street trees.

2. Hazards and Strategies

Street trees face a variety of hazards due to their proximity to vehicle traffic. Soil compaction, air and soil pollution, direct collisions, and refuse in tree beds can all create conditions that can reduce tree growth and increase mortality rates. This prevents trees from providing their full range of ecosystem services, and costs urban greening programs time and money. Tree removal and replacement also creates a system lag wherein new trees will take time to mature, thus not providing their full range of ecosystem benefits for years or even decades. Broadly speaking, NYC Parks staff carry out a wide array of maintenance activities along both parkways, but those activities are frequently cost-limited. Foresters survey the entirety of both parkways for limb and tree hazards and dead trees once per year, and various other tree care contracts overlap with Eastern Parkway and Ocean Parkway. However, there are very few dedicated activities or contracts for providing tree care services specifically to these important historic and environmental resources. Below is a summary of selected hazards as identified by NYC Parks staff, current NYC Parks mitigation or mediation efforts, and a summary of potential maintenance activities as suggested by the literature.

Salt

The use of road salt for road surface deicing is a common practice in the Northeastern United States, despite its well-documented environmental hazards. Commonly used sodium chloride deicer is often preferred by road management officials over potential alternatives because of its availability, relative price, and effectiveness at reducing snow and ice buildup (Shi et al. 2013; Terry et al. 2020). However, as anyone who has owned a car in the northeast can attest, sodium chloride deicers are highly corrosive to vehicles, infrastructure, and can be harmful to human health as a result of salt spray from traffic (Shi et al 2013). The same damaging effects can be seen in the impact of high salt application on trees along roadways. Trees along roads with high salt applications have been found to have reduced canopy and trunk health (Luczak et al. 2021; Galuszka et al. 2010; Equiza et al. 2017). Trees exposed to high salt content, especially sodic soils from sodium-based deicers, face significant health defects that can dramatically increase their mortality (Berrang 1985; Saifullah et al 2018). Trees along Eastern Parkway and Ocean Parkway are especially susceptible to the negative environmental effects of road salt application due to their proximity to both a high-traffic road and the presence of bike and pedestrian throughways which require their own winter maintenance strategies. Addressing the issues of sodic salt pollution is therefore among the top priorities for effective parkway management.

Two main strategies emerged in the literature for addressing salt contamination of roadside trees and soils: reduction of salt usage and amelioration of soil conditions. Mitigation of salt usage generally involves the substitution of a different material that has a similar or complimentary effect to the deicing properties of traditional sodium chloride. Calcium and magnesium chloride products exist as well but have similar environmental interactions as sodium chloride. Several promising non-chloride alternatives

exist, including certain agriculturally derived products like beet juice, glycol-based deicers, and succinic acid derivatives (Terry et al. 2020). However, each of these products has distinct advantages and drawbacks, including cost, environmental interactions, and different corrosive impacts to different materials. Along Eastern Parkway and Ocean Parkway, the New York Department of Sanitation applies sodium chloride as part of their winter maintenance operations. According to city staff, they also incorporate a non-sodic brine as a road surface coating to prevent buildup in an attempt to reduce the use of sodium chloride on city streets. Application of this non-sodic brine to pedestrian and bike paths along Eastern and Ocean Parkways yielded less-than-desirable results, as NYC Parks staff found that the 'brine' was ineffective at reducing icy buildup under typical NYC snowpack.

Similarly, there are a number of amelioration strategies for reducing the salt content of impacted soils. Certain plants have been found to be effective at reducing the salt content of impacted soils, as have certain chemical additives. For example, gypsum has proved a particularly good additive at neutralizing soils with especially high salt content as compared to phytoremediation strategies (Qadir et al 2006). Salt-tolerant plants have recently been found to reduce the impacts of sodic soil on non-tolerant plants, thereby increasing nutrient uptake (Mann et al 2020). An exciting new method involves the application of biochar to affected soils alongside standard fertilizer (Saifullah et al 2018). Each soil remediation effort has drawbacks as well. For instance, excessive use of organic compounds can increase carbon emissions through decomposition, phytoremediation requires careful selection of salt-tolerant plants, and gypsum is often cost-prohibitive.

At present, NYC Parks Brooklyn Borough crews have experimented with Gypsum additives to tree beds as a salt mediation effort, but with limited/mixed follow-up to gauge effectiveness. More attention should be paid both to salt reduction and salt remediation strategies to most effectively manage the health of the urban forest along parkways.

Soil and Air Pollutants (non-sodic)

Proximity to vehicle traffic also increases the concentration of airborne and soil pollutants such as magnesium, nickel, and zinc (Cekstere and Osvalde 2013). The negative chemical interactions between heavy metals and other pollutants can significantly impact the health of roadside trees, and the concentrations of such pollutants are higher the closer the tree bed is to the roadside (Chen et al 2010; Galuszka et al 2010). Pollution effects are so significant that proximity to traffic has been identified by several researchers as a significant predictor of urban tree mortality (Berrang 1985; Koeser et al 2013). Critically, proximity to traffic-induced air and soil pollution has been found to be correlated with insect and disease damage among roadside trees, potentially indicating that negative health impacts can compound (Bignal et al 2007).

There are no readily identifiable strategies for reducing the impacts of vehicle-based air and soil pollution outside. Reducing traffic volumes and increasing distance to travel lanes are potential strategies for improving urban tree health but are not well documented (Koeser et al 2013). In addition, a better understanding of the soil characteristics along the parkways may help practitioners identify strategies for site-specific remediation, as individual chemical pollutants will have distinct impacts on tree health and will require different strategies for amelioration.

Compaction Effects

The amount and proximity of vehicle and pedestrian traffic makes roadside trees along Eastern Parkway and Ocean Parkway susceptible to compaction effects. High vehicle and pedestrian traffic areas have

more intense soil compaction effects, which in turn negatively impact tree health and growth (Berrang et al 1985; Koeser et al 2013; Quigley et al 2004). Compaction effects interrupt water absorption, which can impact runoff levels and reduce the ecosystem benefits of even mature street trees (Booth et al 2002; Gregory et al 2002). Soil compaction is highly related to traffic, and the parkways are both highly susceptible to compaction impacts. Several strategies exist for soil decompaction as a means of maintaining tree health, including plant-based, mechanical, and pneumatic methods (Godoy et al 2009; Hascher and Wells 2007; Smiley et al 2006). At present, NYC Parks staff engage in decompaction activities at many sites citywide including in instances of sidewalk replacement but do not regularly do so along Eastern and Ocean Parkways. Identifying areas for successful decompaction efforts should be explored for the most effective management of the urban forest along the parkways.

Pest and Disease Management

Pests and disease constitute significant threats to certain tree species under certain conditions, and these threats are compounded by the relative cost or unavailability of potential amelioration strategies. Trees, after all, cannot be prescribed tea and bed rest. Certain research has found that compounding stressors such as poor nutrition due to air and soil pollution can make trees more susceptible to pest and disease effects (Bignal et al 2007). As climate change is expected to alter the relative vulnerability of species and ecosystems that are not able to adapt easily or readily to shifting climatic realities, pest and disease forecasting is among the preeminent strategies for modeling effective urban forest care (Brandt et al 2006; Ordonez and Duinker 2015). Certain tools exist for modeling potentially damaging pest and disease effects based on species type and urban forest makeup and can be employed to assess areas of high vulnerability (Lacan and McBride 2008).

NYC Parks foresters carry out extensive work in disease identification and prevention, including selection of disease-resistant species for new plantings, and through citywide contracts (NYC Parks). The most significant of these for Eastern and Ocean Parkway are the Emerald Ash Borer and Dutch Elm Disease, both of which have dedicated contracts awarded for citywide mitigation efforts. However, funding for both contracts is limited, which in turn impacts service provision. Further, while the Dutch Elm Disease treatment contract is highly localized along Eastern Parkway for the protection and preservation of its historic species makeup and canopy type, Ocean Parkway does not receive dedicated contract services. The Emerald Ash Borer contract is managed by the Brooklyn Borough Forestry Office but is dependent on periodic funding renewals to keep operating and operates borough-wide, potentially limiting the scope of treatment and mitigation efforts.

Collisions

Particularly for younger and less-established street trees, collisions with traffic pose a significant risk to tree health and mortality (Berrang 1985; Koeser et al 2013; Lu et al 2016). Collision events can also pose a threat to canopy and limb health, especially in instances where large vehicles impact tree limbs that overhang the road surface. Perhaps rather intuitively, the only available solutions for reducing traffic impacts on street trees are the construction of barriers and/or traffic-calming measures that reduce speed and traffic volumes. Eastern Parkway and Ocean Parkway are both formally closed to commercial traffic, and greater enforcement of existing traffic regulations could help reduce the number of large vehicles on the road, and thereby reduce the number and severity of collision events with overhanging branches.

Stewardship Impacts

Not surprisingly, "…the level of care or maintenance performed on a planted tree is linked to establishment, survival, growth, and longevity" (Vogt et al. 295). However, providing adequate care to all of a city's street trees can be prohibitively expensive for municipalities, which can in turn significantly limit the quantity and quality of care (Kronenberg 2015; Vogt et al. 2015). As a result, volunteer-based and collaborative governance models are attractive for municipal bodies seeking to reduce direct costs and more efficiently mobilize public resources. Collaboration between municipal agencies and nonprofits or public volunteers is a complicated process that involves extensive trust and patience but can yield positive results. Sufficiently motivated volunteers can provide support orders of magnitude greater than the costs to enlist and activate them by promoting healthy planting and growth of urban trees (Breger et al. 2019; Daniels et al 2014; Roman et al 2015). However, public attitudes and capacity must be carefully assessed by practitioners in order to design stewardship activities and governance models that will solicit the appropriate level and amount of care for a given urban forest context (Breger et al 2019; Conway and Bang 2014; Madureira et al. 2015; Wirtz et al 2021). Because collaboration of any kind will involve resource sharing and coordination across municipal bodies and their partners, any new efforts must be designed in a thoughtful and creative way to meet the needs of the project. Successful shared governance models that bear further study are the Olmsted Parks Conservancy in Buffalo, NY, and the Emerald Necklace Conservancy in Boston, MA. Both non-profit organizations work extensively with the park and parkway systems in their respective locations, and both involve cost-sharing and collaborative maintenance with their respective municipal partners. In the city, the extent of stewardship activities and capacity along the parkways should be assessed as opportunities to expand maintenance operations. The importance of public involvement in management activities can be seen in an anecdote about grass reseeding along Eastern Parkway, during which time public pressure regarding the closure of a section of the pedestrian way forced the premature reopening of that section, compromising the restoration effort.

3. Challenges and Recommendations

The above discussion of the hazards faced by roadside trees along Eastern Parkway and Ocean Parkway contains potential solutions and mitigation strategies and is intended to provide a clearer picture for practitioners wishing to undertake better maintenance of these cultural, historic, and critical environmental resources. However, serious institutional and individual challenges exist to the implementation of these strategies. What follows is a brief discussion of the challenges faced and selected recommendations based on the literature for strengthening parkway street tree management activities.

Cost

Not surprisingly, the availability of funding is a major limitation to any new or proposed expansion of maintenance activities. Available funding is allocated based on overall city priorities and can significantly vary from year to year. Expense Contract funding is particularly vulnerable to changes in the city budget, but funding for parks and environmental services as a whole is often subject to extensive review. Stewardship and shared governance, as described above, potentially alleviates some of the cost pressures facing city offices, but itself involves staff and messaging costs that may prove prohibitively expensive at the outset of a project.

Staff Time and Expertise

The nature of the hazards listed above and the strategies for remediation and mitigation will necessitate careful and dedicated analysis and implementation by NYC Parks staff. While NYC Parks staff are among the best, any significant remediation effort or new maintenance activity will necessarily require special attention. This will be a draw on limited staff availability, who are already tasked with responsibilities across the borough. The remediation efforts will require specific scientific and technical knowledge, particularly where soil chemistry is concerned. The successful mobilization of these resources will be no small task for agencies working with limited staff.

Inter-Agency Collaboration

Collaboration among different municipal agencies can be a complicated process under the best of circumstances. Different departments may compete for resources, or else have conflicting missions that may make collaboration difficult, if not impossible. The reduction of sodium chloride usage on the parkway road surfaces will require input with the Department of Sanitation, and of course any significant work or alteration along the pedestrian ways will require input and sign off from the Landmarks Preservation Committee. In addition, any instance of collaboration with non-profit agencies or volunteer groups will necessitate intensive negotiation between impacted agencies.

Recommendations for Future Action

The following are selected recommendations for the implementation of strategies for effective management of the tree health along Eastern Parkway and Ocean Parkway. These recommendations are based on conversations with NYC Parks staff regarding current and best practices, and a review of the literature surrounding urban arboriculture.

- A thorough study of current soil characteristics along the tree beds of both parkways should be conducted to obtain a full picture of the ecological realities of streetside trees. Soil chemistry can vary from site to site, and the specific makeup of chemicals and nutrients can have a significant effect on the long-term health of the tree. Tree health care activities need to be tailored to the specific needs of the tree and site.
- The state of volunteer and public tree care activities along the parkways should be assessed. NYC Parks Stewardship staff should be engaged in the process of identifying public support for greenspace maintenance efforts along Eastern Parkway and Ocean Parkway, and the designing of any collaborative governance structures.
- Further study is needed of existing agency parkway management practices. Interactions among different NYC Parks teams should be better understood before amending or introducing maintenance activities.
- Funding should, wherever possible, be allocated for dedicated maintenance activities along the parkways. As a unique urban form with unique ecosystem benefits and challenges, the most effective tree care will be realized by specifically tailoring solutions to site characteristics.

4. Conclusions

The above summary of hazards and challenges is meant to illustrate the many stressors faced by urban trees, and by trees along Eastern Parkway and Ocean Parkway. These streetscapes are of unique importance to New York City's past, present, and future. Only by approaching the maintenance of these streetside trees with the care they deserve can we hope to preserve and enhance them moving forward.

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