Economic Benefits of Natural Areas within Parks in NYC

Literature Review

November 2022

Background

Trust for Public Land (TPL) and the University of Maryland Environmental Finance Center (UMD EFC) developed a methodology to help the Natural Areas Conservancy (NAC) NYC identify ecological, economic, and social values of forested areas in NYC.

The goal of this literature review was to understand ways researchers have estimated the costs and benefits of urban forests and natural areas, including ecosystem service valuation, to inform the development of a methodology for NAC. Topics included in the review include:

- Benefits and Costs of Urban Forests
- Urban tree maintenance
- The costs of not maintaining urban natural areas
- Potential impacts of climate on urban natural areas
- The benefits of climate resilient species planting
- Urban tree mortality

To the extent possible, the literature review focused on urban forests rather than urban street trees, as street trees are excluded from NAC's Forest Management Framework.

TPL and UMD EFC reviewed 42 papers published between 1995 and 2022. The review is grouped by topic, highlights key findings and figures of relevant papers within each topic, and suggests additional papers to reference depending on future research interests.

Literature Review

Urban Tree Management & Maintenance

Municipalities need to commit to long-term maintenance of their urban street trees. According to Hauer et al. (2015), "Maintenance of tree populations is linked to tree structure and function, which benefits the urban forest. It is likely that benefits will accrue without maintenance; however, indirect costs and disservices may result from this lack of maintenance, including tree failures, debris, pests, branches blocking intersections, and other issues." [1]

Hauer et al. (2015) was a foundational paper for this research as they directly link maintenance activities to the benefits associated with the urban forest by linking them through "system or tree performance."

In order to better connect tree maintenance strategies to outcomes, the researchers recommend precise data collection on tree maintenance intensity, frequency, and type. Their model connecting maintenance to benefits is depicted in Figure 1 (below).

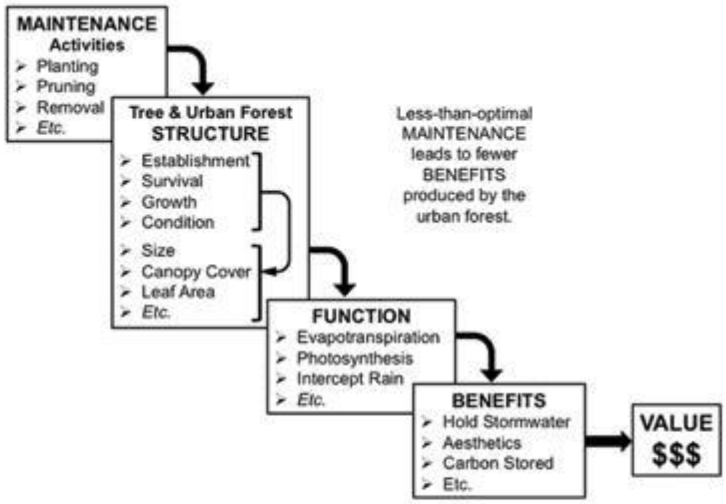

Figure 1. Maintenance directly impacts tree structure, which in turn impacts the functions and benefits provided by the urban forest (Hauer et al., 2015)

Hauer et al.'s assumption that proactive maintenance also "lead[s] to more efficient tree management than reactive (i.e., crisis) maintenance" was essential to designing the methodology in this project. TPL and UMD EFC leveraged the calculators designed by NAC to estimate the costs of no (or deferred) tree maintenance, assuming the degradation rates of natural areas would be higher in the absence of maintenance (i.e., the Forest Management Framework), and higher still in areas deemed high threat.

Song et al. (2018) systematically reviewed research on the methodologies behind identifying costs and benefits of trees in the urban landscape, and "[assessed] the relative balance of benefits and costs, and [attempted] to understand the wide variation in economic values assigned in different studies."[2] Of the 34 studies included in their review, most researched benefits related to environmental regulation, especially air quality and carbon sequestration, while far fewer valued biodiversity, resource provision, noise reduction, and recreation/tourism (see Figure 2 a and b on the following page). The authors theorize that these latter analyses are more challenging and therefore excluded as they are "effects that are experienced across larger spatio-temporal scales," compared to the impact of individual trees.

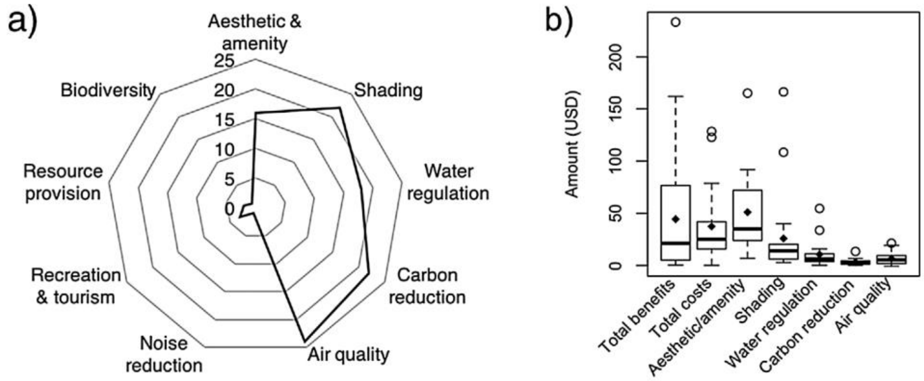

Figure 2. (a) Number of papers that analyze each benefit across the 34 studies on urban trees, and (b) box-and-whisker plot showing annual per-tree values for total benefits, costs, and each of the five commonly quantified benefits. Mean values are denoted by the diamond symbols.

Based on their review, Song et al. (2018) found that, in the analyses that converted benefit values to dollars, “the mean annual benefit and cost per tree were $44.34 and $37.40, respectively,” and “the median annual cost per tree ($25.07) was higher than the median annual benefit per tree ($21.19) across the studies reviewed.” Additionally, the mean benefit-cost ratio (BCR) across all studies was estimated at 5.43 (median 2.72); however, the authors noted that few papers “considered all of the benefits and costs associated with urban trees, though this would be necessary to obtain an accurate estimate of the net benefits of BCR.”

The proposed methodology for valuing benefits of natural areas looks at park-scale impacts, rather than basing benefits on the number, species, and age of trees (though much more research was available on the latter compared to the former). The following section, Costs and Benefits of Urban Tree Maintenance, discusses some of the costs and benefits of urban tree maintenance. Although some of the estimates described below were ultimately not included in the methodology due to differences between individual street trees and urban forested areas, it gives some insight into the potential scale of the cost of avoided damage and benefits of urban greenspace when trees are properly maintained.

Note: Urban Tree Mortality

Although ultimately omitted from the proposed methodology, the literature review did investigate estimating mortality rates in city forests. A potential avenue to evaluate ecosystem services over time was to forecast the health of forested areas in NYC and assign mortality rates, but ultimately modeling this was a challenge beyond the current scope and budget.

Some of the citations reviewed on this topic include:

- Hilbert, Deborah R., Lara A. Roman, Andrew K. Koeser, Jess Vogt, and Natalie S. van Doorn. "Urban tree mortality: a literature review." *Arboriculture & Urban Forestry: 45 (5): 167-200.* 45, no. 5 (2019): 167-200.
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- Lu, Jacqueline W.T.; Svendsen, Erika S.; Campbell, Lindsay K.; Greenfeld, Jennifer; Braden, Jessie; King, Kristen L.; and Falxa-Raymond, Nancy (2011) "Biological, Social, and Urban Design Factors Affecting Young Street Tree Mortality in New York City," Cities and the Environment (CATE): Vol. 3: Issue 1, Article 5.
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- Nowak, David J., Miki Kuroda, and Daniel E. Crane. "Tree mortality rates and tree population projections in Baltimore, Maryland, USA." *Urban Forestry & Urban Greening* 2, no. 3 (2004): 139-147.
- Roman, Lara. "Trends in street tree survival, Philadelphia, PA." *Master of Environmental Studies Capstone Projects* (2006): 4.

Costs and Benefits of Urban Tree Maintenance

The proposed methodology looks at a subset of the costs and benefits of maintaining greenspace in an urban context. There are significant caveats in understanding and interpreting results of these analyses, as described by Koeser et al. (2016):

> "The accounting of benefits and costs can involve many variables, each of which require itemization and price assignment over a common time period and ideally consider changing value of money over time. after this is all considered, a decision could be made that the benefits exceeds the costs (or not), using one of several evaluation mechanisms, such as net benefit (benefits minus costs, annualized or cumulative), net present value (sum of discounted benefits minus discounted costs), benefit-cost ratio (benefits divided by costs), internal rate of return (the discounted interest rate when net present value = 0), or other approach (Miller et al. 2015)[3]...
>
> "Once collected, the data must be analyzed appropriately to quantify costs and benefits. This can quickly become a complicated undertaking. Standardizing maintenance definitions, practices, and data collection activities is also important. Simply reporting that a tree was pruned does not convey how the tree was pruned, the intensity of pruning, the pruning objectives, who performed the works, and the price (i.e., cost) of the work. Further, accounting for the benefits of trees during their life cycle is complex." [4]

Vogt et al. (2015) specifically note the importance of considering trees' benefits and costs over their lifetime, which may fluctuate for many reasons, including the impacts of climate change (e.g. drought conditions and extreme storm events).[5]

The proposed approach balances NAC assessments of costs and TPL-estimated benefits of maintaining urban greenspace with ease of use of the methodology for individual parks in New York City. Benefits should not be considered additive, as it could lead to double counting. The evaluation mechanisms suggested by Koeser et al.(2016) (e.g., net benefits, net present value, benefit-cost ratios) also require the integration of a comprehensive suite of benefits to achieve an accurate result, an analysis of which was not available due to current resource constraints (e.g., the impacts of individual parks on proximate property values).

Costs of Urban Tree Maintenance

Vogt, Hauer, and Fisher (2015) conducted a literature review on the cost of not maintaining trees, including "planting, pruning, removal, and pest and disease management."[6] The authors compiled over 300 papers, and included 163 in the review. Importantly, the paper notes that with the assumption that maintenance "prolongs a tree's useful life (i.e., delays the onset of senescence and a tree's removal), it increases the amount of benefits it produces over its lifespan."

This assumption underpins the proposed method-ology, as any maintenance undertaken as part of the Forest Management Framework would lead to more benefits (e.g., ecosystem services) over time, as compared to the "business as usual" scenario in which the Framework is not implemented. Figure 3 from the paper (right) compares hypothetical costs with and without maintenance of an individual street tree. The proposed approach looks at natural areas holistically, rather than individual trees, but it extrapolates the effects of maintenance onto a forest system.

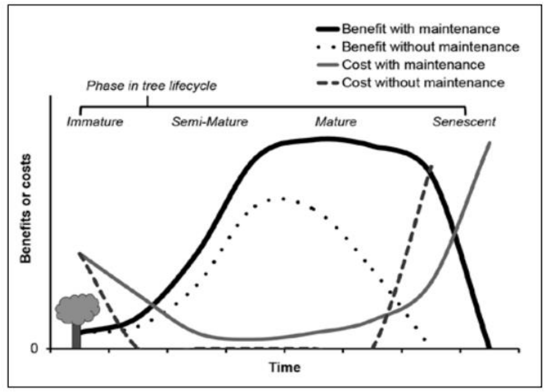

Figure 3. Hypothetical cost and benefit profiles over the lifetime of an individual tree (street tree), with (solid lines) and without (dashed lines) adequate maintenance. Benefits are maximized during the mature phase of a tree, and decline rapidly through senescence, while costs show an inverse pattern…Benefits and costs profiles for an individual tree will vary depending on the tree's location, the party benefitting from and incurring costs of the tree, and other factors (weather, etc.). Figure modified from Vogt et al. (2014).

More recently, Vogt (2020) identified an expanded list of costs included in urban tree maintenance, described in Table 1 (below, and referenced on the following page).[7] The calculators developed by NAC to estimate the costs of the Forest Management Framework calculated the private, direct costs of the Framework, including planting, restoration, management, maintenance, and monitoring. The calculator's outputs vary depending on whether a contractor, in-house staff, or volunteer are used, and on the health/threat level of the area. However, there are additional costs to be considered, including infrastructure interference costs, liability costs, externality-related costs, and opportunity costs.

Table 1 Types of costs associated with urban forests.

	Type of cost	*Explanation/examples*
Private costs	Direct costs (i.e., maintenance and management costs)	Dollars expended to purchase labor and materials involved in the planting, pruning, watering, and other types of maintenance of trees in the urban forest
	Infrastructure interference costs (i.e., repair costs)	Pavement and sewer repair costs; removal of tree limbs or debris blocking signage, power lines, storm drains, etc.; costs from tree-initiated power outages; or other costs incurred when trees damage or interfere with infrastructure
	Liability costs	Damages paid from a lawsuit or settlement awarded when trees or parts of trees cause injury to persons or property, such as an improperly cared for tree falling on a house, vehicle, or person
Public costs	Externality-related costs (aka, "ecosystem disservices")	Emissions of biogenic volatile organic compounds (VOCs) by trees; allergies due to tree pollen; release of carbon dioxide during decomposition of trees or tree debris or by maintenance equipment (gas-powered chain saws, lift trucks used to access tree canopy during maintenance, etc.); leaf/debris clean-up
	Opportunity costs	Space where trees are planted cannot be allocated to other competing uses, such as parking, bike lanes, sidewalk cafés, etc.; shade from trees may preclude use of sunny areas for installation of solar panels or for gardening

Modified from Vogt, J., Hauer, R.J., and Fischer, B.C. (2015b). The costs of maintaining and not maintaining the urban forest: A review of the urban forestry and arboriculture literature. *Arboriculture & Urban Forestry* **41**(6), 293–323.

While it was outside the current scope and budget to calculate these additional costs for parks in New York City, TPL and UMD EFC considered ways that implementation of the Forest Management Framework could possibly defer or avoid some of these costs altogether.

Infrastructure Interference Costs (Private)

Table 1 from Vogt (2020) describes infrastructure interference costs as repair costs incurred when trees damage or interfere with infrastructure.

The paper from Vogt, Hauer, and Fisher (2015) cited a 1996 source in which McPherson and Peper surveyed 15 cities about common repair activities for damage associated with trees, including removing and replacing concrete and root pruning: "Total concrete and sewer repair costs, for damage attributed to trees, was on average $7.11 per street tree annually ($4.28 in 1992 USD), or 25% of annual total tree program expenses."[8] In 2022 USD, the estimate is $8.71 per street tree.[9] McPherson and Peper also published "Costs of Street Tree Damage to Infrastructure, which includes an estimate of $3.01 (1992 USD) per tree for sidewalk repair costs, the single largest tree maintenance expense in all cities in the study (and a subset of the $4.28 value).[10] In 2022 USD, that estimate is $6.13.

These per-tree expenditures add up. In a 2000 study, McPherson surveyed 18 California cities to estimate expenditures to reduce conflicts between street trees and infrastructure. McPherson found that "approximately $70.7 million (SE $11.1 million) was spent annually statewide due to conflicts between street tree root growth and sidewalks, curbs, and gutters, and street pavement," leading to expenditures of $2.19 per capita and $11.22 per tree.[11]

Vogt, Hauer, and Fisher also cite a paper from Ryder and Moore (2013) as one of the few papers (at the time) that "explicitly examine the costs of not maintaining trees (i.e., deferring maintenance)."[12] Due to the difference in costs between younger and mature trees, using inflation rates of 3%-5%, Ryder and Moore calculated the cost of not performing formative pruning on recently planted trees through "the difference between the costs of formative pruning plus normal structural pruning (~$48) [AUD] and structural pruning for non-formatively pruned trees ($78-$112), or between $30 and $64." In 2022, that value would be $38.46 to $82.04 per tree.[13] Pruning trees when they are young therefore results in lower management costs for municipalities over time.

Liability Costs (Private)

Table 1 from Vogt (2020) describes liability costs as "damages paid from lawsuits or settlements awarded when trees or parts of trees cause injury to persons or property, such as an improperly cared for tree falling on a house, vehicle, or person."

Often, infrastructure interference costs are incurred in order to avoid future liability costs. In a 2016 paper, Koeser et al. surveyed urban forestry programs across the U.S. The research found that 52% of communities who responded to the survey said they "had experienced any claim for injury or property damage from public trees."[14] The maximum amount compensated from the survey was $176,000, while the median was $5,000 and the mean was $13,290 +/- $2,463 SE). Communities face a broad range of potential liability costs associated with street trees, and having had past claims filed for damage or injury often motivated regular risk management activity.

McPherson's (2000) survey of 18 cities in California also found that municipalities were incurring significant costs for trip and fall payments and legal staff. Cities spent on average "$2.26 on legal remedies for every $1 spent on mitigation and prevention," though it varies by city, and 21 percent of total dollars spent on mitigation and prevention was for grinding and ramping of sidewalks to reduce displacement hat might results in trip and fall accidents." In 14 of the 18 cities studied by McPherson, the average annual trip and fall case payments associated with tree root growth sidewalk damage was $1.77 million, or $0.26 per capita. In 2022 dollars, annual average payments would be $3.1 million. [15]

Liability costs are one of the more difficult costs to estimate, as they are situation-specific, and were not included in the methodology.

Externality-Related Costs (Public)

In Table 1 from Vogt (2020), externality-related costs are also describes as "ecosystem disservices" - the negative impacts that trees might have on people. Some of the examples listed include:

- Emissions of biogenic volatile organic compounds (VOCs) by trees;
- allergies due to tree pollen;
- release of carbon dioxide during decomposition of trees or tree debris or by maintenance equipment (gas-powered chain saws, lift trucks used to access tree canopy during maintenance, etc.); and
- leaf/debris clean-up.

Shackleton et al. (2016) note that these externalities have been largely neglected in economic literature, which poses a challenge to determining optimal outcomes for investment and human wellbeing. Ecosystem disservices due to planting urban trees may include "allergens from the pollen, leaves blocking stormwater drains, roots cracking pavement and residents' fears of increased crime."[16]

Roman et al. (2021) reviewed recent research on ecosystem disservices, categorizing them into impacts to: infrastructure; health and safety; cultural, aesthetic, and social issues; and environmental and energy issues. These ecosystem disservices should be better integrated into decision making processes through improving tradeoff evaluation, especially because municipalities may spend a significant amount of resources on mitigating their impact.[17]

Opportunity Costs (Public)

Table 1 from Vogt (2020) gives examples of opportunity costs of urban trees, including the loss of space once a tree is planted (competing uses could be parking, bike lanes, and particular commercial uses like sidewalk cafés) or reduced sunny areas for solar panels or gardening due to shade from the trees. At a park scale, municipalities may be foregoing the value of benefits for other projects on an otherwise vacant lot (e.g. a school or a sale to private investors).[18]

Effective analysis of opportunity costs for urban greenspace is a challenge due to the need to evaluate all the other potential uses of that space; in urban contexts that often means where land is incredibly valuable.

Benefits of Urban Tree Maintenance

Koeser et al. (2016) summarized findings and recommendations from a 2015 international symposium on the cost of not maintaining trees put on by The International Society of Arboriculture. Some of the high level benefits of tree maintenance noted in the discussion section were "greater service life of the tree and an increase in its associated ecosystem benefits, decreased tree limb breakage and storm cleanup in the future, or enhanced tree longevity and a reduction in urban forest removal and planting costs."[19]

There was a significant amount of literature on the benefits of individual urban trees, including those reviewed by Song et al. (2018). One example, McPherson et al. (2005), analyzed the costs and benefits per tree accruing from municipal forests, finding that "although these cities spent $13-65 annually per tree, benefits ranged from $31 to $89 per tree. For every dollar invested in management, benefits returned annually ranged from $1.37 to $3.09."[20]

Another study by Kroeger et al. (2018) calculated the returns on investment (ROIs) for various cities in the US based on benefits due to reduced particulate matter and temperature mitigation. The ROIs were defined as the abatement per dollar, and can help cities tailor tree planting efforts in more cost effective ways (see results Figure 4 below).[21]

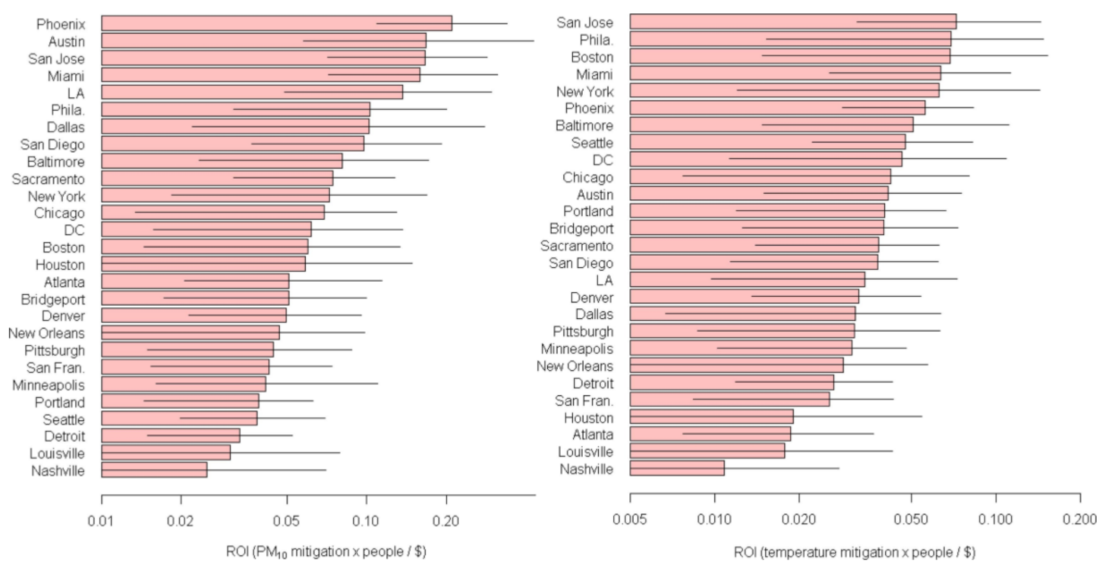

Figure 4. ROI of the median and interquartile (indicated by error bars) planting sites for PM_{10} and heat abatement for medium PM_{10} removal and heat reduction scenarios. Source: Kroeger et al. 2018

The proposed methodology recommends examining benefits of the natural areas holistically, rather than on a tree-by-tree basis. The benefits provided were largely based on the TPL report, "Economic Benefits of Parks in New York City" published in March 2022.[22] The benefits calculated in the report included:

- recreational use value;
- health care cost savings through increased physical activity;
- water quality protection;
- air pollution reduction;
- enhanced property values and associated tax revenue;

- tourism spending; and
- the economic value of the outdoor recreation economy.

Recreational use value, health care cost savings, water quality protection, and air pollution reduction are included in the methodology. Enhanced property values and associated tax revenues are site-specific, and a hedonic model should be created to understand those economic benefits. Given available data, tourism spending could only be estimated at a city-wide scale; additional research, possibly in the form of intercept surveys or analyzing the economic impact of special events at a park, could provide site-specific information. Similarly, the estimated economic impact of outdoor recreation spending from ESRI Business Analyst provides data on household spending related to the industry, but it wouldn't necessarily link directly to parks located near those households.

While parks and urban greenspace provide social and cultural benefits, researchers in the field have noted they are "less studied and are often difficult to monetize in a manner that is widely accepted."[23] Zhou and Rana (2011) do present a conceptual framework for valuation of social benefits of urban green space, including "recreational opportunities, aesthetic enjoyments, adjusting psychological well-being and physical health, enhancing social ties, and providing educational opportunities."[24] Secco and Zulian (2008) also develop a methodology for analyzing natural urban areas' benefits, based on their social benefits.[25]

Healthcare Values

Research has shown that expanding green space in cities strategically can increase well-being, especially for vulnerable populations.[26] Markevych et al. (2017) reviewed and synthesized the literature on the connections between urban greenspace and health. Figure 5 below captures the ways that greenspace improves health and wellbeing, whether through reducing harm (mitigation), restoring capacities (restoration), and building capacities (instoration).[27]

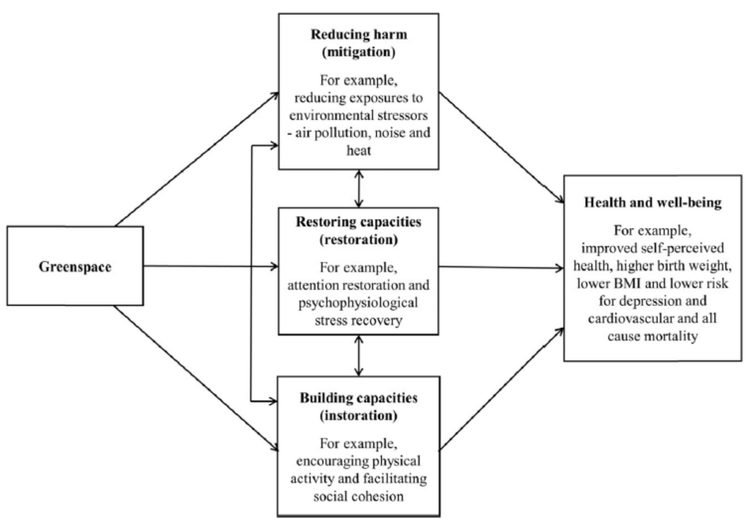

Figure 5. Three domains of pathways linking greenspace to positive health outcomes. The arrows represent hypothetical patterns of influence, with specific pathways in each domain potentially influencing one or more specific pathways in the other domains.

Benefits of Climate-Resilient Species Planting

Climate change continues to significantly impact the natural world, including increasing stress on trees and plants as a result of increased drought conditions and elevated temperatures.[28] There is also increased risk of heat- and drought-related stress to urban greenspace ecosystems where there is significant impervious cover and localized increased temperatures.[29] Fortunately, due to its biophysical features, there are many documented climate benefits associated with expanding urban green space generally (such as cooler microclimates, reduced CO_2, and reduced surface water runoff).[30]

NAC requested a review of existing research of any quantified benefits associated with climate-resilient species planting. "Climate-resilient species" could be considered both flora that are (1) resilient in the face of a changing climate, and (2) flora that can mitigate climate change impacts to the city.

Burley et al. (2019) note that increasing urban forest resilience by shifting the species composition to more climate-ready species "is likely to produce more ecosystem services that can improve environmental quality and human health and well-being, compared to a less resilient forest." Increasing urban forest resilience could also stabilize the delivery of ecosystem services it provides people over time.[31] Espeland and Kettenring (2018) also note the importance of considering "the reciprocal nature of how plants are both influenced by and influence their environment" in order to understand how, and how much, plants can mitigate climate change impacts.

Planting species that mitigate climate change impacts to the city would (a) increase greenspace in New York City generally, (b) increase the climate benefits derived from these natural areas, and (c) effect cost savings over time by introducing resilient species that may require less maintenance or less frequent replantings, or by introducing energy savings to nearby buildings (e.g. McPherson and Simpson 2003[32]).

Espeland and Kettenring (2018) conducted a systematic review of how plant selection can address climate change impacts.[33] Some of the climate benefits from plants altering biological and physical processes include increased soil stabilization and reduced impact from flooding and storm surges (Figure 6).

This review highlights three potential ways plants alleviate ecological climate change impacts in New York City based on Espeland and Kettenring (2018).

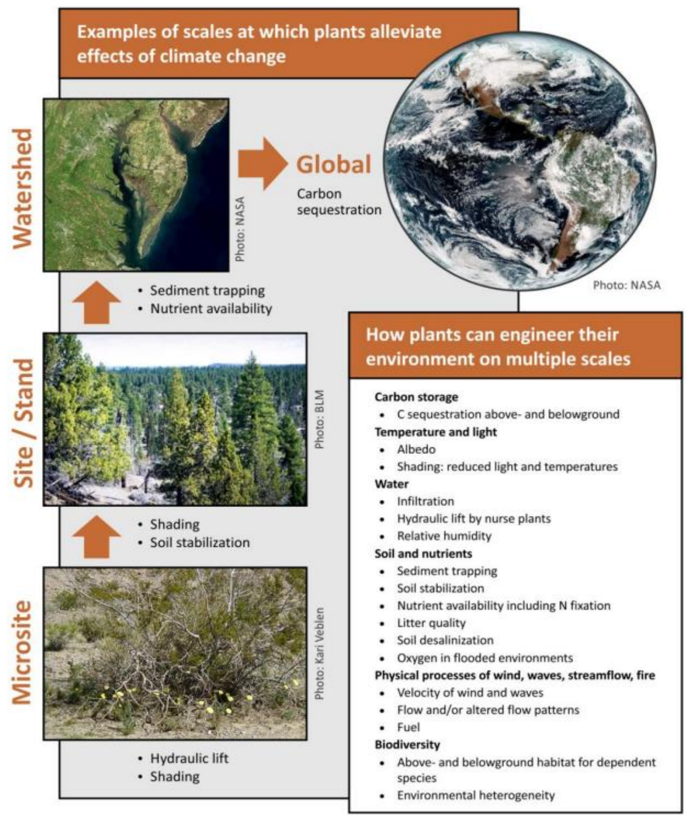

Figure 6. Plants can engineer their environment, including in ways that are important for alleviating the effects of climate change. The spatial scales at which these engineering effects occur vary from the (micro)site to regional/landscape scales.

Mitigating Flooding Impacts

Research has been conducted in several international contexts on the effectiveness of urban greenspace in mitigating floods. One study in central China, for example, integrated data on land use/land cover, soil hydrology, topography, and observed chronic flooding. The researchers "analyze[d] the relationships between spatial patterns in pervious surface and flooding," finding that "larger amounts and patches of dispersed green space mitigate flooding risk."[34]

This aligns with the findings from Bradshaw et al. (2007), who looked at flooding and urban greenspace in 56 developing countries. The research found that "flood frequency is negatively correlated with the amount of remaining natural forest, and positively correlated with natural forest area loss (after controlling for rainfall, slope, and degraded landscape area."[35]

Mitigating Heat Waves

Urban greenspace mitigates heat waves by providing shade and reducing albedo that cools ambient temperatures. This benefits both the other plant species living in the understory, as well as residents living, working, or playing nearby. [36] TPL has documented some of the benefits that forested parks provide in a climate context as well, noting that densely wooded and deep green areas can "counter urban temperatures exacerbated by heat-trapping buildings, pavement, and concrete." [37]

Gill et al.(2007) researched the ways that green infrastructure can help cities adapt in a climate change context, aiming to build the knowledge base on the quantity and quality of greenspace needed to effect change.[38] In modeling additional urban greenspace, the researchers found that "adding 10 per cent green in high-density residential areas and town centres kept maximum surface temperatures at or below 1961-1990 baseline levels up to, but not including, the 2080s High." (The authors ran models for the UK Climate Impacts Program (UKCIP02) Low and High emissions scenarios for the 2020s, 2050s, and 2080s). On a broader scale, Norton et al. (2014) present a framework to help prioritize and select urban green infrastructure in a way that supports reducing surface temperatures.[39]

Additionally, The Nature Conservancy and C40 collaborated on a study that looked at cities around the world, to estimate street trees' return on investment for both temperature and particulate matter (e.g. air quality). The case study for New York City found that "for an additional annual investment of $12 million in street tree planting and maintenance, more than 2.8 million people could have a reduction of 1.5°C (2.7°F) in summertime temperatures.[40]

Moore (2016) calculated the value of several services provided by urban forests in Australia, including shade, using a basis of 100,000 mature trees (Table 2).[41] In addition to the benefits of reducing heat-related illnesses, shade from trees reduces air conditioning use and therefore reduces expenditures on electricity and water (see table below). Moore estimates that 100,000 trees saves ~3 million kWh per year, with a value of $1.45 million AUD annually (or $1.99 million in 2022 USD).[42]

Table 2. Economic value of shade from an urban forest of 100,000 trees (Moore, 2012).

Approximations used	Value
Number of trees in the urban forest population	100,000
Electricity saving due to shade per tree per annum (kWh annum^{-1})	30
Total electricity saving per annum (kWh)	3 million
Value of electricity per kWh (AUD$)	0.30
Total value of electricity saving per annum (AUD$)	1 million
Value of savings in electricity use per annum for one tree(AUD$)	10.00
Water saved by reduced electricity use at 100L per kWH (L)	300 million
Total value of water saved at $1.50 per kilolitre per annum (AUD$)	450,000
Value of savings in water use per annum for one tree (AUD$)	4.50
Total value of savings in electricity and water use per annum (AUD$)	1.45 million
Total value of savings in electricity and water for a tree per annum (AUD$)	14.50

Previously, McPherson et al. (1997) had estimated the increasing tree cover by 10% (or planting about three trees per building lot) “saves annual heating and cooling costs by an estimated $50 to $90 per dwelling unit because of increased shade, lower summertime air temperatures, and reduced neighborhood wind speeds once the trees mature.”[43] In 2022 dollars, the range would be $93 to $168 per dwelling unit.

Mitigating Drought Conditions

Cities are facing increasing instances of drought conditions due to climate change. Urban greenspace can help mitigate these conditions through water regulating services: providing plant cover that works by “increasing water infiltration via root penetration of the soil surface (reducing runoff-based erosion and increasing water availability to plants), reducing wind velocity (i.e., wind-based erosion), reducing soil water loss through shading, enhancing the recycling of water vapor, and promoting greater productivity at higher tropic levels by providing food and habitat.”[44]

While drought conditions create negative economic impacts to communities, there is limited quantified information on the associated risks under climate change generally (and the value of urban natural areas’ role in reducing these risks).

Conclusion

This literature review provides background and rationale for the methodology proposed to evaluate benefits of individual parks and the Forest Management Framework in New York City.

Although three ecological benefits of climate-resilient plantings are highlighted, urban greenspace and other nature-based solutions can also alleviate social and technical impacts of climate change (e.g., Hobbie and Grimm 2013).[45]

Soloviy, Dobovich, and Kuleshnyk (2022) also reviewed 20 years of interdisciplinary research on the role of forests in urban climate mitigation and adaptation, while Van Oijstaeijen, Passel, and Cools (2020) conducted a review on ten ecosystem service valuation toolkits that are applicable to urban green infrastructure.[46] Some of these decision support tools may be helpful in future estimates of the benefits of urban green space in a climate context.

Espeland and Kettenring (2018) found that planting trees is increasingly considered a cost-effective method for improving the adaptability and sustainability of cities to projected changes in climate. Communities are increasingly investing in tree planting and monitoring urban tree and forest assets as a result of these benefits.[47]

Endnotes

[1] Hauer, Richard J., Jessica M. Vogt, and Burnell C. Fischer. "The cost of not maintaining the urban forest." *Arborist News* 24, no. 1 (2015): 12-17.
[2] Song, Xiao Ping, Puay Yok Tan, Peter Edwards, and Daniel Richards. "The economic benefits and costs of trees in urban forest stewardship: A systematic review." *Urban Forestry & Urban Greening* 29 (2018): 162-170.
[3] Miller, Robert W., Richard J. Hauer, and Les P. Werner. *Urban Forestry: Planning and Managing Urban Greenspaces*. Waveland Press, 2015.
[4] Koeser, Andrew K., Jess Vogt, Richard J. Hauer, Robert J. Northrop, and Ward Peterson. "The cost of not maintaining trees: findings and recommendations from an international symposium and summit." *Arboriculture & Urban Forestry* 42, no. 6 (2016): 377-388.
[5] Vogt, Jess, Richard J. Hauer, and Burnell C. Fischer. "The costs of maintaining and not maintaining the urban forest: A review of the urban forestry and arboriculture literature." *Arboriculture & Urban Forestry* 41, no. 6 (2015): 293-323.
[6] Ibid.
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