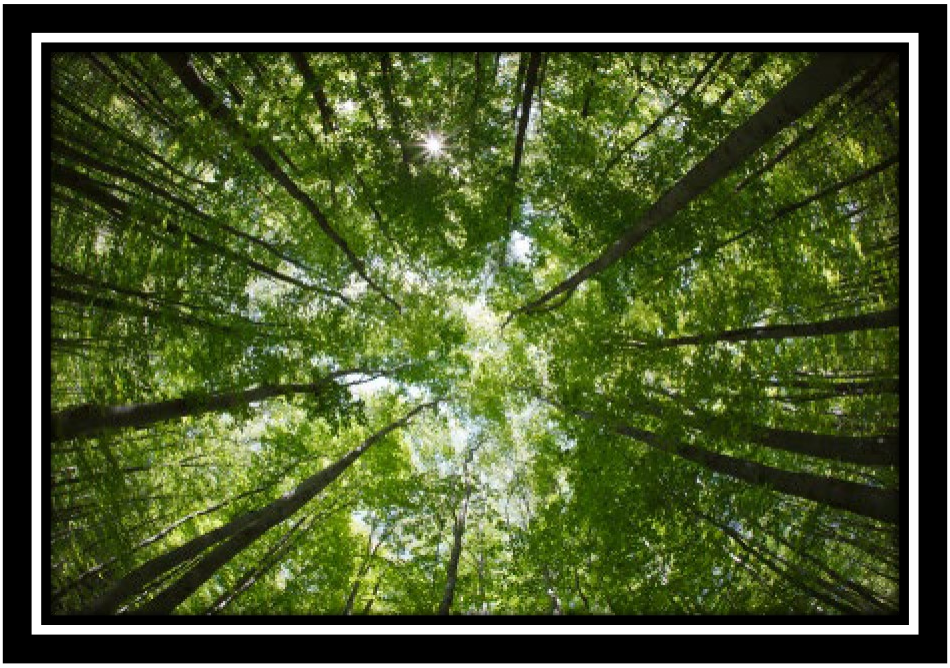


NATURAL CAPITAL INVESTMENT:

URBAN FOREST CANOPY BENEFITS

GUIDE OVERVIEW

Return on investment and accounting guidance for urban forest canopy

Contents

Introduction

The National Urban and Community Forestry Advisory Council (NUCFAC) released a Ten-Year Urban Forestry Action Plan (Action Plan)[1] to raise awareness of the benefits generated by urban forest resources and to promote better urban forest planning and management. The Action Plan identified the need to establish a standardized way to report the benefits and costs of urban forest resources from local to national scales. The 2017 USDA Forest Service's National Urban and Community Forestry Challenge Cost Share Grant Program provided funding to the University of Maryland Environmental Finance Center (UMD EFC) to develop an accessible approach to estimating and reporting cost and benefit data as well as estimating return on investment of urban canopy. Scientific research has established a wide range of benefits for urban forestry. However, benefits may be disparate in quantity across an urban area. Collecting data and reporting net benefits (benefits minus costs) will enable a collective impact report at local, regional or national levels. The impact report can show the magnitude of benefits the urban forests provide, how to assess equity in and priorities for urban forest investments, and the importance of continued - and increased – local and national funding.

> **"For the full range of human and environmental benefits of urban forests to be realized, cities need to be planned with trees and urban forests as a core feature of community infrastructure, instead of as an afterthought."** (Key Issues for 2016-2026 accessed at https://urbanforestplan.org/key-issues-for-2016-2026/).

This guide provides a process for collecting data to support the urban forest community's important work. Urban forest management emphasizes the number of trees, percent canopy cover, tree health, and strategies for increasing tree canopy in urban areas. While managing urban forests and expanding canopy is essential, so is the ability to identify and report urban forest benefits. The ability to articulate the benefits can assist communities in connecting to the importance of the forest resource – especially in urban setting. Total value of benefits is typically positive,[2] and assessing how benefits vary across a community and how these variable benefits compare to costs helps inform investment and management policy decisions. Nationwide, Urban Forestry programs can aggregate the total and net benefits using this guide. The total and net benefits will help understand the magnitude and importance of canopy benefits for communities.

> **"Natural resources such as water and land are often among governments' most important assets, providing the basis for their annual revenue…accounting standards do not yet provide guidance for most natural resources, and this lack of guidance can lead to contradictory practices. Accurate accounting continues to be essential for sound financial decision making by public agencies, private companies, and investors."** (Earth Economics and WaterNow Alliance, 2018 accessed at https://tapin.waternow.org/resources/go-green-muni-bond-financing-for-distributed-water-solutions/).

Many urban forest management plans list the benefits trees provide (see Table 1). The qualitative and descriptive nature of tree benefits is readily accepted and understood. Despite this general acceptance, the benefits often seem abstract in how they relate to a community. Identifying and quantifying benefits helps communicate how the tree canopy provides positive community well-being in a more concrete manner and aids in aggregation across benefits or urban forests.

Comprehensive information on collecting cost and benefit information has been circulated for over two decades.[3] What is increasingly apparent is that recording and reporting costs and benefits over time – as in a lifecycle cost – supports the significance of urban forests to communities. However, increasingly this information needs to be contextualized to address a range of audiences. Aggregate reporting at a large scale is meaningful given the public nature of urban forests, but it may mask disparate benefits in the community. Equity concerns place increasing focus on the ability of some communities to bearthe cost burdens that extend well beyond simply planting a tree.[4] Managing forests to maximize benefits means planning and budgeting over decades. In addition, the existence of negative net benefits in areas helps underscore the value of reporting costs and prioritizing areas for planting based on multiple factors.

Table 1 Qualitative description of urban forest services.*

Urban forest services to humans	
Human health and well-being	Resilience to flooding events
Climate change mitigation	Food and nutrition security
Climate change adaptation	Wood security
Biodiversity and landscapes	Recreation
Economic benefits and green economy	Education
Land and soil degradation	Social cohesion
Watershed protection	Social security and equity

*Endreny, T.A. Strategically growing the urban forest will improve our world. *Nat Commun* **9,** 1160 (2018). https://doi.org/10.1038/s41467-018-03622-0

Who this guide is intended for?

This guide is intended to be user-friendly and applicable to various urban forest management professionals. Budgets and funding source information are necessary for governmental agencies to allocate resources, and for non-profit or private groups working for clients with missions dedicated to urban forestry. This guide helps the user be intentional and explicit about the services and benefits of urban tree canopy and helps advocate for resource allocation for urban forest care. The guide relies on existing essential tools for benefit estimations to describe ways to estimate costs and introduce a "desktop review" of natural capital asset management for forests.[5] [6] Desktop review entails using existing tools rather than gathering time intensive and potentially expensive field data. However, if time and resources are available field data regarding canopy health and composition help supplement an asset plan.

> "Nature provides critical societal benefits to individuals and communities around the world.
>
> The combination of soils, species, communities, habitats and landscapes which provide these ecosystems services are often called 'assets'." [6]

This guide is flexible enough to help small urban forestry programs with limited planning and organizational capacity document and report benefits, costs and returns simply and still have relevance to larger urban forest programs with robust programs and capacity – particularly those with urban forest plans - to link the deployment of urban forest resources with meeting specific environmental or social objectives.

Although other reports and literature document cost and benefit data collection and reporting of net benefits, this guide couples existing tools for data collection with the details on how to treat urban canopy as a community asset. This approach links funding and financing strategies within public budgets (e.g., alignment with asset accounting for utilities and intersecting regulatory programs)[7] and communicating with not-for-profit partners and external private funders.

How to use the guide.

Some users may wish to estimate a return on investment (net benefit = benefits minus costs) for urban tree canopy at a large scale (i.e., municipal boundary) to advocate for forest resources and budget allocations. The information and time required will be related to the size of the area analyzed for benefits. The first step is to define the community focus area, such as the municipal boundary. Existing local forestry and other budgets provide cost estimates that apply to the planting and care of trees. These costs may span several departments. Arbor Day Tree City USA certified communities can use the estimated costs gathered for their certification application. Breaking larger areas into "asset areas" helps describe how net benefits vary and can help support investment and policy choices for healthy canopy growth.

Other users may want a complete asset management plan which requires significant effort.[8] Recognizing that documenting natural assets is new to many, the high-level approach presented here does not include detailed data requirements. Still, it provides a flexible framework that can help integrate urban forestry into broader municipal and budget planning. This guide should supplement existing urban forest plans or assessments and may require collaboration with other departments regarding resources allocated to trees and tree care.

Urban Tree Canopy as a Natural Asset

What is Asset Management, Natural Capital and Natural Assets?

Municipal Natural Assets Initiative (MNAI) champions and supports the actions of municipal governments shifting to a natural accounting approach. A useful guide developed by MNAI titled "Defining and Scoping Municipal Natural Assets"[9] helps users with multiple types of natural asset accounting. MNAI lists the following as reasons for this approach:[10]

> "Asset management is the foundation for understanding near- and long-term operational and capital needs. Asset management plans provide a clear picture of infrastructure-related expenses and future investment needs, which inform financial planning." (U.S. EPA, 2021)
>
> "…better management of natural assets has meant new funding sources, both through the application of Development Cost Charges to support the rehabilitation of natural assets, and through federal-provincial funding streams that can be applied to natural assets. In our experience, not considering natural assets as part of an overall asset management strategy would mean only doing part of our job." (Wayne Rowe, Mayor, Town of Gibsons, British Columbia.)

- Natural assets such as aquifers, forests, streams, riparian areas and foreshores can provide municipalities with vital services equivalent to many engineered assets.
- Emerging evidence shows that identifying, measuring and managing natural assets as part of an overall asset management strategy can save capital and operating costs and reduce risk.
- Local governments are finding that natural assets are resilient and adaptable to climate change. With effective monitoring, maintenance and rehabilitation now, natural assets can provide service and add value for decades in ways that many engineered assets cannot match.
- In some communities, development cost charges may be able to support the rehabilitation of natural assets.
- There are external funding sources to support the maintenance/rehabilitation of municipal natural assets.
- Some natural assets serve multiple purposes. For example, parks may reduce flooding risks as well as provide recreational benefits and can be managed to maximize several objectives.

Natural capital asset planning and management (Figure 1) is not a new concept, but adequate integration of natural capital into financial decision-making is still a work in progress. England established a Natural Capital Committee and published reports [11] regarding the quantity and state of natural resources country-wide. The goal was to embed the reporting and accounting of natural capital as assets in decision-making.

Why Tree Canopy as an Asset?

Individual trees provide amenities and benefits, however the canopy of urban forests provides greater benefits than individual trees. Individual trees have been recognized as "real" assets (assets with an appraisal value) but canopy has not. The urban tree canopy of cities provides many benefits for people, businesses, and homes. Quality and extent of canopy is important to maintain so the canopy benefits are realized. The fact that the main goal of many urban forestry plans it to expand canopy is the reason canopy is recognized as "the asset" in this guide.

Treating urban tree canopy as an asset and incorporating urban canopy in other plans as providing vital services elevates the canopy to a level supported by infrastructure funding and financing streams (e.g. Clean Water Revolving Funds). The steps below describe a process used in the asset management and natural capital accounting arena. This guide specifically links urban forest canopy as the natural capital asset that provides specific benefits to humans with estimates of value for human well-being.

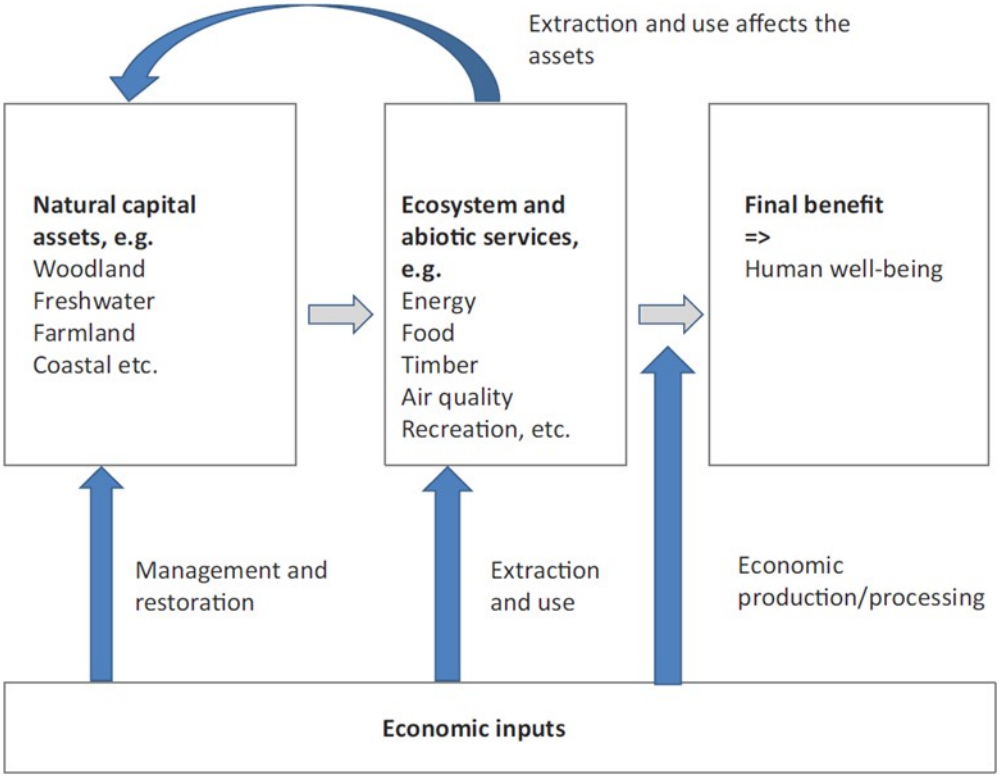


Figure 1 Links between assets services and benefits with necessary economic inputs. (Figure from Bright, G., Connors, E., & Grice, J. (2019). Measuring natural capital: towards accounts for the UK and a basis for improved decision-making. Oxford Review of Economic Policy, 35(1), 88-108.)

Examples of asset management for urban trees, forests, and natural resources.

Many cities already use private asset management programs and consultants to track costs and needs for the care of publicly-owned trees. A few cities have completed asset management plans for publicly owned areas. In the U.S. City of Chula Vista, Kauyga Solutions completed an Urban Forestry Management System Asset Management Plan[12] to be integrated with a city-wide asset strategy. Elsewhere, the Center for Neighborhood Technology listed Accountability Requirements[13] including using an asset approach for the City of Portland to better manage urban forests and align with funding sources (see Capital section below). The City of Knox, Australia's Street Tree Asset Management Plan[14] assessed the city's trees to better maintain and manage canopy and advocate for funding. Trees in the Townscape[15] recommends an asset management approach as part of 12 principles for embedding trees in city planning processes. This guide can be used as support within the Vibrant Cities Lab Urban Forestry Toolkit and the Community Assessment and Goal Setting Tool (see steps in Figure 2).

Figure 2 Vibrant Cities Lab – steps in The Community Assessment and Goal Setting Tool.

During the assessment phase, treating urban canopy as an asset can also help prioritize planting areas based on distinguishing planning area differences and making a case for funding in certain areas. The planning phase describes "looking beyond the borders" which canopy as a community asset also supports. Benefits attained by the canopy are not constrained to jurisdictional borders. Funding sustainability is enhanced by identifying services the canopy provides and can help link to a broader array of funders whose priorities map back to the outcomes associated with these services.

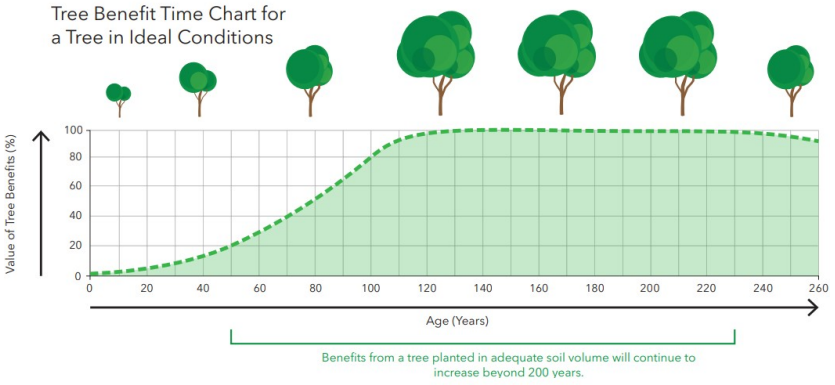
> "The purpose of using an asset approach for urban canopy is to inform all planning, management and investment decisions with a robust understanding of both the costs and the value trees deliver.
>
> – Optimizes costs and benefits from trees in a strategic way.
>
> – Uses best practice to articulate needs for resources: councils understand that they are voting for a resource allocation with a known quantity and value.
>
> – Gets wider buy-in and support for the returns generated by the urban forest." (Pg. 64. Trees and Design Action Group. Trees in the Townscape. 2018. (accessed at https://www.treeconomics.co.uk/wp-content/uploads/2018/08/Guide-for-Decision-Makers.pdf)

It is increasingly important to identify and account for natural resources and document what they provide for human well-being. Considering resources as natural assets translates the services and benefits that people within the community experience. Part of asset planning is identifying ownership of an asset. Urban forests are not just trees on public property but trees on private property as well. Forward-thinking cities include all land-owners in defining and managing the urban forest. "Management of urban trees and associated resources to sustain urban forest cover, health, and numerous socioeconomic and ecosystem services is known as urban forestry."[16]

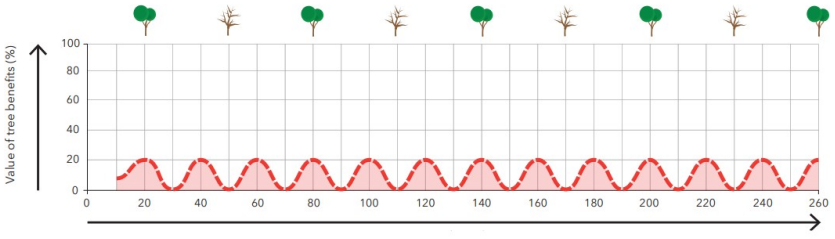
While a city's direct management actions are limited to public property, most progressive urban forest departments define and address planning across the city, regardless of land ownership and measure canopy across all lands. As shown in the benefits listed above in Table 1, many relate to areas beyond publicly owned property. The tree canopy in a broader area, treated as a natural asset, also addresses the inter-jurisdictional nature of benefits for a community and may help to define responsibilities and budget sharing.

The challenge of adequate funding for urban forest expansion and proper maintenance is well documented. Climate Knowledge and Innovation Community (Climate-KIC)[17] lists a few prominent reasons why municipalities lack resources to support forest growth:

1. ***Urban trees are framed as costs rather than assets.***
   The current management paradigm does not take tree longevity as the optimal human benefit (Figure 3a). Rather maintenance budgeting for least cost incentivizes small trees and rapid replacement instead of investing in proper long-term care to achieve ecological benefits of 50 plus year old trees.[18]
2. ***Success metrics are focused on planting rather than maintaining urban canopy.***
   Denser canopy coverage of an urban area relates to better benefit to the community. However, using *benefits of trees to humans* as the target for urban forest management provides metrics that go beyond planting and help focus on the importance of tree longevity (Figure 3b).
3. ***We simplify the financial returns of trees.***
   Trees on private property and in public right of way often have a regulatory replacement value (e.g., for damage or removal) that undervalues actual monetary worth. In addition, it is difficult to report the non-monetary benefits of trees systematically, and these benefits are largely unaccounted for in financial considerations for forest funding.



01.
Trees are the largest, and longest living things on earth – when planted well, and maintained. Most street trees do not attain their species potential simply because the long term requirements are not calculated at planting stage. As you can see from the above graphic, originally formulated by Jeremy Barrell of Barrell Tree Consultancy, the real cost benefits start to increase after about 50 years, and continue to increase for another 150 years! Much of urban development does not look ahead more than 75 years, so well planted trees can shape our cities for decades and even centuries to come!



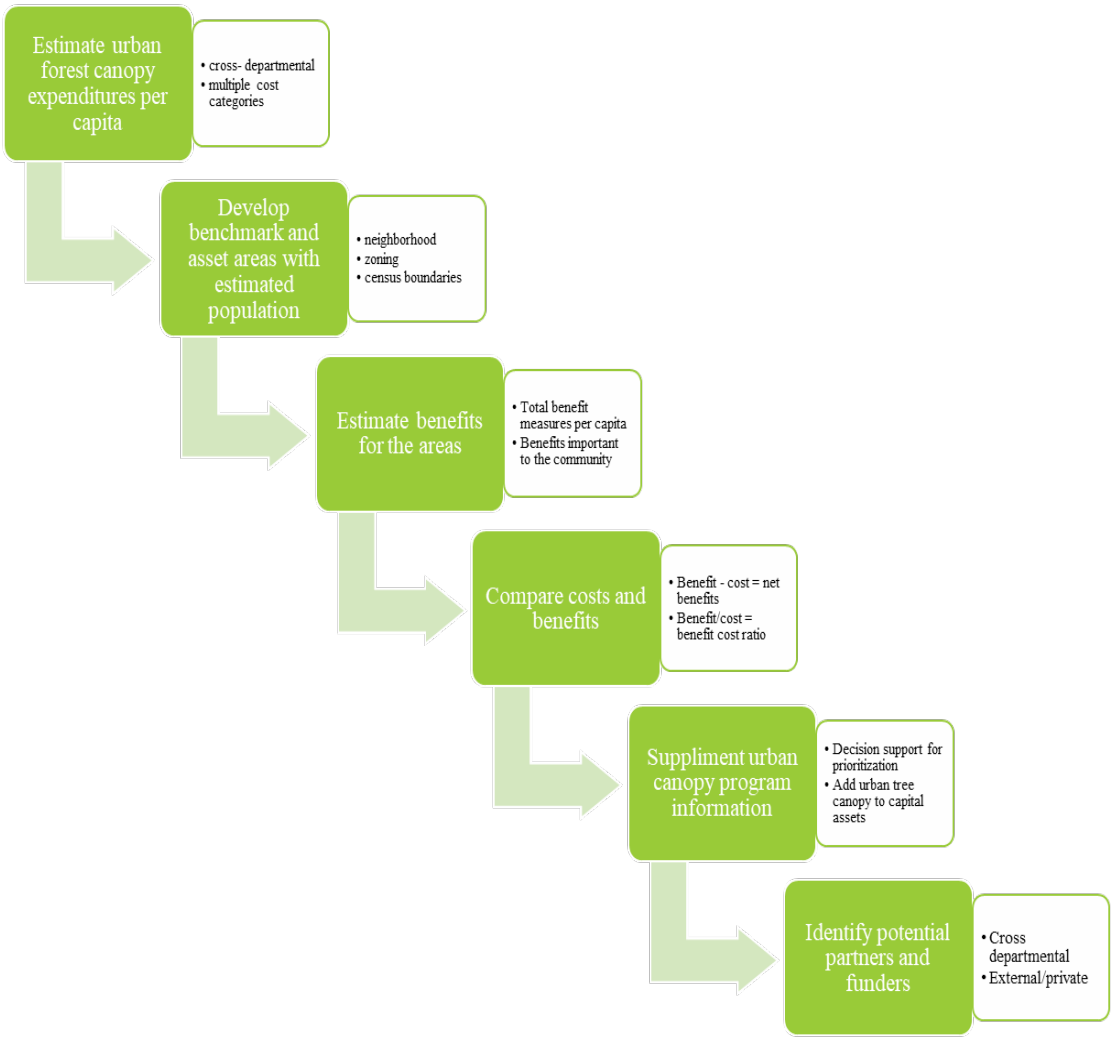
02.
This image shows how regular replanting of trees which fail before they have achieved 10 years of age is not only a total waste of resources, but never provide the multiple and needed benefits to our urban communities. Realistically, they will not give us more than 20% of their potential values – so better to plant one tree well, than 5 trees poorly!

Figures 3a (top) and 3b (bottom). Figure 3a demonstrates the importance not only of maintaining trees for longevity because the majority of benefits increase overtime but also the problem of simply focusing on planting new trees. Figure 3b is similar to taking a short view of the trees benefits and missing the import the long-view and accounting for benefits.[19]

Steps for Urban Canopy Asset Accounting

Steps

1. **Track current costs, funding sources, and amounts**
    - **Use this step to coordinate departments and compile urban forest costs**
2. **Establish benchmark area, assessment areas, study area, or area of interest (asset units)**
3. **Establish local ecosystem services and benefits for urban forest**
    - **Estimate benchmark net benefits**
    - **Compare asset areas net benefits**
4. **Prioritize urban forest areas and add to applicable planning documents**
5. **Track costs and benefits to establish investment with potential for improving funding streams**



Step #1

Track current costs, funding sources, and amounts, which involves:

- *Retrieving tree-related care and planting costs across departments.*
- *Establishing a method to track <u>all</u> costs yearly, on public and private land (i.e., incentives or subsidies for homeowners).*
- *The costs are likely city or municipality-wide and should also be reported as per capita costs.*
- *Establishing tracking for all fiscal sources that support the urban forest resource.*
- *Generally, costs are covered by tax revenue from the community but may include grants, fees, or potentially capital improvement funds.*
- *The support for urban canopy work may come from multiple departments.*

An important point about costs

Costs in budgets typically reflect the management of trees on publicly owned property. They also may reflect what was previously budgeted and not report the gaps in resources for management and maintenance of the canopy.

The extension of this task is to include estimated costs of managing and maintaining privately owned trees that are part of the urban tree canopy.

As Clark et al. states: "…urban forests exist on both public and private land, funding must be both public and private. The amount of funding available from both sources is often a reflection of the level of education and awareness within a community for the value of its urban forest" (p. 25. Clark, J. R., Matheny, N. P., Cross, G., & Wake, V. (1997). A model of urban forest sustainability. *Journal of arboriculture*, *23*, 17-30.).

This step establishes a way to trackall costs across departments that handle tree care in the urban setting. Tree budgets may be allocated for management indifferent areas (e.g., street trees, cemetery trees, public grounds, park trees, and other locations).

The different departments may have costs associated with different tasks that relate to the department's purpose For example, public works, parks and recreation, planning, and either the capital budget and/or the executive budget may have various project types related to trees.If the tree-related costs are not systematically tracked, establish a way to communicate with and retrieve this information yearly.

With up to 80% of urban canopy areas located on privately owned land, this framework establishes the importance of accurately collecting costs to maintain and grow the canopy. Innatural resource management, the boundaries for natural assets are always commonly shared.In this framework, the urban canopy is the natural resource that provides services to the community. Planning to manage the forest asset for commonly shared benefits also means establishing the various costs (e.g., assistance with maintenance, enforcement, permitting, and ordinance establishment) that are associated with canopy services.

Funding information may come from different departments similar to the cost data. Table 2shows the results of budget scans of for eight cities and related per capita amounts. The

funding for tree projects were from various departments and had different sources – but the main source was the general fund. Hauer and Peterson[20] reported that 86% of communities surveyed identified the general fund for 72% of the public tree budgets.

Table 2 Estimated total and per capita funding across departments for urban forestry

Municipality	Municipal Population (2017)	Total Budget (2019)	Per Capita Budget (2021)*
City of Atlanta, GA	465,230	$4,158,341	$9.21
City of Baltimore, MD	619,796	$8,477,863	$14.09
City of Denver, CO	678,467	$475,596	$0.72
City of Detroit, MI	679,865	$6,940,910	$10.52
City of Frederick, MD	69,330	$87,475	$1.30
City of Lancaster, PA	59,556	$286,102	$4.94
City of Philadelphia, PA	1,569,657	$5,474,649	$3.59
City of Portland, OR	630,331	$6,257,872	$10.23

*Consumer Price Index
2019 to 2021, 1.03
2017 to 2021, 1.11

Table 3 below summarizes the budget line scans and searches to establish the current budget and funding levels, as well as common budget lines to break out for tracking future costs. A complete breakdown of costs is imperative to understand what level of resources are needed and establish where urban canopy funding is coming from (as stated there are likely multiple sources) so the investment estimates and potential return on investments can be developed.

If non-profit organizations use this framework, the budget and funding breakdown will contain different sources – potentially private or foundation funding. The task purpose is to delineate the project type and track costs associated with urban tree projects. The point of the assessment is to obtain information on funding for the canopy asset in interest and relate investments (whether private, public, or other) to the benefits the investment creates.

Table 3 Departments that may have tree and forestry budgeting.

Budget and Funding Estimation				
Department	Project Type	Project Task	Funding Source	Annual Budget
• Executive Office (special offices within) • Office of Resilience • Office of Sustainability • Department of Parks • Department of Public Works • Department of Planning • City Infrastructure • Property Management • Real Estate Acquisition & Management • Department of Transportation	• Implementation/Planting • Assessment • Removal • Maintenance • Ordinance work • Permitting and Enforcement • Education and Outreach • Mitigation (permit related)	Specify if the task is contracted, staff, materials, and purpose	Clearly delineate public and private funds	

Capital Improvement Funds: Potential to align future funding and finance.

This framework intends to build support for other funding sources such as greater use of capital budgets for more than tree planting. The ability to justify different uses of capital funds is locally determined; however, using an asset framework helps communicate urban forest canopy assets as infrastructure that provides vital community services. Capital fundsmay go to grants for urban forest non-profits or directly fund urban forest projects.
Therefore, all public and private organizations may be interested in the ability to list canopy as an asset and reporting requirements described below. In 2011, the Center for Neighborhood Technology (CNT) listed Accountability Requirements and that "…quantifiedutility service benefits that would allow trees to be managed as assets, and potentially fundedas capital improvements,"[21] which includes steps suggested in this framework:

- An up-to-date inventory of assets.
- Condition standards and a summary of physical condition assessments.
- Estimate of costs to maintain and preserve the assets at the established target condition level.
- Reporting of actual costs spent on maintenance and canopy expansion.

The CNT report listed possible sources for tree asset management funding and a summary of Governmental Accounting Standards Board (GASB) Statement 34. GASB 34 requires financial reports from state, local, and municipal governments regarding infrastructural capital assets. It has rules which permit accounting fortrees as assets at their historical cost, including acquisition and installation. Trees become eligible for specific funding streams such as bonds. Importantly, GASB 34 allows for a "Modified Approach through which costs associated with the maintenance and preservation of assets can be accounted for as expenses and expansions can be capitalized."[22] Urban forestry programs that use asset accounting and GASB 34 reporting can help fund maintenance and preservation – activities that may not qualify if the urban forest trees and canopy are not considered assets.

In 2016, Earth Economics and the WaterNow Alliance[23] summarized accounting standards (GASB Standard 62 Regulated Operations) currently in place that allow utilities to debt- finance distributed infrastructure (DI), including urban tree canopy if the utility: 1) Has the legal authority to set rates; 2) Will set rates at a sufficient level to pay for DI costs over time;and, 3) Is spending funds currently that are not covered by current rates, but can commit to having rates in place in the future to pay for these costs. Once the utility creates an "asset"

under these conditions - even if those are not traditional assets owned and operated by those agencies – the asset becomes a "regulatory asset." Once an asset is defined under this standard, revenue bonds can be issued to pay for to maintain the asset. This opens the potential to use a funding mechanism that is to municipal fiscal agents to invest in new and innovative strategies at a much broader scale. In using this funding stream, distributed natural systems can be part of long-term, comprehensive capital planning and budgeting.

Step #2

Establishing benchmark area, assessment areas, study area, or area of interest (asset units) involves:

Creating a assessment area(s)which is:

- *User-determined.*
- *A benchmark area to compare data (can be municipal boundary).*
- *Has boundaries (size and location) that are static over time.*
- *Contained by U.S. Census Boundaries to coincide with exiting benefit estimation tools.*
- *Possibly part of an existing management plan, districts, sub-district, neighborhood or planning unit the urban foresters or managers currently recognize.*
- *A method to aggregate costs and benefits at multiple scales on a per capita basis.*
- *Applicable to available tools such as the American Forests Tree Equity Tool (https://www.treeequityscore.org/) to uncover where canopy may aid in disparities (i.e., lack of benefits).*

In an asset management framework, this step sets the asset to manage and the associatedcosts and resource allocation for keeping the asset functioning. The benchmark area establishes a comparison for sub-areas on a per capita basis. The benchmark also helps prioritize and understand how different areas may be receiving greater or lesser canopy services and benefits.

The assessment areas should reflect the values and objectives of an urban forest plan. These values and objectives can reflect community priorities or identified areas where canopy needsare significant because of equity, health, or environmental concerns. In many cases, urban forest management plans establish planning areas by zoning codes, city-wide, sub-districts, neighborhoods, or city blocks. These planning areas can inform the assessment area. For example, the 2020 Trees For Seattle Urban Forest Management Plan [24] breaks the city up into“management units” categorized by general land development of Single-Family Residential, Multi-family Residential, Commercial/Mixed-use, Downtown, Industrial, Institutional, Developed Parks, Parks’ Natural Areas, and Rights-of-Way. “Identifying the area of interest for an urban tree canopy (UTC) assessment often depends on the objectives and desired outcomes of the UTC project. A UTC assessment can be developed based on environmental boundaries such as watersheds, subwatersheds, or riparian areas. Or, the objective of the UTC project may necessitate using jurisdictional, political, or social boundaries such as voting districts or census block groups.”[25] The boundary of the assessment area should be static to allow benefit data collection over time. U.S. Census boundaries may not coincide with typical planning boundaries but are the most useful for calculating benefits in current tools.

The assessment area(s) guides the data collection effort. By establishing specific areas for comparison within the municipal or community area, the urban forest manager can aggregateand compare the tree canopy’s benefits and services in various areas. The beenfits may varyacross the canopy asset areas such as stormwater reduction, carbon sequestration, or temperature reduction in the urban environment. If an urban forest management plan is unavailable or does not establish distinct areas, a number of tools can help. For example, the Vibrant Cities Lab Urban Forestry Toolkit [26] has resources to help develop assessment areasand suggests other canopy resources to use, such as i-Tree Canopy.

Step #3

Estimate benchmark area and asset area benefits by:

- *Identifying why the canopy is essential to the community, specifically within the assessment area.*
- *Using previously established or identified priority benefits in planning documents; for example, the benefits of trees included in sustainability, comprehensive, climate action or other plans.*
- *Recording the benefit estimates from an existing tool such as i-Tree Landscape, i-Tree Canopy, or U.S. EPA EnviroAtlas.*

The objectives and goals for urban forest management are often embedded in a wide range of documents. Review of existing plans, such as sustainability, comprehensive, and climate action plans, helps connect community-wide goals to the services provided by urban tree canopy. For example, the City of Newark, Delaware's Sustainability Plan[27] process included a public engagement component clearly identified urban forestry goals and related environmental, economic, health, and equity benefits related to trees that the community seesas priorities, which has been articulated in the resulting guidance document.

Table 4 below, identifies some of the services that are most commonly identified in existing benefits databases. For example, stormwater runoff reduction for water quality benefits as well as air quality improvement for health benefits are calculated in the tools listed above. Other services like economic development, tangible market goods, environmental market goods, social and community improvement or other environmental services (like pollination)have to be generated by stakeholder involvement as listed in Table 5.

Table 4 Services and benefits for the urban forest.

Services	Benefits
Water Quality	Benefits follow from identifying services urban canopy provides related to what information is available to link the benefit to human interests. The key here is that the user should select only the benefits they will commit to assessing cost and needs for managing and maintaining the asset.
Health	
Economic Development	
Tangible Market Good	
Environmental Market Good	
Social and Community Improvement	
Environmental (Other)	

Table 5 lists the many ways that dollar values can be attributed to trees based on their services.

Table 5 Examples of specific urban forestry benefits and existing tools for estimation.

Benefits Urban Forests Provide to Communities	Tools for Valuation (+ high data need, -existing tool for estimation)
Reduced local flood damage and nuisance (reduced damage costs)	+Local data collection on flood losses
Reduced health impacts from urban environment (cost saving)	- i-Tree Tools, EnviroAtlas
Reduced health impacts from urban environment (recreation values)	+ RUVD[28] data collection applicable to area
Tax revenues (increased property value)	+ Data on property values surrounding the asset area, apply a premium
Productive reuse of fresh cut hardwoods, tree trimmings	- Market prices
Carbon sequestration	- i-Tree Tools, EnviroAtlas
Job creation	*[To be developed on a city-by-city basis: appropriate proxies]*
Crime reduction in neighborhoods	*[To be developed on a city-by-city basis: appropriate proxies]*
Stormwater volume captured (cost of treatment savings)	i-Tree Tools, EnviroAtlas (generally $0.009 pergallon)
Reduced urban heat island effect	*[To be developed on a city-by-city basis: appropriate proxies]*
Neighborhood social cohesion	*[To be developed on a city-by-city basis: appropriate proxies]*
Improved mental health	*[To be developed on a city-by-city basis: appropriate proxies]*
Social and environmental equity improvement	*[To be developed on a city-by-city basis: appropriate proxies]*
Ecosystem health (pollination, biodiversity)	*[To be developed on a city-by-city basis: appropriate proxies]*

Benefit Calculation Examples Benchmark example: City of Newark

Tools to estimate community benefits of urban canopy, such as i-Tree Landscape, can provide benefit valuation estimates for an entire municipal area. The potential urban forest services and benefits, as an example, are below in Table 6. The example of total estimated benefit values for

the City of Newark municipal boundary include. Energy conservation, stormwater runoff reduction, and air quality improvement due to small particulate matter (PM2.5) reduction have positive total benefit values and positive benefit per capita (benefit divided by the population). The net benefits are per capita minus the cost per capita - estimated at $9.47 based on City of Newark Arbor Day reporting for Tree City USA. The stormwater benefit is negative, indicating expenditure for stormwater benefit per capita is below zero.[29] While the benefit-cost ratio is below 1.0 for stormwater, it remains above 1.0 for energy and air quality indicating benefits are higher than costs and provide a return on investment. For example, $1 invested in tree canopy returns $0.45 in energy conservation benefit. Summing the net benefits for energy conservation, stormwater runoff reduction, and air quality improvement ($4.23 + (-$0.34) + $0.58= $4.47 indicates positive net benefits for the city overall.

Table 6 Example of select urban canopy benefit values – municipality wide.

Urban Forest Canopy Service	***Estimated Total Benefit Value (per year)***	***$ Benefit per Capita***	***Net Benefit (benefit minus cost**)***	***Benefit-cost ratio***
Energy conservation^	$459,090	$13.70	$4.23	$1.45
Stormwater runoff reduction^^	$305,937	$9.13	($0.34)	$0.96
Air quality improvement particulate reduction (Particulate Matter 2.5)^^	$336,700	$10.05	$0.58	$1.06

^USFS Trees Reduce Building Energy Use in U.S. Cities. 2017.

https://www.nrs.fs.fed.us/news/release/trees-reduces-building-energy-use
^^i-Tree Landscape, CPI adjustment of 1.21 for the years 2011 to 2021.
https://landscape.itreetools.org/maps/benefits/
**2017 Arbor Day tree care budget per capita $8.53 CPI adjustment 2019 to 2021 (1.11) is $9.47

Benefit Estimation Example: Asset Areas in the City of Newark

Benefit valuation is a complex economic process, and existing tools provide a quick way to gain insight into dollar values associated with ecosystems and their services. The tools most applicable to urban forests are i-Tree Landscape and EnviroAtlas. As Table 5 shows, existing tools do not estimate all potential benefits, and new data collection is necessary. For a very brief introduction to economic benefit and valuation methods, see Appendix A. The examples in this guide will use available tools reporting health (air quality) and water quality benefits.[30]

To characterize benefits as the value of service the urban forest provides to an assessment area, total benefits and net benefits are essential to consider. Economists also emphasize marginal benefits,

which describe the values related to changes desired or not desired in an ecosystem. For this guide, basic benefit values – total and net – will be used as the process is to describe the urban forest areas as they currently exist. Comparison of these values for the benchmark and assessment areas help in prioritization and decision making. Marginal analysis helps determine the value of increasing the benefits in an area. The assumption herein is increasing canopy is linked to increased benefits. This assumption is simplistic economically but valuable for a high-level assessment of urban forest to characterize the general magnitude of asset (forest) services.

Tables 7 and 8 show examples of stormwater and health benefits from i-Tree Landscape. These are total benefits based on an example asset assessment area. It is appropriate to add the total values for discrete services in the separate areas: however, keeping the services and benefit values separate will help explain the discrete values to other entities interested in specific canopy benefits (i.e., communication of urban forestry programs with stormwater to departments tasked with improving stormwater). Total benefits are all positive for the separate areas. The relative contribution to the total municipal benefits (Table 6) is almost half for the stormwater benefit (53%) and over half for the air quality benefit (59%). These numbers indicate this total area (WN1-WN7) area is a vital canopy area for the municipality.

Table 7 Stormwater Benefits From Tree Canopy

Area Name	Reduction in annual runoff (gal/year)	Reduction Value ($0.009/gal)
WN1	6,100,000	$ 54,131
WN2	5,300,000	$ 47,744
WN3	1,500,000	$ 13,010
WN4	400,000	$ 3,426
WN5	1,100,000	$ 9,679
WN6	1,400,000	$ 12,253
WN7	2,600,000	$ 23,243
Total		$ 163,486

Table 8 Particulate Matter (PM2.5) Removal BenefitsFrom Tree Canopy

Area Name	Value of human mortality avoided due to particulate matter [PM2.5] removed ($/yr)
WN1	$ 66,131
WN2	$ 58,327
WN3	$ 15,895
WN4	$ 4,186
WN5	$ 11,824
WN6	$ 14,970
WN7	$ 28,396
Totals	$ 199,729

Step #4

Net Benefits and Return on Investment Estimates for Canopy Assets

Total Benefits: This is a number that is helpful to compare the magnitude of benefit in a particular area – it helps understand relative benefits when you have multiple areas to assess.

Net Benefits: This number shows how expenditures produce net gains or net losses. Simply, positive net benefits mean you are making positive outcomes with spending. Negative net benefits may mean you have to change something to increase benefits, reduce costs, or potentially reallocate expenditures. (Similar to revenue and profit, profit is the money you makeafter subtracting costs from making and selling your product.)

Benefit/Cost Ratio: An estimate of how the costs compare to the benefit. If this ratio is 1.0 is shows how much the investment produces in benefits. If the ratio is below 1.0 the investment isnot producing benefits. For example, a BCR of 2.0 means the return is twice the cost of the investment. A BCR is a simple way of relating returns on investment in the urban tree canopy.

Managing urban forests often require private and public funds. While the funds can be pooled, each funding stream tends to have specific interests or objectives. Public funds may secure a benefit that is not directly quantified but generally understood to be of value. Many benefit-cost studies focus on measuring these public benefits. Available tools place monetary values on tree'sbenefits and give a unit dollar value of the particular benefit. Reporting total benefit values as shown in Tables 7 and 8 is "benefit valuation," where the benefits are not related to costs. A second way public and private funders may view return is in a cost-benefit framework where the benefits are is compared to all of the costs associated with the benefits. Figure 4 below shows basic components for a benefit-cost assessment.

With private funders, the focus may be on establishing a return on investment (ROI). In this setting, the focus is on aligning specific service/benefit outcomes with potential partners (Figure5) interested in supporting the urban forest. In this sense, accounting and asset planning providecost savings or value that returns investment capital to the funder.

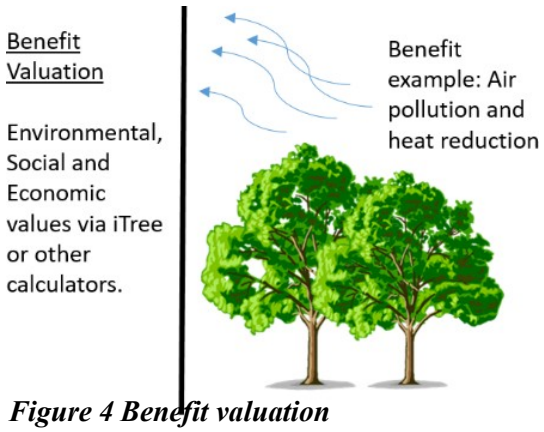


Figure 4 Benefit valuation

Benefit valuation (Figure 4) reports the total benefit (dollar values) that trees provide to the community and region. Benefits, such as air quality improvement from particulate reduction, may be added to other benefits; however, adding values can lead to double counting (see Appendix A). The benefit values enable communication of the urban tree canopy as not just "being a tree" but providing a function that addresses the human concern. A benefit valuation does not report costs.

In benefit-cost analysis or ratios (BCR, Figure 5) – the benefit is estimated as a dollar value compared with the investment costs, typically on a project basis. A BCR provides a general return on investment and estimates how much benefits are compared to costs. Net benefits are the benefits minus the costs associated with an investment. If net benefits are negative, then the investment costs more than the benefits.

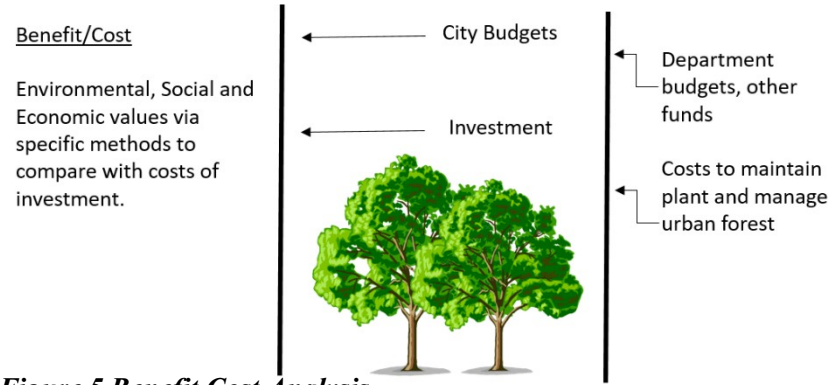


Figure 5 Benefit Cost Analysis

Tracking project investment costs and benefits enables alignment with other funders or sources of revenue interested in the outcomes of a project (Figure 6). For example quantifying water quantity benefit through runoff avoided and issuing credits to new development for stormwater benefits. Tracking and reporting the benefits of a project and connecting with other entities interested in the benefits can result in those entities investing in the project for the benefits. These projects are sometimes termed a pay-for-performance (further described in step 5) or potentially impact investment. If the benefits attract new investment, then an actual fiscal return occurs because the dollars expended resulted in new dollars acquired.

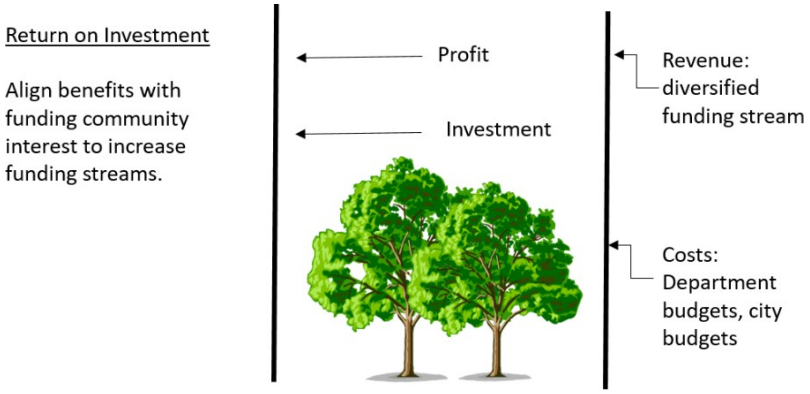


Figure 6 Return on Investment

Example of Net Benefits and Prioritization Decision Support

Table 9 Example of asset areas and tree canopy benefit assessment in support of different management options.

Area Name	$ per Capita Benefit		Net Benefit = Benefit-Cost per Capita**		Total PM2.5 + Stormwater	Planting Priority (i-Tree)^
	Value of mortality avoided due to particulate matter [PM2.5] removed	Stormwater Reduction Value ($0.009 per gallon*)	Mortality avoided (PM2.5) removed	Stormwater	Net Benefits	
WN1	$ 41.33	$ 33.83	$ 31.86	$ 24.36	$ 56.23	33
WN2	$ 22.74	$ 18.61	$ 13.27	$ 9.15	$ 22.42	34
WN3	$ 17.51	$ 14.33	$ 8.04	$ 4.86	$ 12.90	46
WN4	$ 2.52	$ 2.07	$ (6.94)	$ (7.40)	$ (14.35)	100
WN5	$ 5.22	$ 4.27	$ (4.25)	$ (5.20)	$ (9.45)	67
WN6	$ 11.41	$ 9.34	$ 1.94	$ (0.13)	$ 1.81	46
WN7	$ 17.84	$ 14.60	$ 8.37	$ 5.13	$ 13.50	0
WN Totals	**$ 118.56**	**$ 97.05**	**$ 52.29**	**$ 30.77**	**$ 83.06**	

*i-Tree Landscape uses the U.S. national average dollar value of $0.008936/gallon to estimate the value avoided runoff due to trees. The value is based on 16 research studies on costs of storm water control and treatment (https://www.itreetools.org/)

**	$ 9.47	This value is the dollars per capita benefit divided by the adjusted 2017 Arbor Day tree care budget per capita $8.53 (CPI 1.11)

^The index is from 0 to 100, where 0 is a low priority and 100 is a high priority.

Asset strategies help provide information that supports investment decisions. Prioritizing or categorizing needs based on canopy benefits can help with budget decisions. A key concept of asset management planning is that not every asset has the same needs and resource requirements. Supporting decisions by connecting the protection or enhancement of benefits, planning for maintenance, preservation, and subsidies for private parcels are as important as planting new trees.

A per capita cost over generalizes expenditure but is a starting point for allocating expenses across the community. Table 9 shows an example of benefits, net benefits, and priority planting areas based on i-Tree Landscape estimates. Benefits are unequallydistributed in the areas WN1 – WN7 and the total net benefits are negative in areas 4 and 5. These are also areas identified as priority planting areas in i-Tree Landscape. Using the asset and benefits calculation supports why these areas are a priority for planting and helps support the values associated with maintaining canopy in the other areas.

Table 10 shows the return on investment (ROI) using the BCR. The areas with positive net benefits have a positive return on investment; for example, area WN1 has $56.23 in net benefits with an ROI of $4.40 for mortality avoided and $3.60 for stormwater runoff reduction for every dollar spent. Area WN4 has a negative net benefit of $14.35, meaning the dollars spent do not generate positive benefits, and the ROI is less than one, meaning for every dollar spent, less than a dollar ($0.30 – $0.60) is returned in benefits.

Table 10 Estimated net benefits compared with benefit-cost ratios.

Area Name	Total PM2.5 + Stormwater	*Benefit-cost ratio*	
	Net Benefits	*Human Mortality avoided by PM2.5 removed*	Stormwater Runoff Reduction
WN1	$ 56.23	4.4	3.6
WN2	$ 22.42	2.4	2.0
WN3	$ 12.90	1.8	1.5
WN4	$ (14.35)	0.3	0.2
WN5	$ (9.45)	0.6	0.5
WN6	$ 1.81	1.2	1.0
WN7	$ 13.50	1.9	1.5

Step #5

Tracking benefits and costs of canopy services for return on investment [1]

The purpose of tracking costs and benefits of specific urban canopy services (not services in aggregate) is to identify, justify and communicate with potential new funding sources. Governments and non-profits have traditionally relied on municipal, state, or federal dollars to develop and implement many projects and initiatives, including urban and community forestry projects. In this approach, funding for the entirety of the project and all related aspects are allocated and appropriated upfront. Although this approach has its advantages, funding is spent on projects before the expected outcomes being delivered. Therefore, this financing structure usually means that riskier projects, i.e. those with untested approaches or uncertain outcomes, may be less likely to receive funding.

Outcomes-based financing is a relatively new financing model that takes an innovative approach to mitigate this risk. In this structure, investors are providing the upfront capital needed to fund these projects, and the repayment of this funding is tied to the achievement of project outcomes and deliverables. Shifting the financial risk of funding innovative projects onto investors allows governments, non-profits, and other similar entities – who typically have less financial capital – to access. New funding from non-traditional sources based on the multiple benefits projects may create, allows more innovative projects to be implemented. In outcomes-based financing, there are usually several parties involved. Figure 7 maps the responsibilities of each party and the relationships between them.

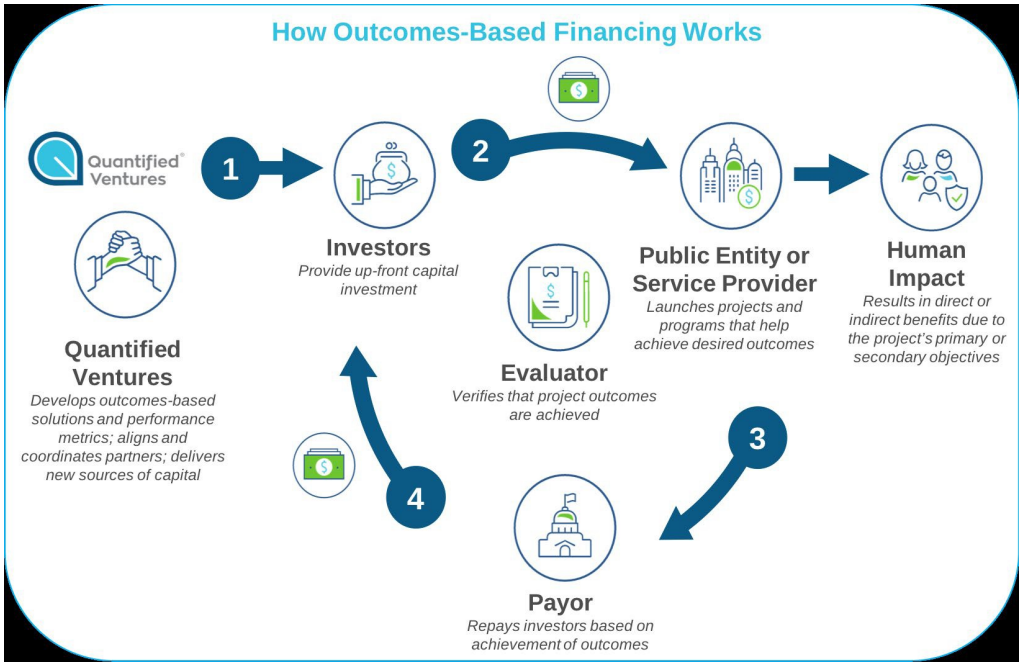


Figure 7 Outcomes-based financing model

Central to the development of any outcomes-based financing approach is the identification of the various stakeholders that would participate, and stand to benefit from an assessment and accounting

[1] This section written with project partner Quantified Ventures.

of the varied outcomes generated by the projects that are being financed. In the context of urban and community forestry projects, the following types of entities to be the most significant and important types of "users" the accounting framework should target:

1. **Outcomes Payor:** An entity that benefits from the value of urban tree canopies, and thus may be compelled to be a "payor" in an outcomes-based financing entity, or contribute to financing of these projects. For example, based recent project team conversations and the link between urban trees and health, this could potentially be a health plan based in a city like Louisville where urban heat island effects and the ability of tree cover to mitigate them are strong. It could also potentially be a municipality itself.

2. **Service Provider:** An organization that plants trees in urban settings and implements urban and community forestry projects, such as Casey Trees in Washington, DC. This is the target entity for scaling from capital provided by outcomes payors. If the service provider is also one that incorporates social and economic goals in their operations, such as workforce development training, a broader set of payors may be incentivized to participate to help pay for projects.

3. **Lobbyist:** Scaling from the local to the national level, an accounting framework that values the benefits of an urban tree canopy could better equip for organizations that lobby for urban trees around the country, such as American Forests. By ensuring buy-in of, and providing tools for, a lobbyist as a "user" of the framework, it would enable easier replication of urban and community forestry projects across the country.

There are different categories used for accounting for urban forest costs and benefits. The costs can fall into direct costs (similar to the costs described above in budgets across departments) in addition to cost savings. These are estimates provided by the benefits, for example, stormwater runoff reduction reducing treatment costs. Revenue can fall into the following categories further described in Table 11.

Table 11 Urban forest accounting system tracking

Costs - Direct	Costs associated with creating and maintaining urban/community forest resources.
Costs - Indirect	Costs that are impacted by urban/community forest resources. These costs could be reduced or avoided through an investment.
Revenue	Revenue generated directly or indirectly from urban/community forest resources.
Non-Revenue Benefits	Non-revenue benefits are generated directly or indirectly from urban/community forest resources. *In italics below are benefits that may be difficult to quantify, so proxies may have to be developed on a city-by-city basis.*

Table 12 Benefit and Cost connections

	BENEFITS Types of data that can be tracked related to investments in urban/community forestry projects	**COST DIRECT/INDIRECT POTENTIAL Specific illustrative data and metrics that can be tracked to assess value in a pay for success or impact investment transaction**
Category	**Data Types Relevant to Urban/Community Forestry**	**Data Examples**
Costs - Indirect	Improved water treatment	Avoided water/stormwater treatment through reduced run-off into waterways
Costs - Indirect	Reduced local flood damage and nuisance	Volume capture of (storm)water, as flow or stock/capacity removal from the floodplain
Costs - Indirect	Reduced urban heat island effect	Ambient temperatures before and after installation of urban forestry resources
Costs - Indirect	Reduced health impacts from urban environment	Recreation-obesity surrounding parks/urban forests
Costs - Indirect	Reduced health impacts from urban environment	Air quality-EMS Calls for cardiac and respiratory distress during high heat index days (>103 degrees F)
Revenue	Tax revenues	Taxes associated with tourism, visitation, neighborhood improvement, etc.
Revenue	Productive reuse of fresh cut hardwoods, tree trimmings	Revenue from sales of hardwoods, wood trimming material
Revenue	Carbon	Carbon credits
Non-Revenue Benefits	Property values	Changes in property value (assessed tax value) before & after park creation
Non-Revenue Benefits	Job creation	# park / maintenance employees over time, # employees of contractors engaged
Non-Revenue Benefits	Crime reduction in neighborhoods	Neighborhood crime rates
Non-Revenue Benefits	Stormwater volume captured	Quantity of volume captured
Non-Revenue Benefits	Reduced urban heat island effect	Ambient temperatures before and after installation of urban forestry resources

Non-Revenue Benefits	Reduced health impacts from urban environment	Asthma rates, obesity surrounding parks/urban forests
Non-Revenue Benefits	Reduced health impacts from urban environment	EMS Calls for cardiac and respiratory distress during high heat index days (>103 degrees F)
Non-Revenue Benefits	*Neighborhood social cohesion*	*[To be developed on a city-by-city basis: appropriate proxies]*
Non-Revenue Benefits	*Improved mental health*	*[To be developed on a city-by-city basis: appropriate proxies]*
Non-Revenue Benefits	*Social and environmental equity improvement*	*[To be developed on a city-by-city basis: appropriate proxies]*
Non-Revenue Benefits	*Ecosystem services (pollination, biodiversity)*	*[To be developed on a city-by-city basis: appropriate proxies]*

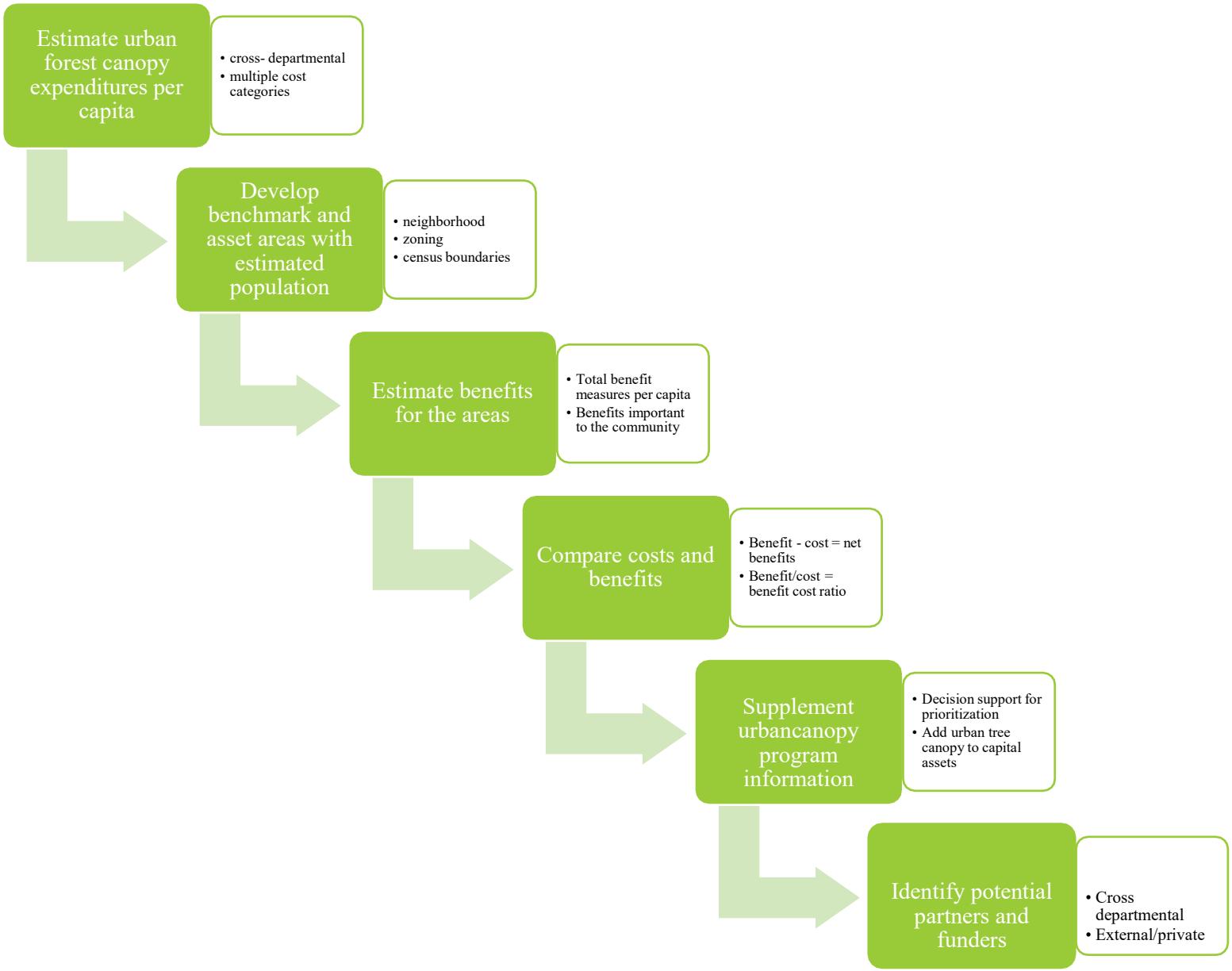
Table 12 shows examples of data types and metrics that urban and community forest managers can collect to value their investments. This data could be used in justifying and structuring new financing sources for urban forestry programs.

Putting it all together

Once the user has collected the information on priorities and services, circling back to add budget needs and prioritization for canopy areas helps determine "service costs" other funders may provide. The exercises herein help communicate and quantify the costs and benefits to provide and maintain urban forests as an asset to the community. Appendix A provides details for human health benefits an return on investment and Appendix B contains an example for the steps described.

The asset management approach for urban forests is part of a larger natural asset approach to address the degradation of natural resources. Humans rely on resources such as watersheds and wetlands for water quality and forests play an integral part in ecosystem health as well as water resource health. The steps described are intended to be a part of a whole planning process either at the comprehensive plan level or the utility planning level. Explicitly accounting for benefits and costs help the urban forest community describe in monetary terms what the forests do for communities and also where the forest investment is not adequate to support benefits. Aggregating these areas in positive (and negative quantities as may be the case with negative net benefits) illuminates the magnitude of importance of the urban forests' importance to humans.

Summary of steps for assessing urban tree canopy for return on investment.



Acknowledgments

Advisory Group

Many thanks to the time and feedback from the advisory group. The process of exploring urban tree canopy as an asset involved multiple work sessions with an expert committee. The committee was asked to consider the elements of asset management and its application, or barriers for application, to managing tree canopy as an asset. Members of the committee included:

Cindy Blain	California Releaf
Dave Nowak	USFS
David Sivyer	USFS
Jana Vandergoot	UMD School of Architecture, Planning & Preservation
John Harris	American Society of Consulting Arborists (ASCA)
Judy Yi	Trees Atlanta
Karen Firehock	Green Infrastructure Center
Larry Wiseman	American Forests
Nancy Duncan	Trees Forever
Nancy Hughes	CA Urban Forestry Council
Ray Tretheway	Sacramento Tree Foundation
Scott Maco	The Davey Institute

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Appendix A – Urban Forestry & Urban Greening for Human Health Prospects for Return on Investment

Urban Forestry & Urban Greening for Human Health:
Prospects for Return on Investment

Prepared by Kathleen L. Wolf, Ph.D.; University of Washington
Partial support for this work was provided by TREE Fund.
draft 17 August 2021

Introduction

This report, *Natural Capital Investment: Urban Forest Canopy Benefits*, offers concepts and methods for conducting benefit-cost analysis of urban forest community services, for the purposes of asset management. Better human health and wellness derived from exposure to and experiences of trees is one dimension of benefit that is inferred in the main report. This appendix offers additional information and opportunity for analysis. Extensive evidence about human health can be an important motivation for local governments and organizations, and the public to support urban forest planning and management. This appendix provides concepts and existing analysis concerning health benefits valuations. Further development of these ideas, with research support, could reveal additional (and substantial) marginal value for tree planning and management in communities.

In 2019 U.S. healthcare costs were $3.8 trillion, representing 17.7% of the nation's GDP[1]. While there is variability in what each person pays, the annual average healthcare spending for each person in the U.S. is $11,582, with the cost burden being shared by individuals, insurers, and government. Medical providers, health insurance companies and public health officials are all exploring ways to reduce costs, while still promoting better health and quality of life.

The concept of social determinants of health describes how the full range and composition of one's situations and circumstances affects health in synergistic ways. These direct and indirect health influences include access to and quality of housing, food, education and income. Even if one has access to affordable health care, gaps in essential support structures and conditions can diminish health and well-being. Impacts occur at scale from individuals to households to entire communities.

Considering the exceptionally high costs of U.S. healthcare, public health officials and medical professionals are increasingly interested in costs reductions that could be achieved by improved provision of multiple social determinants of health. Expanded policies and programs are being implemented at the local to national level. One social determinant (and the general term recognizes physical as well as social conditions) that is often under-represented in health intervention programs is nature and ecology. Natural systems, particularly in relation to high density population centers such as cities and towns, are the ultimate sources of food, water, building materials and fuel. Another contribution of nature to health, supported by research in recent decades, is the array of physical, mental and social benefits gained by exposure to or experiences of nature. Both direct experiences (such as forest bathing) and indirect exposures (such as window views of trees) promote health, being salutogenic or biophilic health factors.

What are the nature and health benefits? As a field of science expands there emerges enough research publication to support a focused review of a topic. Patterns of findings are shared to chronicle science progress and inform new research activity. While studies do address benefits of time in wilderness, such as hiking and camping, this report focuses on nearby nature experiences, that is, the encounters of even small bits of nature near one's home or within community. This report also focuses on community level

or city-wide scale of health reporting, often represented by cross-sectional studies or natural experiments. Scientific reviews of nearby nature and health peer-reviewed publications report a wide array of benefits; here are a few examples:

- Exposure to natural environments is associated with stress reduction, measured using physiological measures, such as salivary cortisol levels, blood pressure, and heart rate variability for adults. (31 studies[2])
- Forest-based interventions (such as forest therapy/bathing) generated beneficial therapeutic effects in adults for hypertension, stress, and mental-health disorders, such as depression and anxiety. (131 studies[3])
- Confirming similar physiological outcomes, additional positive mental and emotional responses result from forest exposure on variables of anger, confusion, depression, fatigue and vigor. (40 studies[4])
- Synthesis of effects of nature exposure on immune system health include positive anti-inflammatory, anti-allergic, anti-asthmatic outcomes, as well as increased NK (natural killer) cell activity. (33 studies[5])
- Addressing childhood mental health and development, measures of NDVI within buffers of 100 m, 250 m, and 500 m were related to emotional and behavioral well-being. (45 studies[6])
- Green space might be a tool to advance health equity. Lower-SES people show more beneficial effects than affluent people and generally, public green spaces/parks are more beneficial than green land covers/greenness. No notable differences in the protective effects of green space between racial/ethnic groups were found. (90 studies[7])

This small sample of an extensive research literature on nature and health in cities, now represented by thousands of studies, suggests that, as a social determinant of health, providing opportunities for nature exposure in communities may help to reduce public health and healthcare costs. Economic valuation of benefits derived from urban green systems has been undertaken in the environmental and natural resource economics fields, but has received little attention in public health economics. Urban trees, parks, gardens, open spaces and other nearby nature elements, generate many positive externalities that have been largely overlooked in urban economics and policy[8].

This brief report provides concepts and background information that can inform economic modeling of urban nature and human health response. It focuses on salutogenic response, that is, the positive responses associated with nature exposure near one's home, workplace or school. Another valuation potential is the use of nature to mitigate health risks, such as tree planting to address excessive heat or poor air quality. The next section introduces social goals and policies associated with investment in nature for health. Following that will be a section that explain economic valuation methods, and the last will present a sample of the existing studies that report economic analysis.

Investment Concepts

Across local to national governments public health has long been recognized as an economic good. The attributes of public health policies and programs are preventive, thus the benefits from consuming such goods usually accrue in the distant future and are large[9]. In this regard public health and urban forestry are similar. In addition, for both, up-front costs are required to produce such goods. As with urban forestry, scale of benefit and public perception play important roles. Expenses of personal healthcare and social care are immediate. Benefits of population-level public health tend to be long term and individuals, health systems and governments are often reluctant to pay up-front for services and benefits that are not manifest until much later.

Allocation of public budgets requires deliberate analyses of the benefits and costs of alternative uses of budget resources, and the use of monetary terms is a standard metric for government and organizational budgeting[10]. Rational decision-making is needed as public and political support of public health interventions is often lacking. Interventions with a high public return on investment (ROI) are often not funded because they may be opposed by powerful commercial interests, or the health gains for individuals and communities are often perceived as being too small to earn their votes. Though large and certain at the population level, benefits are perceived as small and uncertain for individuals so political support may be lacking[11].

Comparative Valuations

A 'culture of accountability' can better assure that public health (and other public goods) funders are achieving economic and social efficiency and are effectively allocating resources for the wider good of the people and community[12]. While there are multiple strategies for estimating and succinctly communicating fiscal responsibility, benefit-cost ratio (BCR) and return on investment (ROI) are two approaches to economic evaluation that value the financial return, or benefits, of an intervention against the total costs of its delivery. The BCR is the benefit divided by the cost, and the ROI is the benefit minus the cost expressed as a proportion or percentage of the cost.

Considered in more detail, BCR is an indicator showing the relationship between the relative costs and benefits of a proposed project, often expressed in monetary, but sometimes in qualitative terms. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to an organization and its sponsors or investors. If a project's BCR is less than 1.0, the project's costs outweigh the benefits, and it should not be considered[13]. ROI is another performance measure that originated in the business sector, but can be used in other contexts to evaluate the efficiency of a project or to compare the efficiency of a number of different projects. ROI measures the amount of return on a project relative to its cost[14] [15].

Public health interventions take many forms, ranging from changes in physical environments to behavior motivation programs, to address a variety of the social determinants of health. A recent review of 52 studies demonstrates the likely social value of public health[16]. The median ROI for all public health interventions was 14.3 to 1, and median BCR was 8.3. The median ROI for 29 local public health interventions was 4.1 to 1, and median BCR was 10.3. Recognizing the importance of scale in program development and potential efficiencies, larger benefits were reported in 28 studies analyzing nationwide public health interventions; the median ROI was 27.2, and median BCR was 17.5.

Social Return on Investment

Defined by Acheson of the World Health Organization in 1988, "public health is the science and art of promoting and protecting health and well-being, preventing ill-health and prolonging life through the organized efforts of society". Recognizing the limitations of reducing this complex and multi-faceted endeavor to economic valuation, social return on investment (SROI) is an expanded model of economic analysis.

SROI offers a framework for measuring and accounting for much broader concepts of value and can reduce inequality and environmental degradation and improve wellbeing by incorporating social, environmental and economic costs and benefits[17].The methodology seeks to measure broader socio-economic outcomes, analyzing and computing views of multiple stakeholders in a singular monetary ratio. It is an extension of BCR and ROI that can incorporate broader socio-economic and environmental

outcomes. Ultimately monetary analysis is used in decision-making and investment decisions. Traditional benefit-cost analysis (which may be expressed as BCR or ROI) is used to compare different investments or projects; SROI is used more to evaluate the general progress of certain developments, showing both the financial and social impact that an intervention can have.

SROI has potential for application in public health intervention analysis for any single social determinant of health, or a composite of inter-related interventions. Nonetheless, such analysis has not been widely implemented. But the potential for use is there, particularly for urban forestry, which is a natural resource that generates a wide range of ecosystem services that directly and indirectly influence human health. There are four main elements that are needed to measure SROI (with examples of application to urban forestry and urban greening and human health response[18]):

- Inputs, or resources investments in the intervention (tree plantings and routine management),
- Outputs, or the direct and tangible products from the activity (improved air quality, improved stormwater management, extreme heat reduction),
- Outcomes, or the changes to people resulting from the activity (improved mental health, cardiovascular health and social cohesion due to nature exposure), and
- Impact, or the outcome less an estimate of what would have happened anyway (change in human response to due planting trees or conserving existing ones, such as number of employees showing improved work performance or fewer people using medications for depression or dementia).

Economic Valuation Methods

This appendix will not construct an entire CBR or SROI evaluation; it serves to initiate discussion and future analysis about the economic modeling potential of urban forestry and urban greening as an intervention for public health. In this section you will find an array of concepts and processes that can be used to translate health outcomes and impacts to monetary terms. The purpose is not to explain all valuation approaches but to demonstrate the wide range of economics methods and tools that can be employed to reveal value.

Environmental economics often addresses the negative externalities of outside environments, such as flooding or, more recently, wildfire. The legacy of the field of environmental health is to address concerns of toxicants and environmental risk and their societal costs. Equally important is the potential for wellness from salutogenic nature encounters, with monetary consequences[19]. Where markets exist, prices for goods and services are used to estimate value. Yet many of the health services and benefits of urban greening carry no market prices, so quantifying their economic value is performed through analysis of observed or hypothetical behaviors. Behavior measures can include observable changes in lifestyle, changes in goods and services purchases or self-report measures by way of surveys or interviews.

The values of urban greenspace and natural infrastructure can be quantified using a variety of methodologies, adapted from natural resource, recreation, tourism and environmental health[20], organized by these four categories:

- **Market-based -** valuations using avoided costs, preventative expenditures, and human capital costs (such as reduced use of prescriptions).
- **Revealed preference** - valuation methods that examine voluntary expenditures or resources commitment for both direct and indirect use, including hedonic pricing, travel-cost, and defensive expenditures.

- **Stated preference** - contingent valuation and contingent behavior methods that are used to assign value to non-market goods based on preferences solicited from the target beneficiaries, often through self-report such as willingness to pay surveys.
- **Subjective well-being** - self-evaluation around life satisfaction, the ability to flourish in the environment (eudaimonic subjective well-being) and changes in momentary well-being from specific interventions[21], often captured using surveys, interviews or large scale panel studies (such as national health surveys), with valuations typically expressed as a dollar value related to a change in the environment.

Table A-1 - Economic Methodologies and Valuation Methods (adapted from Smart Prosperity Institute[22])

Methodology	**Method**	**Strength**	**Limitation**	**Proposed Application**
Market-based approach *(Direct Use)*	Market Price	Prices are established and objective. Easy to integrate this type of valuation into existing project-decision making structures	Partial valuation of health benefits (costs only) Requires an existing market whereby a nature-based health good is actively being priced and traded (ex/ paid park fitness program)	Substitutability of nature exposure for real costs, such as medications, treatments or facilities investments.
	Avoided Costs	Prices are established and objective. Inherently values the conservation of natural infrastructure	Partial valuation of health benefits (Costs only) Avoided costs are indirect estimates, contingent	Comparing the effectiveness of nature-based health interventions to traditional public health or medical interventions
	Human Capital Cost	Estimates the opportunity cost of avoiding illness based on lost income/productivity due to poor health.	Assumes health status is reflected by income. Value of life based on present and future earnings – ethics concerns Undervalues non-paid service, often provided by women, people of color and people with disabilities	Evaluate the disease burden related to specific environmental conditions, climate impacts
Revealed Preferences *(Direct and Indirect Use)*	Travel-cost	Semi-objective assumed willingness-to-pay based on travel-costs to access greenspace Uses established market prices to infer benefits from access Evaluates user preferences	Limited by data sampling design Health implications may not be primary Limited examples in enviro-health	Estimating the direct use value of recreational greenspaces and key sites or destinations

Methodology	Method	Strength	Limitation	Proposed Application
	Hedonic Price Model	Health impacts are valued based on price variations in market traded goods Health seeking choices/ behaviors are integrated in valuation estimates	Unable to account for multiple externalities affecting market values, which can cause health benefits to be overestimated Limited ability to address specific health impacts	Total value of enviro-health benefits in urban areas Evaluate difference in health benefits between neighborhoods Evaluate price implications of adjacency to nature facilities or access
	Preventative Expenditure	Costs required to prevent adverse health outcomes These costs are considered a proxy for the value of observed benefits	Costs required to prevent adverse health outcomes may not be congruent with existing benefits for certain population groups	Using nature-based solutions as an intervention to improve an existing negative health impact- e.g., costs to plant trees and reduce heat island effects
Stated Preferences *(Indirect Use)*	Contingent Valuation	Ability to measure hypothetical scenarios and existence values	Sensitive to survey design and respondent affirmation bias	Existence values of urban greenspaces Willingness to pay for projected services or facilities, such as a new park or trail
	Discrete Choice Experiment	Ability to separate value of choices, from outcomes Reduces affirmation bias by offering multiple responses Can identify marginal values with proper design	Value of health is wholly ascribed to stated price Survey design may influence value choices - e.g., inflated value	Applied to understand value preferences underlying price value choices for design options, such as features in a new park
Mixed *(Direct and Indirect - depends initial case)*	Benefits Transfer	Established methods, can quickly determine value of local health impact Good option with limited local resources and data	Limited by the availability of case studies, thus questions of relevance Assumes equal welfare across cases	Rapid assessments for health benefits of nature-based solution in low resource settings
Subjective Well-being *(Mostly Direct Use)*	Life Satisfaction	Self-reported feelings of well-being based on multiple criteria Includes social determinants of health and is measured over the long term	Limited by self-reporting bias, difficult to verify responses Typically used in cross-sectional studies; can be challenging to establish causality	Can be used in conjunction with state preference methods to value nature-based changes to well being Easy integration with large scale projects and routine assessments, such as state/county health surveys
	Eudaimonic well-being	Self-reported feelings of well-being based on multiple criteria Focuses on the concepts of flourishing in the environment (belonging, inclusion)	Difficult to verify measures and health influences Can be challenging to find comparative cases	Valuing the subjective feelings based on environmental health conditions associated with flourishing

Methodology	Method	Strength	Limitation	Proposed Application
	Momentary well-being	Captures acute and situational mental health impacts Established sampling methods - Positive and Negative Affect Schedule (PANAS) Less resource intensive for sampling and data collection – can be more integrated in mobile platforms	Challenge to evaluate long-term health benefits Issues of self-sampling and long term respondent retention Limited application to value benefits from natural infrastructure	Eliciting direct feedback from users of urban greenspaces Sampling method can be developed to gauge stakeholder feedback during project cycles

Nature & Health Valuations Review

This section presents an interpretive overview of current publications that have provided economic analysis and estimates for human health benefits associated with having nearby nature in cities, meaning the everyday parks, trees and green spaces that promote health and wellness. This is not a systematic review, meaning no formal scan was conducted to identify all potential studies. Nonetheless, recent formal reviews (from which content was derived for this section) indicate a paucity of valuation activity[23]. While the evidence of nature and health is extensive, the translation of those findings to monetary terms lags. There is tremendous potential for economic modeling, and perhaps more importantly, for introducing urban forestry and urban greening as social determinants of health into local to national public health policy, based on substantial economic implications[24].

Market-based valuation

Market -based approaches are dependent on knowing the health effect sizes of nature exposure. Publication of effect sizes, if determined across a larger study, or if extrapolated from a smaller sample study, begins to indicate health impact extent, which can then be converted to economic calculations using market prices, avoided costs or human capital costs. A recent article assembled effect sizes across multiple locations and geographies[25]. The effect sizes in the associations between nature and health outcomes are often quite large. A study of 345,143 people in the Netherlands found that individuals living in settings with the lowest access to green spaces had higher incidences of anxiety (44% increase), depression (33%), asthma and Chronic Obstructive Pulmonary Disease (COPD) (30%), coronary heart disease (27%), musculoskeletal complaints (26%), and upper respiratory tract infection (24%) than those living in the highest-access settings[26]. A longitudinal study of children reported a 13% reduction in the chance of BMI (Body Mass Index) increasing in neighborhoods with more greenness during the study period, and a 15% increase in childhood obesity was related to children living in less green areas[27]. Individuals living in areas with less natural space were 16% more likely to report insufficient sleep (for three to four weeks) than individuals in areas with more nature[28]. A decrease of 28% in immune function has been associated with lower contact with nature[29]. Diabetes mellitus onset odds were 16% lower for a 10% increase in the amount community greenspace[30]. Large effect sizes have also been found in mortality studies, with a 27–30% reduction in mortality for those living in the highest quartile of greenness compared to those in the lowest quartile[31].

The health outcomes studies that reveal effects sizes may not be feasible in all communities. Valuations can potentially be assembled from studies conducted in other places, if applicable based on demographic and cultural contexts. Extrapolation of findings from one study to other similar landscapes

and situations is commonly done in ecosystem services valuations, termed *benefit transfer*[32]. Table 2 is a summary of how a benefit transfer process can be conceptualized.

Table A-2 – Benefits transfer modeling of nature-based health valuation

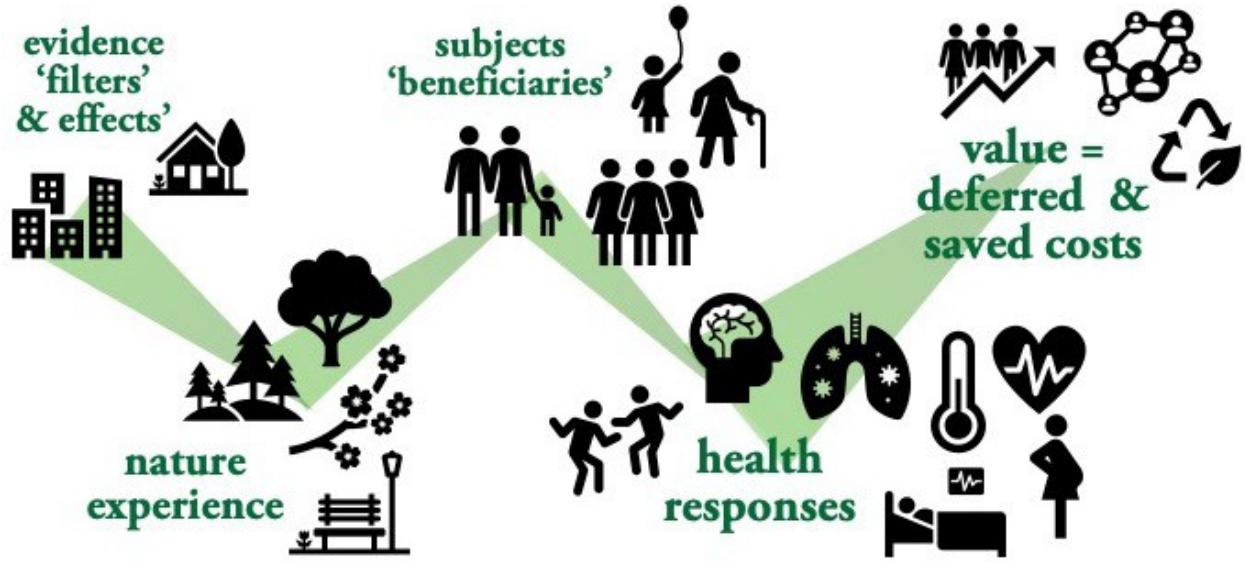
local health condition or concern	scope	nature-based health benefit	effect size	economic cost of health condition or concern	valuation
air particulates and cardiovascular health	geographic area or patient/beneficiary population	reduced PM10 particulates with related decrease in hospitalization for acute myocardial infarction	10.40% decrease in hospitalization[33]	determine typical per patient hospitalization cost, then aggregate expenses or determine proportion of national costs for heart disease attributed to hospitalization	calculate or estimate of costs savings using market valuation

The first step is to identify local health conditions or concerns. There are many data sources to help determine public health trends. At the national level the CDC (U.S. Centers for Disease Control and Prevention) collects health data using surveys and extensive reporting networks and is a resource for maps and data concerning health, often reported at the county level. In addition, the EPA (U.S. Environmental Protection Agency) has created the EnviroAtlas platform which presents 400+ datasets in an interactive format, which include environmental risks, human health influences, and climate projections from NASA. State health departments collect comprehensive information about morbidity (disease incidence) and mortality (death by cause) and often report by county (or even to the Census tract level). Some states, such as Washington, also present this information in terms of specific socio-economic conditions, vulnerabilities and equity. County health departments often have comprehensive local indicator systems and records. Finally, local universities may have assembled or published data for local jurisdictions or neighborhoods.

Once identifying a health concern, the scope of application of the valuation should be decided. Scope may be a geography, such as a county or a beneficiary population, such as the number of people receiving treatment for heart disease. Then one can search the science literature for studies indicating a nature-based health outcome and the statistical level of effect. Numerous government agencies and non-profit organizations assemble periodic or annual reviews of medical and public health program and treatment costs. Proceeding through these data sources, one can calculate a rough estimate of nature for health value. Figure A-1 illustrates the highlights of the process.

One paper, using health response effect sizes and health cost burden data from government agencies and nonprofits, calculated annual U.S. national savings premised on access to nature experiences[34]. Six situations of benefits valuation potential were addressed: infant birth weight, attention deficit hyperactivity disorder (ADHD) in children, school performance, neighborhood crime reduction, adult cardiovascular disease, and Alzheimer's disease. The situations also demonstrate the importance of nature contact in urban areas over the course of the human lifespan. Estimated potential cost savings, avoided costs, and increased income ranged between $2.7 and $6.8 billion annually (2012 USD).

Figure A-1 – Benefits transfer modeling of nature-based health valuation



In recent years, as the cross-sectional evidence of nature exposure and health has accumulated, there has been a call for dosage studies to better understand the specifics of health consequences supported by diverse landscapes and for diverse people, including across the human life course[35]. Such studies are experimental, expanding the understanding of causal relationships and finer details of nature exposure and health[36] [37]. In these studies nature interventions are calibrated, and outcomes are directly measured. Health savings implications can be estimated in greater detail and with greater confidence, and aggregation of value can be specified in relation to distinct human populations or communities.

Revealed preference

Cross-sectional studies that explore the relationships of large scale land cover classification data (such as satellite sourced NDVI or LIDAR) and large scale health survey data (conducted by some nations or states) report revealed preferences. By way of living situation or place, and associated degree of green cover, broad patterns of health relationships are revealed. This information is (or can be) converted to monetary valuation. For example, mental health is an increasingly concerning public health situation. Numerous studies, at national and regional scales, show relationships between nature exposure and improved mental health[38], and monetary implications can be inferred.

Measures of health include morbidity (disease or illness) and mortality, both of which have monetary implications. A study evaluated the relationship between parks spending and human mortality in the U.S. from 1980 to 2010, finding that increased government funding for parks and recreation services had a significant association with decreased county level mortality. A hundred-dollar increase (in 2010 dollars) in per capita parks and recreation expenditures was associated with an average decrease in morality of 3.4 deaths per 100,000[39].

Why might be the causal pathway? One possibility is the observations that street trees and other vegetation can reduce concentrations of particulate matter, the most damaging type of air pollution globally. One study of 10 U.S. cities found that urban trees remove enough particulate matter to reduce annual health impacts, with significant annual savings ranges of $1.1 million (Syracuse) to $60.1 million (New York)[40]. Another health impact, urban heat is becoming an ever greater health concern. High air

temperatures during heat waves can increase mortality in cities, and heat waves kill more people on average than other weather-related sources of mortality in the United States[41], up to 1,300 per year (U.S. E.P.A.). Tree shade cools the air and heat absorbing surfaces such as paving, and cool the atmosphere by evaporative cooling as they transpire. Parks and open spaces can have a cooling effect downwind reducing temperature up to 1 kilometer away, measured as change in air conditioning energy use[42].

Other studies have explicitly determined economic consequences. A study of the association between residential green space and reimbursed cardiovascular medication sales for adults (in Belgium) found that having forest cover with a 600 m buffer was associated with less medication sales[43]. When evaluating per-capita Medicare expenditures (2010-2014), forest and shrub covers were associated with lower Medicare fee-for-service spending.[44] Nearby green space can support academic achievement, creativity, and emotional regulation, and these traits might help children rise out of poverty. Examining the relationship between incomes of children born into poverty and densities of residential green space during childhood, findings suggest that children growing up in tracts with the most vegetative cover will earn $28,000 more over a 30-year career[45].

Stated preference

Public surveys have been used for decades to evaluate stated preferences for parks and environmental conditions. At this time, few studies have queried about willingness-to-pay with a focus on human health. Limited analysis of regional surveys has found that the public values green and blue spaces and are willing to pay to conserve or gain the health benefits from leisure activities in such spaces. A review of twelve studies found that individuals were willing to pay between $7.31 and $19.98 (2019 values) one time to not postpone or lose an outdoor experience and for walking in local environments[46]. Frequent users have a higher willingness to pay as a study in the UK found value response ranging from $3.67 to $4.99 per month (2018 values) and related to perceptions of well-being[47]. In a study about better walking infrastructure in communities (providing a cost-effective way to increase physical activity levels) demand for walkable environments was estimated at £13.65 ($19.08 U.S. 2019) per person per week or £710 ($901 U.S. 2019) per person annually to instigate a policy change[48].

Subjective well-being

Self-report is a common measures approach for assessing health, ranging from survey or interview questions that explore specific health conditions, to questions of a general sense of wellness. One study used this health study model, finding that people who live in neighborhoods having a higher density of street trees reported better health perceptions and fewer cardio-metabolic conditions. In this, and in most of the studies reported here, socio-economic and demographic factors were controlled. Relating tree count to demographic patterns, having 10 more trees in a city block improved health perception comparable to an increase in annual personal income of $10,000 and or moving to a neighborhood with $10,000 higher median income. And having 11 more trees in a city block decreased cardio-metabolic conditions comparable to an increase in annual personal income of $20,000 or moving to a neighborhood with $20,000 higher median income [49].

Next steps - nature and wellness valuation

While the scientific evidence of nearby nature experiences and human health response is not entirely consistent nor conclusive, there are important patterns of positive response, thus opportunities to translate findings to economic terms. A recent review of studies addressing the return on investment for social determinants of health found that this field of research is nascent, and the availability of high-

quality studies is limited[50]. The same can be observed in the valuation studies concerning nature and human health response. This appendix presented data sources and interpretations that are credible or promising, as the translation of health outcomes to economic terms is essential for input to policy and fiscal support.

Challenges and Opportunities

There are methodological challenges. Nature based restorative experiences are an example[51]. Urban nature experiences help people restore their mental capacities from cognitive fatigue[52]. Despite Attention Restoration Theory dating back decades[53] no studies have investigated the monetary value of such effects. One approach is to determine the costs of alternative ways to restore cognitive abilities after fatigue. However, precise estimates are challenging. Stress due to cognitive fatigue may not initiate costs, but associated medical conditions, such as anxiety attacks and depression, accrue costs to patients and society. Also, the amount and types of exposure to nature affect the degree of anxiety, depression or other clinical conditions, so estimations should be condition specific, with attention to exposure quantity and effect pathway.

There are other health conditions that have long-term consequences for individuals, and may be precursors to chronic disease, but can be difficult to monetize as there are no direct costs to attribute to the condition. Numerous negative conditions may develop as a result of obesity and eventually require medical attention which generates costs for the patient and healthcare systems. Longitudinal studies that test for effects of nature-based interventions could reveal direct and indirect costs and savings. For example, parks have been shown to reduce obesity and increase cardiovascular health as they offer opportunities for recreation and exercise. One study in Los Angeles found that with more parks within 500m of a home a child's Body Mass Index (BMI) was lower at age 18[54], suggesting potential medical savings across the life course.

Better valuation information is dependent on more robust studies. One science reviewer suggests three priorities[55]. First, more precise measures of urban nature impacts on human health are needed, including how to generalize to broader geographies or beneficiary populations. Second, the translations between health effects and monetary valuation needs to be improved and conducted more consistently, so that valid, trustworthy numbers are estimated and provided. Third, better efforts to define and refine valuation methods are needed, then eventually shared as guidelines for practitioners for choosing and using valuation methods.

Conclusions

Public and private sector costs for public health and healthcare services are increasing and are a substantial portion of GDP (in the U.S. and other developed nations). Social determinants of health are the synergistic supportive conditions of communities that can be managed for public health improvement, and include urban forestry and urban greening. Extensive research evidence supports the relationship of nearby nature exposures and positive physical, mental and social health outcomes.

While the health effects evidence is extensive and ever growing, there has been less analysis of economic value and implications. This is important as determining social return on investment is a major influence in program investment and policy-making for both urban greening and public health. Market and non-market valuation methods have been developed and refined in other disciplines and can be applied to evidence of nature exposure and health response.

Preliminary estimates are promising, indicating important messages for public investment decisions. For instance, data from the UK National Health Service suggests that parks and green spaces are estimated generate savings of around £111 million (2018, $ 148m U.S.) per year based only on a reduction in the number of visits to general medical services and excluding other costs such as prescriptions and referrals[56].

Does money grow on trees? It seems the answer is yes. The challenge is to prove the premise using carefully designed, defensible economic analysis.

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[53] Kaplan, R. 1984. Impact of urban nature: A theoretical analysis. *Urban ecology* 8, 3, 189-197.
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[55] See Endnote 10.
[56] See Endnote 47.

Appendix B Asset Accounting Example: Standardizing the Return on Investment in Urban and Community Forestry Resources

Example: Newark, Delaware

Community Profile

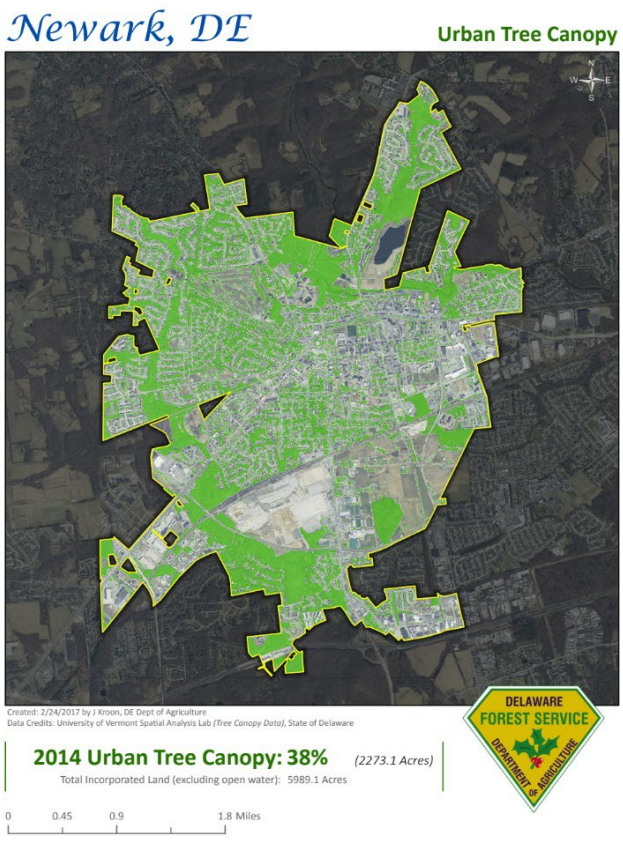

Figure 1 Tree canopy map for Newark, Delaware from Delaware Forest Service.

The City of Newark, Delaware, is home to the University of Delaware with approximately 33,500 people during the school year. The City has 52 park and open space areas totaling 650 acres of which 386 acres are forested. In 2018, the Conservation Advisory Committee began Reforestation Day to engage volunteers to help plant trees in the parks and free trees to residents to plant on private property. Newark also has the distinction as an Arbor Day Foundation Sterling Community after ten years as a Tree City USA community and a per capita expenditure of $8.53 on urban forest activity. Both the Comprehensive Plan (2016) and Sustainable Newark (2019) plan list urban canopy as important in providing "…numerous environmental services…" (p. 37). The area within the municipal limits (Figure 1) is approximately 38 % canopy which translates to 14 persons per canopy acre. There are 86 persons per forested acre using the forested area within parks (publicly owned, 33,500/386 acres).

Tree Canopy as a Natural Asset

Using an asset management approach connects the environmental services, benefits, and values of the canopy for the City's residents. The asset approach shifts managing urban trees from providing a narrow set of environmental benefits to their role in the delivery of broad community environmental services. Integrating natural assets into City planning promotes sustainable service delivery and the proactive protection, maintenance, and enhancement of these assets into strategic and operational decision-making. Small, proactive investments in operations and maintenance of forest resources can help provide a continued level of service and avoid the need to undertake larger, costly projects when the forest resource becomes compromised (e.g. invasive species causing mortality). Privately owned canopy provides community services and ordinances and incentives to maintain the private canopy are important in an asset management plan.

The Challenge

The Sustainable Newark (2019) plan lists numerous environmental services urban canopy provides that it warrants preserving and improving and that the City should ensure that the value of the trees is preserved (p. 37). Adequate funding is necessary to support reforestation, afforestation and maintenance of existing urban canopy. Much of the canopy is within private land. Figure 2 shows the location of City owned parklands. How can the City prioritize planting using an asset management approach focused on benefits of trees and return on investment analysis?

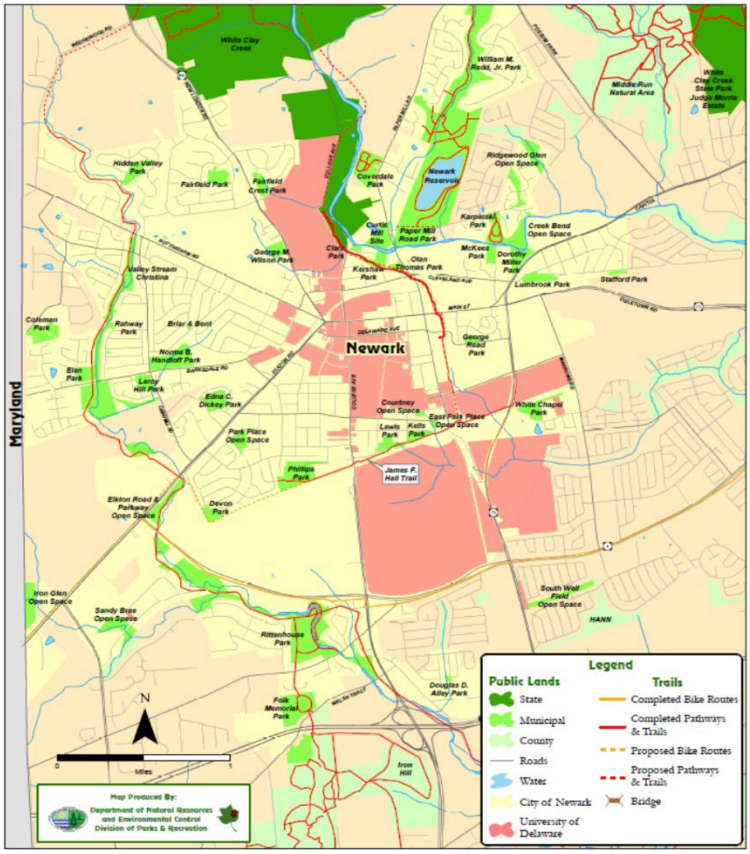

Figure 2 City of Newark parklands and recreation assets.

Canopy Asset Area Planning

The City could plan for tree canopy on a city-wide basis using the benefit values above or it may make sense to break the areas up into discrete asset planning areas. For example, west Newark contains approximately 11 parks and approximately 1,000 acres of canopy. As with many natural resources, boundaries of the benefits experienced do not match jurisdictional boundaries. Figure 3 (from i-Tree Landscape) shows the seven Census block groups for western Newark that also fall outside of the City of Newark municipal boundary. These areas are with in New Castle County and some property is State of Delaware ownership. The seven block groups identified by their Census identification and hypothetical name (west Newark "WN #") is in Table 2.

Table 1 Area Names, Population, Size, Canopy Acres and Plantable Space in west Newark, Delaware

Area Name	Area (acres)*	Pop.	Canopy (acres)*	Plantable Space (acres)*
WN1	700	1600	441	162
WN2	879	2565	241	245
WN3	209	908	106	53
WN4	108	1658	27	26
WN5	162	2267	78	32
WN6	212	1312	100	53
WN7	421	1592	189	146

Urban Canopy Asset Registry
This is to establish the areas for evaluation. These areas should not change over time.
Size and boundary considerations available in i-TreeLandscape US Census Block Group, US Census Place
Citywide systems - Hydrologic Unit Code (HUC) or watershed boundary.

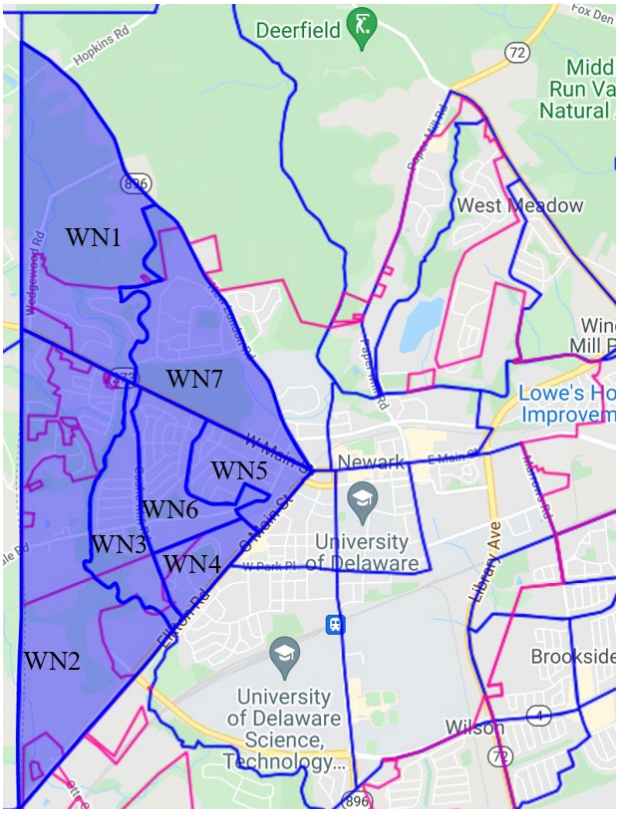

Figure 3 i-Tree Landscape Census Block Group and CensusPlace delineation Newark, Delaware.

Estimating Canopy Asset Service Benefit Values

Tree canopy in the areas WN 1- WN7 have varying sizes, canopy cover, and census populations. They also provide varying levels of benefits to the residents of the City of Newark. In general, benefits are related to the intensity of tree canopy cover in the area. Presenting the benefit values to stakeholders helps them understand the importance of trees for human health and wellness as well as ways trees help communities save money by reducing air pollution and stormwater runoff.

i-Tree Landscape was used to estimate benefits in west Newark (Figure 4, Tables 2 and 3). i-Tree Landscape can be used for a quick estimate of benefit categories and planting prioritization. The stormwater and air quality health benefit categories are shown as examples in the tables below. These are yearly values that demonstrate how trees reduce the amount of stormwater running off into the waterways and absorb pollution (PM 2.5 or particulate matter of less than 2.5 microns) that can cause human illnesses. i-Tree Landscape assigns values from research to the reductions in runoff and deaths from pollution. The total values for west Newark (shown in Figure 4) are $163,486 per year for stormwater reduction based on reduced treatment costs for drinking water, and $199,729 per yearin value of protecting humans from death due to respiratory illness caused by PM 2.5. Breaking the area into block groups helps determine where benefits are high and low which can help in planning and budgeting for canopy protection, maintenance and new tree planting. Total benefitsfor west Newark are positive and a way to determine if there are areas that have different net benefits (benefits minus costs) calculating the net benefits per block group demonstrates plantingand canopy investment options in this area.

Table 2 Stormwater Benefits From Tree Canopy

Area Name	Reduction in annual runoff (gal/year)	Reduction Value ($0.009/gal)
WN1	6,100,000	$ 54,131
WN2	5,300,000	$ 47,744
WN3	1,500,000	$ 13,010
WN4	400,000	$ 3,426
WN5	1,100,000	$ 9,679
WN6	1,400,000	$ 12,253
WN7	2,600,000	$ 23,243
Total		$ 163,486

Table 3 Particulate (PM2.5) Removal Benefits From Tree Canopy

Name	Value of mortality avoided due to particulate matter [PM2.5] removed ($/yr)
WN1	$ 66,131
WN2	$ 58,327
WN3	$ 15,895
WN4	$ 4,186
WN5	$ 11,824
WN6	$ 14,970
WN7	$ 28,396
Totals	$ 199,729

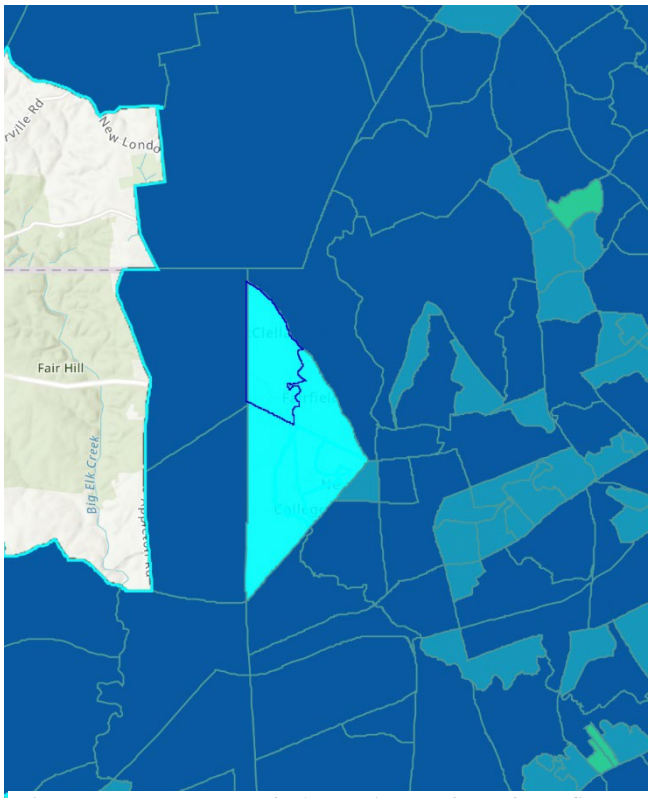

Figure 4 West Newark Asset Area where benefits were estimated from i-Tree Landscape.

<u>Results: Net Benefits and Return on Investment Estimates for Canopy Assets</u>

i-Tree Landscape provides information available space and user selected priorities to suggestplanting priorities. There are custom scenarios in i-Tree Landscape to focus the planting prioritization on population, minority, and poverty census data. The three scenarios weight scenarios for tree cover per capita, tree stocking level, with population density, population below poverty line, or minority population density respectively. Population planting priority index is shown in Figure 5.

Coupling this information with the benefit information per capita helps determine where to prioritize planting and maintenance activities based on increasing and maintaining the canopy benefits (Table 5). For example Table 5 shows that the return on investment may be highest in WN6 for air pollution reduction as well as stormwater. The i-Tree Landscape planting prioritiyindex indicates this is also an area that could be prioritized for planting (0 is not priority and 100 is high priority).

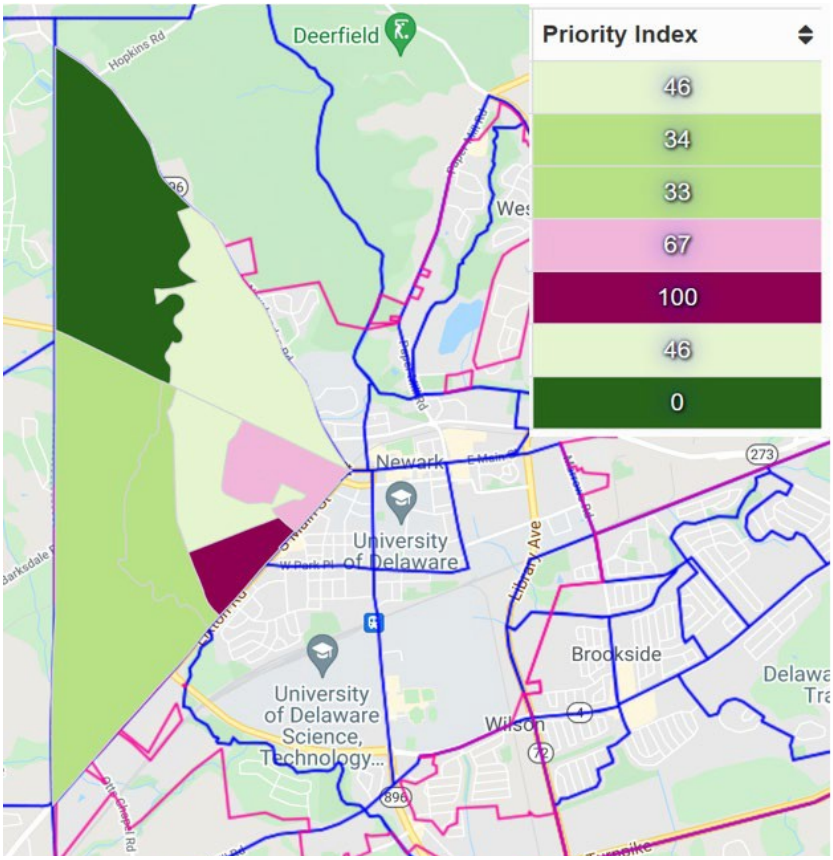

Figure 5 The index is from 0 to 100, where 0 is a low priority and 100 is a high priority based on population density. For more information see https://landscape.itreetools.org/references/data/.

i-Tree Landscape uses a combination of factors to compare the block group areas for priority including land cover data for existing trees and grass space and population density. The return on investment is negative in the highest priority areas WN4 and WN5 is indicative of the lack of trees in those areas. That is – to increase benefits, trees need to be planted in those areas. The other areas (green and yellow) may be suited for preservation or maintenance investment focus. Using the priority planting and per capita return on investment shows where maintenance of existing canopy is important (i.e. WN1 and WN6) and where more investment in trees is needed to increase benefits (i.e. WN4 and WN5). Reporting net benefits in local areas as well as total benefits helps understand where investment in canopy is necessary and provides a way to communicate specific investment priorities related to increasing benefits. The key is that the prioritization helps focus the investment and connects the expenditure with specific benefits in a targeted areas. It also illuminates where there are negative benefits and potential to increase investment for more equitable benefit outcomes.

Table 5 West Newark block group asset area per capita values, estimated return on investment and planting priority for tree canopy. Green and yellow indicate maintenance and preservation orange indicates potential good investment for new canopy and increasing benefits.

Area Name	Dollars per capita benefit		Return on investment (net benefit) = benefit-cost per capita**		Total PM2.5 + Stormwater	Planting Priority (i-Tree)^
	Value of mortality avoided due to particulate matter [PM2.5] removed	Stormwater Reduction Value ($0.009 per gallon*)	Mortality avoided (PM2.5) removed	Stormwater	Net Benefits	
WN1	$ 41.33	$ 33.83	$ 31.86	$ 24.36	$ 56.23	33
WN2	$ 22.74	$ 18.61	$ 13.27	$ 9.15	$ 22.42	34
WN3	$ 17.51	$ 14.33	$ 8.04	$ 4.86	$ 12.90	46
WN4	$ 2.52	$ 2.07	$ (6.94)	$ (7.40)	$ (14.35)	100
WN5	$ 5.22	$ 4.27	$ (4.25)	$ (5.20)	$ (9.45)	67
WN6	$ 11.41	$ 9.34	$ 1.94	$ (0.13)	$ 1.81	46
WN7	$ 17.84	$ 14.60	$ 8.37	$ 5.13	$ 13.50	0
WN Totals	**$ 118.56**	**$ 97.05**	**$ 52.29**	**$ 30.77**	**$ 83.06**	
*i-Tree Landscape uses the U.S. national average dollar value of $0.008936/gallon to estimate the value avoided runoff due to trees. The value is based on 16 research studies on costs of storm water control and treatment (https://www.itreetools.org/)						
**	$ 9.47	This value is the dollars per capita benefit divided by the adjusted 2017 Arbor Day tree care budget per capita $8.53 (CPI 1.11)				
^The index is from 0 to 100, where 0 is a low priority and 100 is a high priority. For more information see i-Tree (https://landscape.itreetools.org/references/ data/)						

Canopy Asset Management and Investment Planning for Benefits

Communities that adopt an asset management framework for natural resources recognize that there are certain services and benefits that nature provides to humans that can be measured and managed in a similar manner to other traditional assets. Asset management involves a holistic approach to natural resource management and provides a systematic manner to evaluate the resource. Core components of asset management include identifying the location of the asset, the condition and what service the asset offers, how critical the asset is and prioritizing critical assets for proper long term funding to maintain the service. The location of the canopy asset helps describe the inter-jurisdictional nature of canopy and the ensuing benefits residents in an area receive from the canopy. For natural assets – the services are the benefits humans receive such as the health and stormwater benefits described above. The importance of the benefits to the community and the estimated return in net benefits (benefits minus costs per capita) when

dollars are spent helps a community understand how to better manage, maintain, and prioritize funds for urban forest canopy.

Table 6 Benefit Cost Ratios for Air Quality and Stormwater Runoff

Area Name	***Benefit/Cost Ratio (BCR)***	
	Mortality avoided (PM2.5 reduction)	**Stormwater Runoff**
WN1	4.4	3.6
WN2	2.4	2.0
WN3	1.8	1.5
WN4	0.3	0.2
WN5	0.6	0.5
WN6	1.2	1.0
WN7	1.9	1.5

For the City of Newark the return on investment (benefit/cost ratio or BCR) assessment for stormwater and air quality compared to the benchmark of the municipality as a whole is shown in Tables 6 and 7. Areas 1, 2, 3 6, 7 all have positive returns for air quality and stormwater runoff. Areas 4 and 5 do not have positive returns. The comparison demonstrates there are areas where the benefits are greater than the costs for both stormwater and air quality and that these areas should potentially have a maintenance and preservation focus. The areas that have a BCR below 1 such as WN 4 and 5 compare to the municipality wide BCR. Increases in canopy coverage in areas lacking trees will yield highest returns in neighborhoods with lowest average canopy levels because areas that have trees, adding more has a lower benefit value than adding a tree to an area lacking trees.

Table 7 City of Newark Benefit Cost Ratio

Municipality-wide	
Service	BCR
Stormwater Runoff	0.34
PM 2.5 reduction	0.58

Different policy and investment decisions can be made for these areas to increase benefits – shift investments and discuss various options for urban forest planning based on benefits and returns on investment. This may seem obvious, but the process to support decisions based on estimated benefits helps describe the magnitude and direction of equity and distribution of the benefits across a municipality with urban tree canopy.

[1] 2016–2026 National Ten Year Action Plan. 2015. (Accessed at https://urbanforestplan.org/engage/)
[2] Canopy can create negative benefits values by increasing allergens at certain times and regions.
[3] McPherson, E.G., S.E. Maco, J.R. Simpson, P.J. Peper, Q. Xiao, A.M., VanDerZanden and N. Bell. 2002. Western Washington and Oregon Community Tree Guide: Benefits, Costs, and Strategic Planting. Silverton, OR: International Society of Arboriculture, Pacific Northwest. Web:

www.fs.fed.us/psw/programs/uesd/uep/products/5/CUFR_164_Western_WA_OR_Tree_Guide.pdf; McPherson, G., Simpson, J. R., Peper, P. J., Maco, S. E., & Xiao, Q. (2005). Municipal forest benefits and costs in five US cities. *Journal of forestry*, *103*(8), 411-416; Tenneson, Karis & Ciecko, Lisa & Dilley, Jana & Wolf, Kathleen. (2012). Seattle's Forest Ecosystem Values: Analysis of Structure, Function, and Economic Benefits. 10.13140/RG.2.2.12857.67686.

[4] City of Portland Parks and Recreation 2018 Growing a more Equitable Urban Forest (https://www.portland.gov/sites/default/files/2020-08/tree-planting-strategy-12.18.pdf)

[5] Water Research Federation recommends "…an iterative process that starts with a simplified, reconnaissance-level implementation of asset management (AM) to relevant natural assets. The reconnaissance-level application is intended to help orient utility practitioners to the concepts and process, without getting bogged down in a level of detail that may not be warranted. The initial, reconnaissance-level effort is then followed by a more detailed level of implementation of the AM framework, where additional depth and/or breadth may be pursued, as informed by the initial screening effort." P. 17

[6] Q&A: What is "natural capital" and why should investors care? Schroders. July 2021. (accessed at https://www.schroders.com/en/insights/economics/qa-what-is-natural-capital-and-why-should-investors-care/"

[7] Water Research Foundation. 2020. Incorporating Forestry into Stormwater Management Programs: State of the Science and Business Model Evaluation for Nutrient Reduction and Volume Control (https://www.waterrf.org/system/files/resource/2020-01/DRPT-4837.pdf) and Integrating Watersheds and other Water Research Foundation. 2020. Asset Management Framework for Forested and Natural Assets. 2020. (https://www.waterrf.org/research/projects/asset-management-framework-forested-and-natural-assets).

[8] Kayuga Solutions. 2016. City of Chula Vista Urban Forestry Management System Asset Management Plan (https://www.chulavistaca.gov/home/showdocument?id=12382)

[9] MNAI. 2017. Defining and Scoping Municipal Natural Assets. (Accessed at https://mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf

[10] U.S. EPA. 2021. Asset Management Plans and the Clean Water State Revolving Fund, Fact Sheet accessed at https://www.epa.gov/sites/default/files/2021-02/documents/asset_management_plans_and_the_clean_water_state_revolving_fund.pdf).
MNAI. Why Manage Natural Assets? Web page https://mnai.ca/why-manage-natural-assets/);Town Town of Gibsons (https://gibsons.ca/wp-content/uploads/2018/01/GibsonsFinancialPlanningReportJan2018-PRINT.pdf)

[11] Natural Capital Committee End of Term Report To the Domestic and Economy Implementation Committee of the Cabinet 2020. (accessed at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/931695/ncc-end-of-term-report.pdf)

[12] Kauyga Solution. 2016 U.S. City of Chula Vista Urban Forestry Management System Asset Management Plan. (Accessed at https://www.chulavistaca.gov/home/showdocument?id=12382)

[13] Center for Neighborhood Technology. Tree Asset Management in Portland, Oregon. 2011. https://www.cnt.org/sites/default/files/publications/CNT_PDXTreeAssetMgmt.pdf

[14] Knox City Council. 2016. Street Tree Asset Management Plan. (Accessed at https://www.knox.vic.gov.au/sites/default/files/knox-files/our-council/policies-strategies-and-plans/street-tree-asset-management-plan-2016.pdf)

[15] Trees and Design Action Group. Trees in the Townscape. (accessed at https://www.treeconomics.co.uk/wp-content/uploads/2018/08/Guide-for-Decision-Makers.pdf

[16] Pg. 4. Nowak, David J.; Stein, Susan M.; Randler, Paula B.; Greenfield, Eric J.; Comas, Sara J.; Carr, Mary A.; Alig, Ralph J. 2010. Sustaining America's urban trees and forests: a Forests on the Edge report. Gen. Tech. Rep. NRS-62. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 27 p.

[17] See https://www.climate-kic.org/?s=trees+as+infrastructure.

[18] iTrees Tree compensation calculator uses a life cycle cost approach to determine value of trees based on how many trees are necessary to replace a lost tree. See https://www.itreetools.org/tools/research-suite/tree-compensation-calculator.)

[19] *GreenBlue Urban. Street Tree Cost Benefit Analysis. 2018. Accessed at https://www.treeconomics.co.uk/wp-content/uploads/2018/08/GBU_Street-Tree-Cost-Benefit-Analysis-2018.pdf.*

[20] Koeser, A. K., Hauer, R. J., Miesbauer, J. W., & Peterson, W. (2016). Municipal tree risk assessment in the United States: Findings from a comprehensive survey of urban forest management. *Arboricultural Journal*, *38*(4), 218-229.
[21] Center for Neighborhood Technology. 2011. Tree Asset Management in Portland, Oregon. (Accessed at https://www.cnt.org/sites/default/files/publications/CNT_PDXTreeAssetMgmt.pdf)
[22] Id.
[23] See Earth Economics and WaterNow Alliance "Go Green Muni Bond Financing for Consumer Rebates and other Distributed Water Investments, A Primer for Water Leaders on How to Debt-Finance Distributed Infrastructure Projects and Consumer Rebates." (accessed at https://tapin.waternow.org/resources/go-green-muni-bond-financing-for-distributed-water-solutions/)
[24] Trees for Seattle Urban Forest Management Plan. 2020. (Accessed at http://www.seattle.gov/documents/Departments/UrbanForestryCommission/Resources/UFMPv11100620.pdf)
[25]Pg. 4. Hermansen-Baez, A. (2019). Urban tree canopy assessment: A community's path to understanding and managing the urban forest. *FS-1121. Washington, DC.*, *2019*, 1-16. (Accessed at https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Urban%20Tree%20Canopy%20paper.pdf)
[26] Vibrant Cities Lab Urban Forestry Toolkit. (Accessed at https://www.vibrantcitieslab.com/toolkit/urban-tree-canopy/)
[27] Sustainable Newark. 2019. https://newarkde.gov/DocumentCenter/View/12803/SustainableNewark_FINAL_30OCT19?bidId=
[28] Recreational Use Values Database (http://recvaluation.forestry.oregonstate.edu/)
[29] WRF at 5. Pg 42 "If stormwater management is the only benefit considered, then the return on investment is low (negative) as life cycle costs far exceed the benefits. However, if a suite of benefits is considered, then a positive return on investment is obtained, indicating trees are a good investment from the standpoint of the broader community."
[30] Benefit valuation methods that may apply to other categories lacking tools, such as benefit transfer, is beyond the scope of this document. Integrating Natural Assets into Asset Management. (2019). https://www.assetmanagementbc.ca/wp-content/uploads/Integrating-Natural-Assets-into-Asset-Management.pdf

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