DeepRoot

Investment vs. Returns for Healthy Urban Trees:

Lifecycle Cost Analysis

Prepared by: The Kestrel Design Group, Inc.

Mature trees can contribute significantly to healthier soil, air, and water in cities. According to the US Forest Service, a large tree with a trunk diameter 10 times larger than a small tree produces 60-70 times the ecological services (McPherson et al, 1994). But cities are not typically hospitable places for plant growth so trees seldom live long enough to reach maturity and provide meaningful ecological services. Studies have found that trees surrounded by pavement in most urban downtown centers in North America only live for an average of 13 years (Skiera and Moll, 1992). This short lifespan deprives the areas most in need - the built environment - of the myriad benefits that trees can provide.

The most significant obstacle to reaching maturity that urban trees face is the scarce quantity of soil useable for root growth. A large volume of uncompacted soil, with adequate drainage, aeration and fertility, is the key to the healthy growth of large urban trees. Research demonstrates that trees need 2 cubic feet of soil volume for every square foot of canopy area (Urban, 2008). Most urban trees have less than 1/10th the rooting volume they need to thrive. Using innovative techniques, such as suspended pavement, to extend rooting volume under HS-20 load bearing surfaces and create favorable tree growing conditions in urban areas, enables trees to grow to their mature size and provide the stormwater and ecological benefits commensurate with mature trees.

So why aren't all urban trees planted with suspended pavement? Perhaps the main barrier to using suspended pavement to provide trees with the rooting volume they need is that this technique has higher up-front costs. But does the initial investment into suspended pavement pay off over the long term?

To answer this question, we estimated costs and benefits over a 50 year study period for the following 2 scenarios:

(1) An urban tree, with pavement suspended over adequate uncompacted soil volume, which:

- Costs more to install than a traditional urban tree with insufficient uncompacted soil volume
- Has an estimated lifespan of 50+ years
- Lives to be a mature tree that provides significant ecological and financial benefits

(2) An urban tree with insufficient uncompacted soil volume, which:

- Costs much less to install than the tree with suspended pavement
- Has an estimated lifespan of 13 years, so it has to be replaced 3 times during the lifespan of the tree with suspended pavement
- Dies before it grows large enough to provide significant ecological and financial benefits

The tree with suspended pavement over adequate soil volume was modeled as a tree with Silva Cells containing 1,000 cubic feet (28 cubic meters) of uncompacted bioretention soil. This soil not only provides the tree with adequate rooting volume, it also provides stormwater storage volume. The value of this stormwater storage was included in the calculation of the estimated benefits of the tree with Silva Cells for stormwater. This tree will henceforth be called the "**Tree With Silva Cells for Stormwater**."

The tree with insufficient uncompacted soil volume was modeled as a traditional urban tree in a 4'x4'x4' tree pit surrounded by pavement (providing 64 cubic foot, or 1.8 cubic meters of uncompacted soil). This tree will henceforth be called the "**Tree Without Silva Cells**."

We estimated costs and benefits of each tree for a typical example in Minneapolis, MN, using i-tree, a peer-reviewed software suite from the USDA Forest Service that provides urban forestry costs and benefits assessment tools.

For a 50 year study period, our analysis indicated:

(1) Estimated BENEFITS outweigh estimated COSTS by $25,427.22 for the Tree With Silva Cells for Stormwater

(2) Estimated COSTS outweigh estimated BENEFITS by $3,094.29 for the Tree Without Silva Cells.

While the **Tree Without Silva Cells** had lower installation costs than the **Tree With Silva Cells for Stormwater**, analysis of total estimated costs and benefits showed that planting an urban **Tree with Silva Cells for Stormwater SAVES $28,521.51** over a 50 year study period compared to planting an urban **Tree without Silva Cells**.

Table 1 and Figures 1-4 below show our methodology and results in more detail.

Lifecycle Costs and Benefits over 50 years	Tree Without Silva Cells: Estimated Lifespan 13 years	Notes for Tree Without Silva Cells	Tree With Silva Cells: Estimated Lifespan 50+ Years	Notes for Tree With Silva Cells
Installation Costs	$4,000	Estimated at $1,000 per tree, installed 4 times over a 50 year study period	$14,000	Estimated at $14,000 per tree, installed 1 time over a 50 year study period
Total Benefits	$2,717.66	Includes savings from reduced building energy costs, stormwater interception, increased property values, and the net value of carbon sequestration in the tree.[1]	$41,769	Includes savings from reduced building energy costs, stormwater interception, increased property values, the net value of carbon sequestration in the tree,[1] bioretention,[3] and stormwater utility fee credit.[4]
Total Maintenance Costs	$1,211.95	Includes estimated costs for pruning, pest and disease control, infrastructure repair, irrigation, cleanup, liability and legal costs, and administration costs.[2]	$2,341.75	Includes estimated costs for pruning, pest and disease control, infrastructure repair, irrigation, cleanup, liability and legal costs, administration costs[2] and bioretention maintenance.
Removal Costs	$600	Estimated at $200 per tree, 3 times over a 50 year study period	$0	Removal Costs
Net Lifecycle Cost	$3,094.29		$-25,427.25	

Table 1: Urban Tree Lifecycle Costs and Benefits for a 50 Year Study Period, Based on Typical Costs and Benefits for Minneapolis, MN

Table 1 Footnotes

1. Values are based on values documented by i-tree, a peer-reviewed software suite from the USDA Forest Service, that provides urban forestry cost and benefit assessment tools. A description of how trees provide these benefits can be found in the i-Tree Streets User's Manual (available at http://www.itreetools.org/resources/manuals/i-Tree%20Streets%20Users%20Manual.pdf) as well as in the Midwest Community Tree Guide (McPherson et al 2006). A detailed description of how these benefits were quantified in i-tree can also be found in the Midwest Community Tree Guide (McPherson et al 2006).

   McPherson et al (2006) note the following about the level of accuracy of the estimated costs and benefits in i-tree: "Estimates of benefits and costs are initial approximations as some benefits and costs are intangible or difficult to quantify (e.g., impacts on psychological health, crime, and violence). Limited knowledge about the physical processes at work and their interactions make estimates imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Tree growth and mortality rates are highly variable throughout the region. Benefits and costs also vary, depending on differences in climate, air-pollutant concentrations, tree-maintenance practices, and other factors. Given the Midwest region's large geographical area, with many different climates, soils, and types of community forestry programs, this approach provides first-order approximations. It is a general accounting that can be easily adapted and adjusted for local planting projects. It provides a basis for decisions that set priorities and influence management direction (Maco and McPherson 2003)."

   The property value benefits in our calculations were based on Donovan and Butry 2010. The Midwest Community Tree Guide (McPherson et al 2006) states "Well-maintained trees increase the 'curb appeal' of properties. Research comparing sales prices of residential properties with different tree resources suggests that people are willing to pay 3 to 7 percent more for properties with many trees versus properties with few or no trees. One of the most comprehensive studies of the influence of trees on residential property values was based on actual sales prices and found that each large front-yard tree was associated with about a 1 percent increase in sales price (Anderson and Cordell 1988) (p.13)…Anderson and Cordell (1988) surveyed 844 single-family residences in Athens, Georgia, and found that each large front-yard tree was associated with a 0.88-percent increase in the average home sales price. This percentage of sales price was used as an indicator of the additional value a resident in the Midwest region would gain from selling a home with a large tree…to our knowledge, the onsite and external benefits of park trees alone have not been isolated (More and others 1988). After reviewing the literature and recognizing an absence of data, we assumed that park trees had the same impact on property prices as street trees" (p.74, 5). In 2010, an even more comprehensive study was published, which focused on 2,608 single family homes sold in Portland (Donovan and Butry 2010). Results showed that a street tree adds 3.4% to the sales price of a property it's in front of. Since the results of this Portland study were closer to the 3 to 7 percent increase found by others than the 1% increase found in the Athens study used by i-tree, and the Portland study also had a significantly larger sample size than the Athens study, our cost benefit analysis estimated increase in property value based on the Portland study, extrapolated to 2010 Minneapolis home prices.

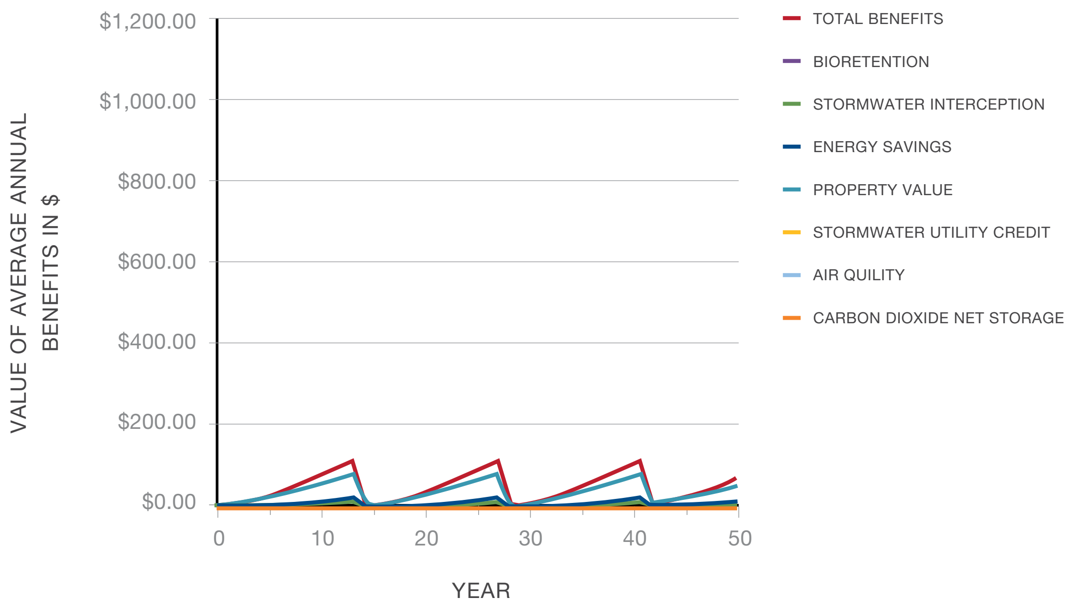
2. Costs are based on McPherson et al, 2006.

3. Bioretention storage for 1 tree with 100 Silva cells, totaling 1000 c.f. of bioretention soil with 200 c.f. of water storage capacity, enough to capture 1" rain from 2,400 s.f. of impervious surface. Treating the one inch rain event treats about half the annual rainfall in Minneapolis. Annual rainfall is 29.4 inches in Minneapolis, so half the annual rainfall is 14.7 inches per year. Treating 14.7 inches per year on 2,400 s.f. amounts to 21,990 gal per year. According to McPherson et al, 2005, the annual cost of stormwater storage in a holding pond in Minneapolis is $0.027/gal, so treating 21,990 gal/year provides $594 per year in benefits.

4. Stormwater utility credit for 1 tree capturing runoff from 2,400 s.f. of impervious surface = $8.45 per year. Calculation of yearly stormwater charge is 2,400 s.f./ 1530 = 1.57 Equivalent Stormwater Unit (ESU); 1.57 ESU x $10.77/ESU = $16.9 stormwater charge per year. Stormwater utility credit for treating 1" from this area is 50%, so $16.90 * 0.5 = $8.45 per year. See City of Minneapolis website at http://www.ci.minneapolis.mn.us/stormwater/fee/SewerStormwaterRateResolution.pdf and http://www.ci.minneapolis.mn.us/stormwater/docs/Stormwater_QualityChklstApp_Instruct.pdf for more detail about Minneapolis stormwater charges and credits.

TREE WITHOUT SILVA CELLS

Benefits Over 50 Years



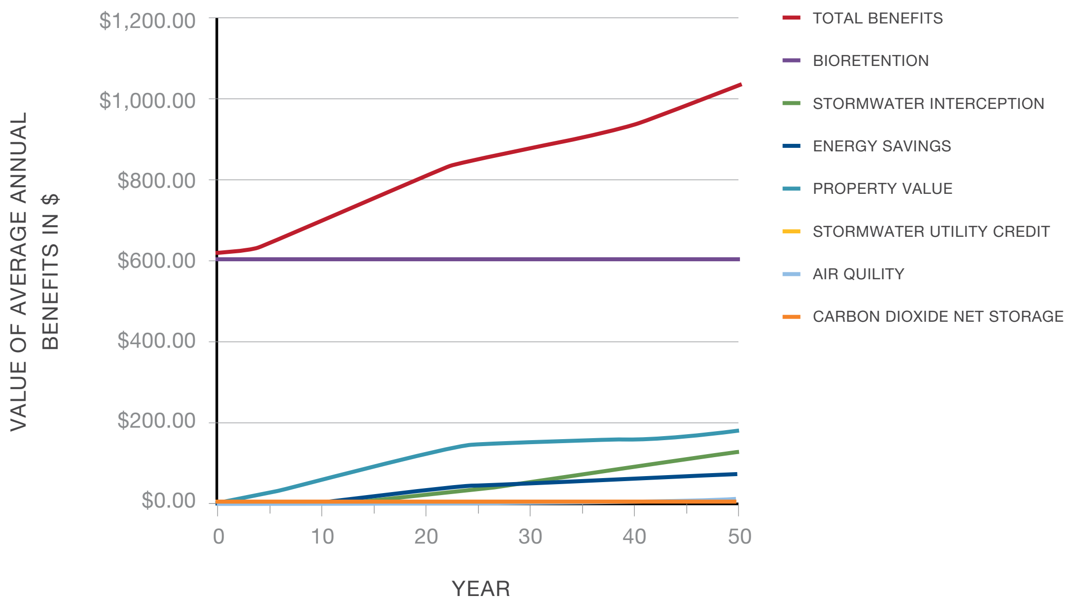
Total Benefits over 50 years: $2,717.66
Total Costs over 50 years (installation plus maintenance): $5,811.95
Net Lifecycle COST over 50 years: $3,094.29

Figure 1: Estimated Value of Benefits of a **Tree Without Silva Cells** over 50 years (modeled as a tree planted in a 4'x4'x4' tree pit surrounded by compacted soil)

Since the Tree **Without Silva Cells** needs to be re-planted every 13 years, it never grows large enough to provide nearly the benefits a mature tree provides. Tree benefits plateau at 13 years old and $121.21 of annual benefits. Then the tree dies and is replaced with a smaller tree (3" DBH) that provides only $7.81 of annual benefits.

TREE WITH SILVA CELLS FOR STORMWATER

Benefits Over 50 Years



Total Benefits over 50 years: $41,769
Total Costs over 50 years (installation plus maintenance): $16,341.75
Net Lifecycle BENEFITS over 50 years: $25,427.22

Figure 2: Estimated Value of Benefits of a **Tree With Silva Cells for Stormwater** over 50 years (modeled as a tree with Silva Cells for Stormwater with 1000 c.f. of bioretention soil)

The **Tree With Silva Cells for Stormwater** continues to grow beyond 13 years and throughout the rest of the 50 year study period. At 50 years old, it provides $1,013 of annual benefits: 8 times the benefits of the 13 year old tree without adequate soil volume, and 130 times the benefits of the urban tree without adequate soil volume the first year it is planted.

Figure 3 shows net present value, i.e. combined tree benefits and costs to date, at each year of the 50 year study period for each tree.

NET PRESENT VALUE FOR TREE WITH SILVA CELLS FOR STORMWATER VS. TREE WITHOUT SILVA CELL

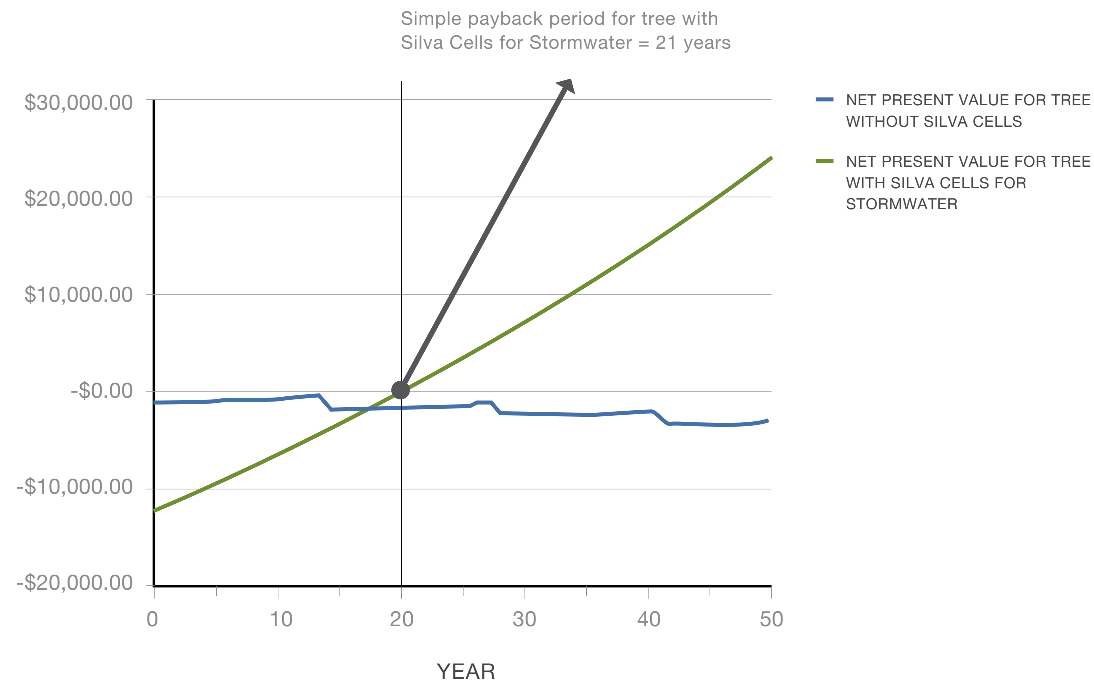


Figure 3: Net Present Value of a **Tree Without Silva Cells** vs. a **Tree With Silva Cells for Stormwater** over 50 years (Tree Without Silva Cells modeled as a tree planted in a 4'x4'x4' tree pit surrounded by compacted soil; Tree With Silva Cells for Stormwater modeled as a tree with Silva Cells for Stormwater with 1000 c.f. of bioretention soil)

Because the costs of the **Tree Without Silva Cells** outweigh the benefits throughout the study period, the net present value never rises above $0. Each time a tree reaches the estimated 13 year lifespan, it costs $1,200 to remove and replace it, so every 13 years there is a large dip in the net present value.

The **Tree With Silva Cells for Stormwater** has an estimated lifespan of more than 50 years, so it does not have to be removed and replaced during the 50 year study period. Additionally, it grows to a large enough size to start providing significant benefits that outweigh the installation and maintenance costs. After the initial $14,000 investment to install the tree and Silva Cells, net present value gradually increases as the tree provides larger and larger benefits. By year 21, benefits have accrued enough to pay back for the initial installation cost as well as the maintenance costs for the first 21 years. After 21 years, net present value becomes positive, so the tree has not only paid back for all the costs that have been put into the tree, the benefits actually start to outweigh the costs. By year 50, tree benefits have not only paid back for the tree installation and maintenance costs, it has actually paid back $25,427.22 in addition to the installation and maintenance costs invested into the tree!

Additional Benefits Not Quantified in our Analysis

Research studies have also found other tree benefits that were not included in our lifecycle cost-benefit analysis. These benefits include, for example:

- Shoppers in well-landscaped business districts are willing to pay more for parking and up to 12% more for goods and services (Wolf 2005).
- Increased property values increase tax base resulting from higher property value.
- Tree shade has been correlated with better pavement performance, which translates into reduced pavement maintenance costs, and increased pavement durability (McPherson and Muchnick 2005).

Additionally, estimated costs and benefits in this analysis are not adjusted for the time value of money.

Conclusion

Urban trees need adequate rooting volume to be able to grow large enough to provide significant ecological services. Providing this rooting volume can be very costly in urban areas, but until now the long-term value of this investment has not been well understood. Unlike most infrastructure, long-living, mature street trees actually appreciate over time, providing tremendous ecological value and significant cost savings for communities in the form of avoided infrastructure costs, reduced energy loads, higher rents, and urban heat-island mitigation.

Our lifecycle cost analysis showed that the investment into adequate uncompacted tree rooting volume can more than pay back for itself, as estimated benefits outweigh estimated costs by $25,427.22 over a 50 year study period for a typical urban tree in Minneapolis, MN.

References:

Donovan, G., and D. Butry. 2010. Trees in the City: Valuing Trees in Portland, Oregon. Landscape and Urban Planning, vol. 94.' Cited in Augustin, S. and J. Cackowski-Campbell. 2010. What's a Street Tree Worth? Landscape Architecture Volume 100, Number 8.

McPherson, E. G., Nowak, D. J., Rowntree, R. A., eds. 1994. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 201 p.

McPherson, E.G., J.R. Simpson, P.J. Peper, S.E. Maco, S.L. Gardner, S.K. Cozad, and Q. Xiao. 2006. Midwest Community Tree Guide: Benefits, Costs and Strategic Planting PSW-GTR-199. USDA Forest Service, Pacific Southwest Research Station, Albany, CA

McPherson, E.G., J.R. Simpson, P.J. Peper, S.E. Maco, S.L. Gardner, S.K. Cozad, and Q. Xiao. 2005. City of Minneapolis, Minnesota Municipal Tree Resource Analysis. Center for Urban Forest Research. USDA Forest Service, Pacific Southwest Research Station.

Skiera, B. and G. Moll. 1992. The Sad State of City Trees. American Forests. March/April: 61-64.

Urban, James. 2008. Up by Roots: Healthy Soil and Trees in the Built Environment. International Society of Arboriculture: Champaign, IL.

Wolf, K. L. 2005. Business District Streetscapes, Trees And Consumer Response. Journal of Forestry 103, 8, 396-400.