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Mutual Economic Incentives for Urban Tree Canopy Restoration

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Abstract

Potential alignment of economic incentives for tree canopy restoration are modeled using data from a 2015 Louisville Metro Government (KY) Urban Tree Canopy Assessment. The study revealed marked declines in urban canopy coverage from 2004-2012; accelerating losses are forecast through 2050. Tree coverage conveys substantial financial benefit to private property owners, primarily through increased property valuations. Benefits to local government may be derived from the corresponding increase in property tax assessments. A comprehensive cost-benefit analysis demonstrates the economic efficiency of tree purchase vouchers (issued by government to private property owners) as a potential contributing solution to urban canopy loss.

Keywords

tree canopy, Louisville, environmental economics

Cover Page Footnote

Thanks to Per G. Fredriksson of the University of Louisville, and to my beautiful family, whose support I depend on in all things.

Case Study Overview: The Status of Louisville's Tree Canopy

Louisville Metro Government commissioned the Davey Resource Group to conduct an urban tree canopy assessment. The results, released in 2015, revealed a serious and growing threat to the city's local ecosystem and quality of life. [1] Using archival aerial and satellite imagery, the study found only 94,000 tree-covered acres (38,040 ha) in 2012, accounting for 37% of the city's surface area. This represents a decline from 40% in 2004, and 38% in 2008; tree loss during those periods occurred primarily on private properties. This is well below the 40% canopy coverage widely recommended by environmental groups, such as *American Forests*. Louisville had previously established, in its 2013 *Sustain Louisville* plan [2], that urban canopy loss and urban heat island effects were a significant and worsening problem. The 2013 plan identified urban canopy restoration as crucial in mitigating the risks of climate change, achieving clean water & air standards, decreasing energy consumption, and mitigating the local heat island effect, while providing secondary benefits such as increased opportunities for nature-based recreation and active living. Unfortunately, the 2015 study also revealed that given current trends, Louisville's canopy may decline to 31-35% within ten years (fueled in part by widespread die-offs due to the arrival of the Emerald Ash Borer), and fall as low as 21% over the next four decades. Among other complicating and exacerbating factors, studies indicate the effects of canopy loss tend to disproportionately affect minority groups and low-income individuals, creating environmental inequity. [3][4] This disparity is apparent in the canopy coverage data used in Louisville's 2015 study, and highlights the extent to which urban canopy loss is a socioeconomic, as well as environmental, issue.

Benefits of Trees to Individuals & Property Values as Economic Incentives

Louisville's 2015 tree study identified efforts by private landowners as the best means to improve canopy cover, and estimated the total benefits of the canopy at ~$330 million annually (as of 2015) – with another $230 million of carbon sequestration over the current canopy's lifetime (see *Figure 1)*. However, because this estimate includes the value of global stock pollutant reduction, it does not accurately reflect microeconomic incentives for the individual homeowner. The most immediate financial impact to the homeowner is often in the form of marginal monthly energy cost savings, which are variable, and difficult to estimate across homes of various ages and design. Most of the projected benefits of increased canopy coverage are positive externalities, so widely distributed in effect they offer insufficient motivation for individual action. This is evidenced by the apparent market failure resulting in the current state of canopy decline.

Canopy Benefits	*Annual Value*
Stormwater Management (Runoff Reduction)	\$62,909,790
Energy Savings	\$5,463,356
Property Values	\$239,969,791
Air Quality (CO^2 Removal)	\$99,078
Air Quality (NO^2 Removal)	\$219,678
Air Quality (O^3 Removal)	\$7,932,540
Air Quality (SO^2 Removal)	\$78,727
Air Quality (Dust, Soot, Particulate Removal)	\$3,879,821
Carbon Sequestration	\$8,599,490
Total Annual Benefit of Current Canopy	*\$329,152,271*

Figure 1

Numerous academic studies however, have examined the increased property values associated with higher canopy coverage. As early as 1985 it was recognized that simply adding trees to a home's landscaping can add 3-5% to its future sale price. [5] According to the US Census Bureau, the median value of owner-occupied housing units in Louisville Metro was \$140,700 by 2016 estimates [6]. Just a 3-5% increase in sale price would provide the typical homeowner in Louisville with \$4,221-\$7,035 in equity, extractible at sale, or with HELOC financing. Increased property values would also provide additional revenue to the Metro Louisville Government in the form of increased property tax revenues. Such revenues currently account for 25% of the city's operating budget, providing a means to offset financial incentives that might be offered for urban canopy restoration. The dynamics of canopy coverage and property values therefore, offer shared economic incentives for homeowners and the government. Accordingly, the added property value of tree plantings is an area of ongoing research; selected works are summarized below (*Figure 2).* [7] [8] [9] [10]

Property Valuation Changes from Trees

Study	*Valuation Change Cited*	*Notes*
Anderson & Cordell (1988)	3.5-4.5%	Uses landmark study of 844 residential properties in Athens, GA.
Dwyer, McPherson, Schroeder (1992)	5%	Cited as "conservative estimate"
Wolf (2007)	3-5%	Landscaping with trees
	6-9%	If neighborhood also has good coverage
Sander, Polasky, Haight (2010)	2-20%	Review of previous literature finds wide range.

Figure 2

These studies employed both contingent and hedonic pricing, and are representative of the wider body of work on the topic. Sander, Polasky, and Haight (2010) provide an extensive review of this literature and previous findings, and concur with previous estimates in the 3-5% range [10]. Sander et al. also reveal a wider range of sale price changes may occur depending on the degree of tree coverage, region, climate zone, adjacent properties, and other factors. Notably, lots adjacent to larger forests may be valued as high as 20% over lots of similar description lacking forest access. Accordingly, a sales price (and implicitly, property valuation) increase of 4% will be used in modelling the potential use of tax incentives. This figure finds wide support in published literature, and is a conservative within the ranges provided. This 4% increase in the median home value of $140,700 yields $5,628 in home equity to the homeowner who undertakes even basic landscape tree plantings. It should be noted, however, that studies typically address the contribution of mature trees, using size restrictions which exclude smaller dwarf and ornamental trees at any stage of development. General prudence (and the Davey Resource Group), suggest extending tax benefits only to plantings of fast-growing, native trees, capable of reaching 29’ (~9 m) average crown diameter within 40 years. This permits the use of many common native tree varieties (oaks, maples, elms, etc.), but ensures realization of projected economic and environmental impacts. Given these standards, planting just 66 trees equates to the addition of one fully canopied acre (0.40 ha). [1]

In terms of marginal benefits, property value increases occur whenever the tree coverage on a given property exceeds the average coverage of the adjacent properties or area. [11] It seems likely then, that any residential property not already enjoying substantial tree coverage may benefit economically from planting a single tree. The homes assessed by Anderson & Cordell (1988) had an average of five trees visible from the front of the property and enjoyed the full direct economic benefit of enhanced tree cover. Accordingly, the benefit to the typical individual homeowner will tend to be maximized with 1-5 tree plantings. Potential incentives may be wisely restricted to properties with <5 trees visible at street frontage, subsidizing up to that number. This would maximize property tax valuation increases and resultant tax receipts, relative to the cost of those incentives.

The Cost of Tree Plantings

The full, long-term cost of planting a tree includes the purchase price of the tree, plus labor and maintenance (primarily disease prevention & pruning); Louisville's 2015 Tree Canopy Assessment used a generous cost assessment of $480. Elsewhere however, cost estimates as low as $50 per tree may be found, to include planting and long-term care. [12] The long-term (and somewhat optional) costs of tree maintenance may be overlooked by individual homeowners, as immediate cash outlays tend to be of greater concern. It is simpler, and certainly more efficient, from the perspective of the government providing tax incentives, to address only the purchase price of the tree. This provides the property owner real near-term benefit – to include energy savings – at no initial cost, without further diluting the economic benefit to the taxing body. The absence of initial cost would enable participation by property owners who previously found the cost of adding trees prohibitive. That in turn, may enhance environmental equity (given that canopy coverage tends to be lowest in economically depressed neighborhoods).

Payment of the initial cost may be made by reimbursement, or with a system of vouchers to local nurseries and home improvement centers. Payment should be done at-cost, and up to a specified price limit, to further reduce liabilities to the taxing authority. The use of vouchers would also streamline the species control process, allowing the city to incentivize only those native tree species which have the greatest economic and environmental impact. Such a program would also have sufficient purchasing power to negotiate a sizeable price discount, with negligible transaction costs. As of 2017, common tree species remain widely available from local nurseries and home improvement centers for less than $30[*]; common retail discounts of 20-30% may reduce the unit purchase price to $21-$24. The upper bound of $24 per tree will be used as a reasonable price estimate for cost-benefit analysis.

Benefits to Government, Positive Externalities & Cost-Benefit Analysis

Increased property tax revenues have been identified as primary economic incentive – and cost offset – for a voucher-based canopy restoration program. Using median housing prices and expected property valuation gains established above, the increase in median property tax can be calculated as follows:

Initial Price	$140,700 median housing price[†]
Valuation Gain	4% increase over initial price yields an additional $5,628 to the home's value
Property Tax Rates	a) 0.3538% property tax rate within Urban Services District (80.6% of Metro Louisville population in 2010 Census)[‡]
	b) 0.1254% property tax rate county-wide (19.4% of Metro Louisville population in 2010 Census) [§]

Weighted Avg. of Tax Rates = (0.003538*0.806) + (0.001254*0.194) ≅0.3095%

Finally, median gain in housing price ($5,628) * weighted average tax rate (.003095) yields ≅ $17.42 median annual increase in property tax revenue per unit of housing.

Gains in property value may be recognized on an annual basis during Louisville Property Valuation Administration assessments, or at the time of sale or refinancing the home, or when property valuation review is requested by a

[*] Tree prices for a variety of common native species, and common bulk/contractor discounts obtained directly from local retailers, various ZIP codes within Louisville Metro.
[†] Median housing values and population data obtained from US Census Bureau, US Census Data Collections 2011-2015, and 2010 US Census, respectively.
[‡] Tax rates obtained directly from Louisville Metro Government website, https://louisvilleky.gov/

property owner. Once a property has appreciated in value, higher property tax payments continue annually for the life of the home, or until other factors reduce the property valuation. If the Federal Reserve target inflation rate of 2% were maintained, then the net present value of tax revenues for a 10-year period following property valuation change may be calculated as follows:

(Present Value of an Annuity of *p*=10, *i*=2) * (Annual Property Tax Revenue Increase)

$$\text{PVA} = 1\text{-}\frac{1-\frac{1}{(1+i)^n}}{i} = 8.98259$$

Thus, 8.98259 * $17.42 = $156.48 additional property tax per housing unit, over 10 years.

The resulting present value of the 10-year cash flow ($156.48) is sufficient to offset the cost of even maximal costs, for 5 tree plantings per housing unit ($120). Even at that level, a $36.48 surplus will remain – a sizeable 30.4% return on investment over 10 years. When projections are extended to a lower average number of tree vouchers per property owner, and considering various participation levels, the net gain in revenues become sizeable, as shown below in *Figure 3*.

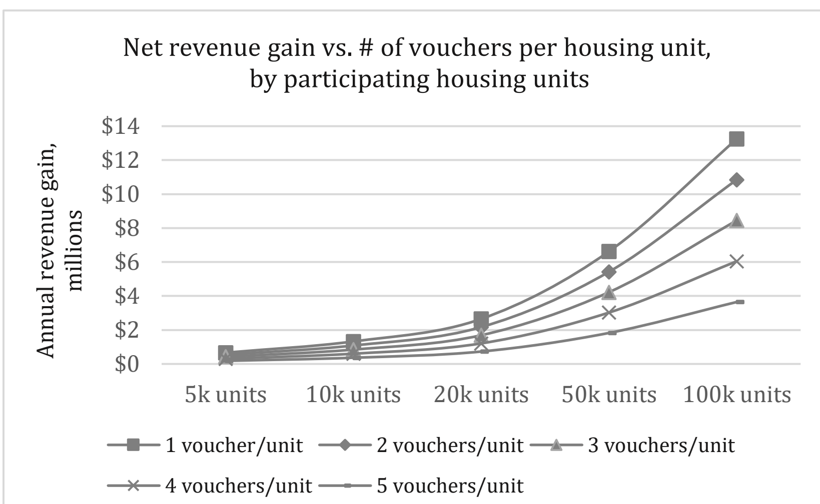

Figure 3

Further, the number of trees planted as the result of such a program is easily calculable across participation levels and average number of vouchers. The result, divided by 66 (the approximate number of mature trees per acre, previously discussed), yields the total additional acreage, which is shown in *Figure 4.* Using the values provided in *Figure 1*, the total positive externalities may be separately calculated; dividing the total benefits by number of acres, and trees per acre, to derive the positive externalities of a single tree, shown in *Figure 5*. In turn, the positive externalities are graphed across average voucher and participation levels in *Figure 6*.

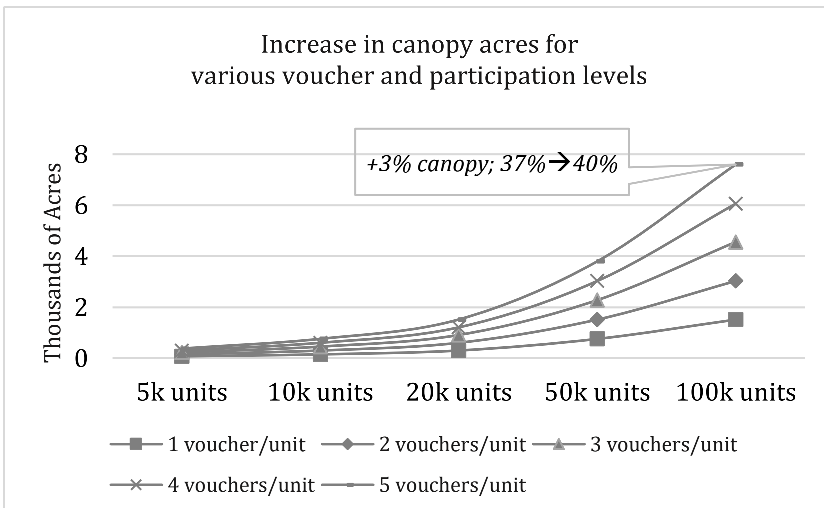

Figure 4

Annual Positive Externalities of a Single Tree	
Stormwater Management (Runoff Reduction)	$10.14
Air Quality (CO2 Removal)	$0.02
Air Quality (NO2 Removal)	$0.04
Air Quality (O3 Removal)	$1.28
Air Quality (SO2 Removal)	$0.01
Air Quality (Dust, Soot, Particulate Removal)	$0.63
Carbon Sequestration	$1.39
Total Annual Positive Externalities (Per Tree)	*$13.49*

Figure 5

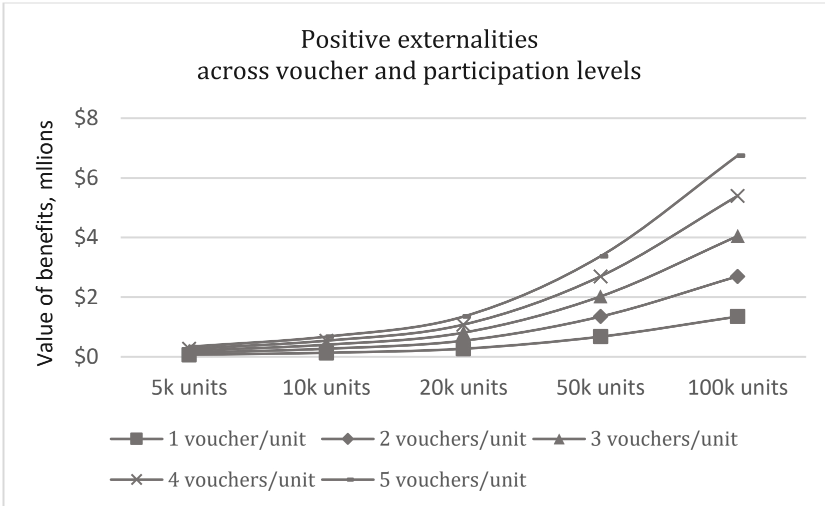

Figure 6

An increasing number of vouchers per property diminishes the relative revenue gains to the taxing authority, but increases positive externalities. To simply maximize social benefits, the voucher program would be targeted to properties requiring higher numbers of trees to impact property valuation. More prudently however, the government will use its resources as efficiently as possible; while any number of expenditures might create social benefit, the ideal expenditure creates the greatest total benefits at least cost. To determine the impact of the number of vouchers per housing unit on cost efficiency, a simple benefit-cost ratio may be derived from the data above, and is shown in *Figure 7* (annual social benefits were summed and discounted over a 10-year period to yield net present value; p=10, i=2).

Cost-Benefit Analysis					
# of Vouchers per home	1	2	3	4	5
Initial Cost	24.00	48.00	72.00	96.00	120.00
Positive Externalities, 10 yrs.	253.66	350.83	448.01	545.20	642.38
Increased Revenues, 10 yrs.	132.48	108.48	84.48	60.48	36.48
Total Social Benefit, 10 yrs.	386.14	459.31	532.49	605.68	678.86
Benefit-Cost Ratio	*16.09*	*9.57*	*7.40*	*6.31*	*5.66*

Figure 7

Conclusions

Urban canopy restoration presents mutual economic incentives to governments and individual property owners; changes in property valuation alone yield substantial benefit to both groups. Income levels and minority status are reflected in the disparity of canopy coverage across different areas of Metro Louisville, indicating cash outlays may be prohibitive to canopy restoration in those areas. [1] Typical property valuation gains from tree landscaping result in sufficient additional property tax revenues to offset the cost of a government tree purchase program. [7] [8] [9] [10] [11] Property valuation increases typically require no more than five trees be visible from a property's street frontage, and as few as one tree may be sufficient when the resultant canopy coverage on a property exceeds the neighborhood average [11]. The use of a voucher system allows the government to control costs, regulate tree species to ensure economic and environmental impacts are realized, and target specific populations or neighborhoods.

Cost-benefit analysis revealed that revenues to the taxing authority are maximized when fewer trees are needed on each participating property (*Fig. 3*). However, positive externalities and net social benefit are higher when the participating properties require the maximum five trees to reach the desired property valuation gains (*Figs. 4 & 6*). Those benefits come at a rising cost to the government, and benefit-cost ratios indicate the most effective strategy is to target properties requiring only one tree to see meaningful property valuation gains (*Fig. 7*). Such marginal increases in canopy coverage yield highest returns in neighborhoods with lowest average canopy levels, typically those with low average incomes. As a result, a program of targeted vouchers to families in low-income areas would be most efficient. In doing so, environmental equity would also be enhanced. Based on the 2015 Louisville Urban Tree Canopy Assessment, low-canopy areas in West Louisville should therefore be prioritized [1].

The transaction costs of establishing such a voucher program, operated in conjunction with local nurseries and home improvement centers, are likely to be minimal. The low cost of initiating the program translates to a lower break-even point, and the program may be financially justified even at low participation rates. The location, current canopy status, and number of properties participating in the program directly impact the distribution and relative proportion of financial and environmental benefits. Although further research is required to identify candidate properties and constrain potential participation levels, a targeted voucher program appears a promising tool for addressing urban tree canopy loss. Comparable programs are likely to be viable in other metropolitan areas with similar median property values and tax regimes.

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