Urban Tree Canopy Assessment and Planting Plan

Urban Service Area in Fayette County, Kentucky

Lexington-Fayette Urban County Government

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Introduction

The trees of Lexington's Urban Service Area are a major component of the infrastructure and provide more than the traditional values of aesthetics and shade. They also provide numerous quantifiable environmental benefits, including stormwater management, watershed protection, water quality improvements, temperature moderation and cooling, reduction of air pollutants, energy conservation, and overall increases in property values. The amount of urban tree canopy (UTC) and its location determines the amount and types of economic, environmental, and social benefits provided by trees to the government and the citizens.

Trees contribute greatly to the quality of life in Lexington and—unlike the other components of the community's infrastructure—the tree population, with proper care and protection, will actually continue to increase in value with each passing year.

Over the last 20 years, great advances in quantifying the environmental, economic, and social benefits of the urban forest have been made. Tools are available to community and government stakeholders and managers. These advances have been driven by an increasingly common shift in how communities around the country value their trees and green spaces.

This project provides the Lexington-Fayette Urban County Government (LFUCG) with a current baseline land cover percentage including canopy, assessment of possible UTC and planting areas, and an analysis of ecosystem benefits.

The results of this UTC assessment and prioritized planting plan will be especially valuable for the reasonable, rational, and defensible planning of the Urban Service Area's current and future urban forest and green infrastructure.

The UTC assessment results will assist the Lexington-Fayette Urban County Government in managing and growing the urban forest in addition to:

- **Setting Canopy Goals**
- **Revising Policies Associated with Tree Canopy**
- **Determining Ecosystem Benefits Provided by the Urban Forest**
- **Promoting the Benefits of Trees**
- **Developing Sound Urban Forest Management Plans**

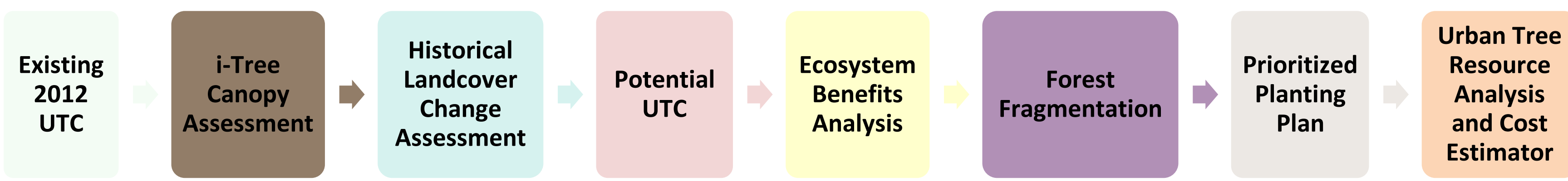
Purpose

The purpose of the project is to use aerial photographs and satellite imagery with geographic information systems (GIS) data to map and analyze the existing UTC and identify target areas for planting trees in Lexington and Fayette County's Urban Service Area. Mapping and quantifying UTC will allow LFUCG to establish baseline conditions for current use and future monitoring, set goals for improvement, and create plans for planting and protecting trees. Quantifying the benefits of the urban forest will allow LFUCG to promote the benefits of trees and the urban forest to staff, elected officials, stakeholders, and the citizens and gain support for urban forest management, stormwater, and sustainability programs.

Scope

The 2012 National Agricultural Imagery Program (NAIP) leaf-on, multispectral imagery acquired and processed by the US Department of Agriculture (USDA) was used as the primary source to identify Lexington's Urban Service Area current land cover. Remote sensing and GIS software extensions provided the automated feature extraction tool to generate the baseline percentage of the final tree canopy and land cover layer. Ancillary GIS data aided in determining potential planting site locations and established the current overall possible UTC. Land cover areas designated as canopy, pervious, or bare soils was considered in the calculation of possible UTC. Land uses designated as interstate corridors, highways, streets, open space, residential lots, or parks were identified as target areas for tree planting and canopy growth and was included in the analysis. Conversely, land uses designated as agricultural land, cemeteries, golf courses, utility rights-of-way, or recreational fields were defined as unavailable for future planting and excluded from the analysis. Prior to implementing this planting plan, further and more precise assessment by LFUCG or any other organization utilizing this information for selecting potential planting sites is needed to determine the presence of other land use constraints and whether the land is truly appropriate for planting trees.

The project objectives include: identifying and quantifying the current contributions of urban trees by establishing UTC baseline information that can be used to track canopy gains and losses over time; developing a prioritized planting plan based on environmental factors that support the overall project goals; and determining the benefits of the future forest.



Urban Tree Canopy Assessment

The results of the 2012 UTC assessment are provided in Table 1. The boundary of Lexington's Urban Service Area covers approximately 54,630 acres (85.36 square miles) (Figure 1). Based on the UTC analysis results, the estimated canopy coverage of this study area is 24.56%. Several methods were used to quantify the 2012 existing UTC. Further results of this UTC assessment are provided in the following sections of this report and the methodology and accuracy assessment documentation are presented in Appendix A.

Table 1. Existing UTC Assessment Results in Lexington's Urban Service Area

Land Cover Class	Acres	Percent
Tree Canopy	13,420	24.56%
Impervious Surfaces	18,763	34.34%
Pervious Surfaces	21,470	39.30%
Bare Soils	416	0.76%
Open Water	560	1.03%
Total	54,630	100.00%

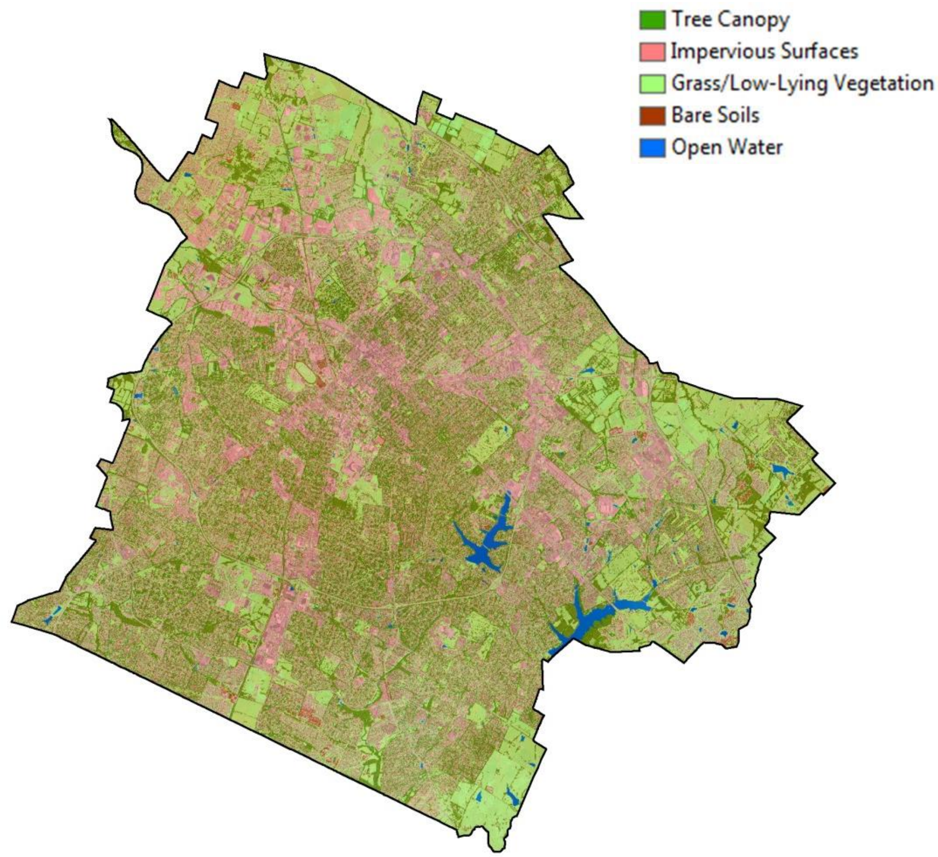


Figure 1. Visual results of the 2012 Urban Tree Canopy Assessment in the Urban Service Area of Lexington, Kentucky.

Detailed Land Cover Results

The results of a more detailed UTC assessment are provided in Table 2. Pervious and impervious surface were identified further using the five-class land cover layer and other available GIS layers to illustrate more realistic views (Figure 2). Pervious surfaces were assessed in greater detail to represent the true nature of Lexington's landscape and include grass/vegetation/open space, agricultural fields, wetlands, and future development. Impervious surfaces were assessed in greater detail to give statistics on the current amount of pavement and include canopy over impervious, buildings, roads, and other impervious.

Table 2. Detailed Land Cover Assessment Results in Lexington's Urban Service Area

Land Cover Class	Acres	Percent
Tree Canopy	11,679	21.38%
Canopy over Impervious	1,827	3.35%
Buildings	6,181	11.31%
Roads	4,500	8.24%
Other Impervious	7,842	14.35%
Agricultural	1,397	2.56%
Grass/Vegetation/ Open Space	17,788	32.56%
Wetlands	26	0.05%
Bare Soil	415	0.76%
Open Water	560	1.03%
Future Development	2,415	4.42%
Total	54,630	100.00%

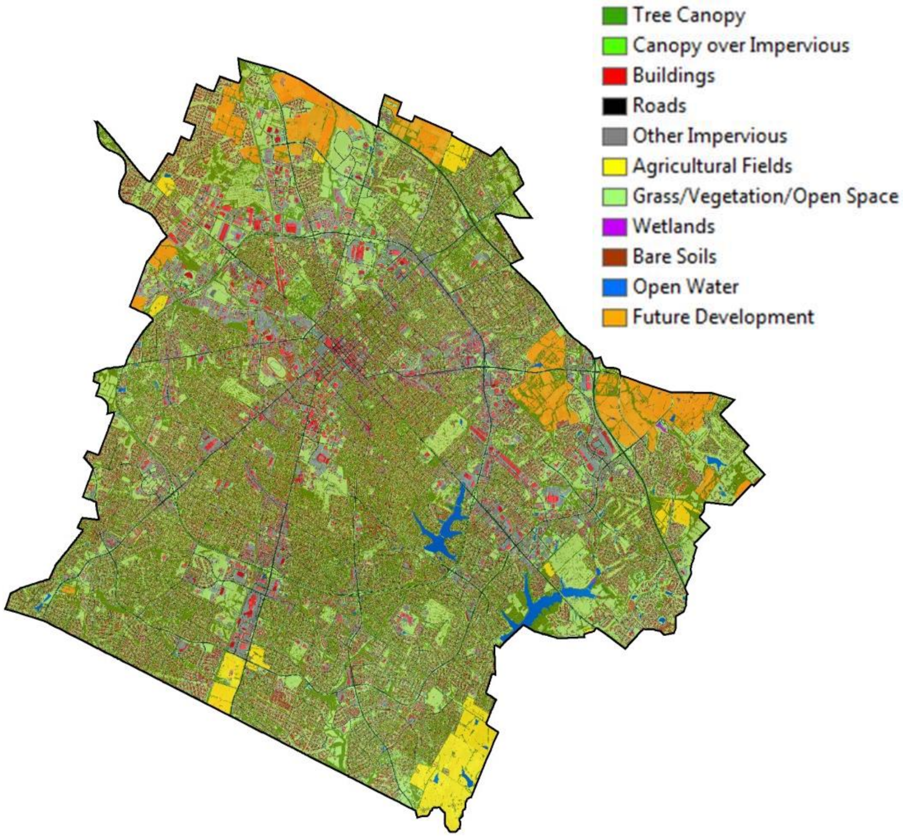


Figure 2. Visual results of the 2012 Detailed Land Cover Classification in the Urban Service Area of Lexington, Kentucky.

i-Tree Canopy Analysis

Davey Resource Group compared the existing land cover percentage values with the statistical results generated from i-Tree Canopy to determine the project area’s historical land cover percentage values.

The i-Tree Canopy tool (Figure 3) allows users to easily interpret Google Earth aerial imagery for areas of interest and produce statistical estimates of tree cover and other cover types. Calculation of estimate uncertainty is provided as well. This tool provides a quick and inexpensive means for communities, government stakeholders, urban forest managers, and non-profits to accurately estimate tree canopy cover.

This i-Tree Canopy tool can be used by LFUCG in future land cover assessments to provide land cover analysis using new aerial images as they become available in Google® Maps. The random point locations derived from i-Tree Canopy can be re-imported in future works to produce a statistically valid estimate of land cover. The i-Tree Canopy data were provided along with this report on CD-ROM. LFUCG can use this tool to quickly evaluate canopy effects after future severe weather events, increased development, and collective planting efforts.

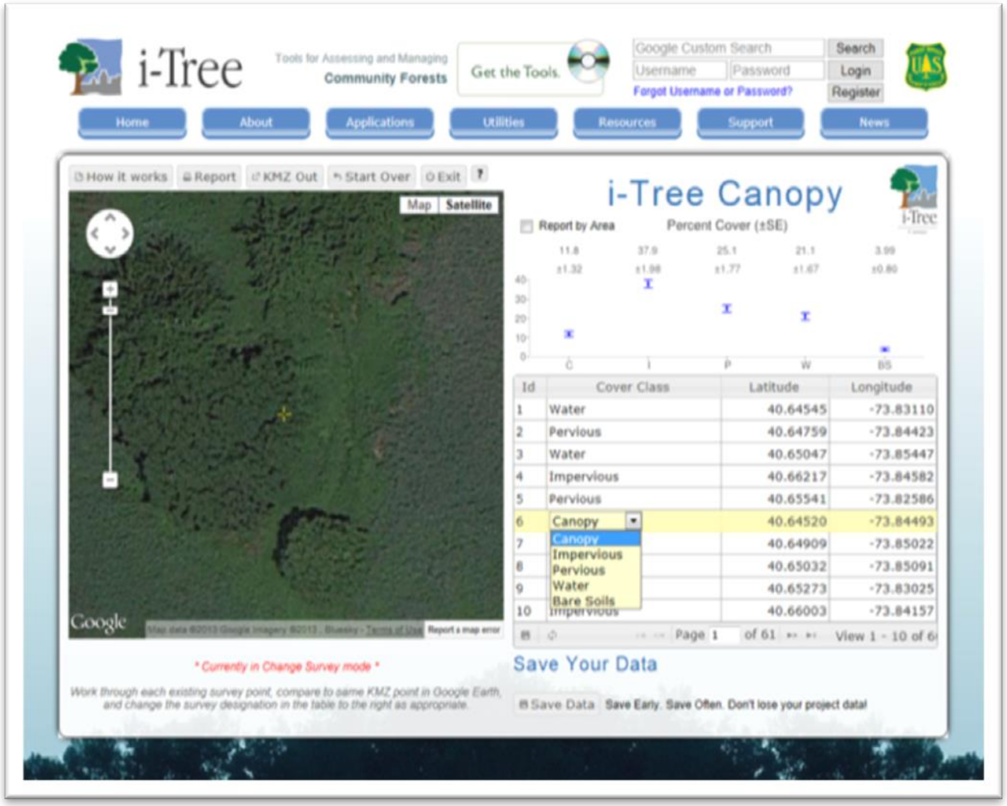


Figure 3. Screen shot of i-Tree Canopy interface.

Historical Land Cover Change Assessment

Davey Resource Group generated a Google® Earth KML file of the random point locations derived from i-Tree Canopy analysis for the project area to complete a statistical canopy assessment for two additional years. Davey Resource Group performed a historic UTC change assessment for Lexington's Urban Service Area using images from March 1994 and June 2004. Figure 4 illustrates land cover change from grass or low vegetation and a single impervious road to buildings, parking lots, and more impervious road surface areas.

Results of the land cover change analysis from 1994 to 2012 are reported in Table 3. Over an 18-year period, Lexington's tree canopy coverage has increased by 5%, impervious surfaces have increased by 4%, and pervious surfaces have decreased by 10%. The increase of tree canopy cover—attributed to the growth of existing trees and the addition of new trees—is helping to mitigate the negative trend of losing pervious surfaces.

Table 3. i-Tree Canopy Results in Lexington's Urban Service Area

	i-Tree Canopy Assessment (%)			
Land Cover Class	1994	2004	2012	% Change
Tree Canopy	19.20	21.00	24.56	5.36
Impervious Surfaces	30.50	34.90	34.34	3.84
Pervious Surfaces	49.50	40.10	39.30	-10.20
Bare Soils	0.40	3.59	0.76	0.36
Open Water	0.40	0.40	1.03	0.63

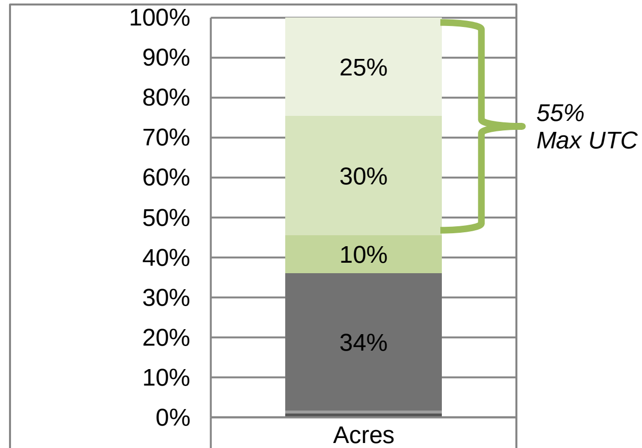
Figure 4. Example of land cover change from March 1994 to June 2004 to June 2012.

Urban Tree Canopy Goals

The amount of tree canopy drives the amount of benefits that an urban forest provides. Whether LFUCG wants to increase or maintain tree canopy, setting goals will help organize tree planting programs and inform tree preservation efforts. Establishing realistic and achievable tree canopy goals will help capitalize on the economic, environmental, and social benefits trees provide to the community. Appendix E provides a planting list that offers smart choices for species selection and diversity to build a resilient urban forest that will not be greatly affected by any single invasive pest or disease.

"Possible UTC" is the result of all land cover that is open, pervious ground. While it is theoretically possible that all pervious surfaces could be planted to increase future tree canopy, considering all land use areas is understandably not practical for implementing actual planting projects nor is it realistic for urban forest planning and management.

"Preferred UTC" or "future planting area" is based on a "real world" approach to the identification of reasonable areas to plant trees. Davey Resource Group assessed and prioritized these areas based on maximizing ecological services, providing equal access to trees and natural resources, and protecting public health and safety benefits. Preferred planting areas include the pervious surfaces within interstate corridors, highways, streets, and parks within Lexington's Urban Service Area. Land uses such as agricultural land, cemeteries, golf courses, utility rights-of-way, and recreational fields were excluded from the analysis.



	Acres
Tree Canopy	13420
Preferred Planting Area	16280
Pervious Surfaces	5190
Impervious Surfaces	18763
Bare Soils	416
Open Water	560

Figure 5. Maximum urban tree canopy cover within Lexington's Urban Service Area.

Many communities have set canopy coverage goals, standards, or policies. One of the most widespread uses of UTC technology is to set canopy coverage goals. American Forests, a recognized leader in conservation and urban forestry, has established canopy goals for metropolitan areas. American Forests' goals are an accepted standard and can be used as a general guideline or target for communities to achieve. While tree cover will vary across a city, American Forests recommends cities set a canopy cover goal of 40% overall—the equivalent of 20 large trees per acre. Lexington's amount of existing tree canopy is 25%; the realistic estimate of tree canopy is 30% within preferred planting areas; and the true maximum tree canopy is 55%. Maximum potential is the sum of existing UTC and possible UTC based on the findings of this assessment (Figure 5).

Individual UTC assessment summaries for geographical areas identified by LFUCG are included in Appendix B.

Ecosystem Benefits Analyses

Trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff (Figure 6). In addition, trees provide numerous economical, psychological, and social benefits.

The ecosystem benefits of Lexington's UTC resource were quantified using the latest version of the i-Tree Vue 4 model and TR-55 hydrologic equations. i-Tree Vue estimates carbon storage and sequestration and air pollutant removal. Air pollutants included in estimates are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10}), and sulfur dioxide (SO_2). TR-55 hydrologic equations model stormwater runoff. The following is an explanation of each analysis.

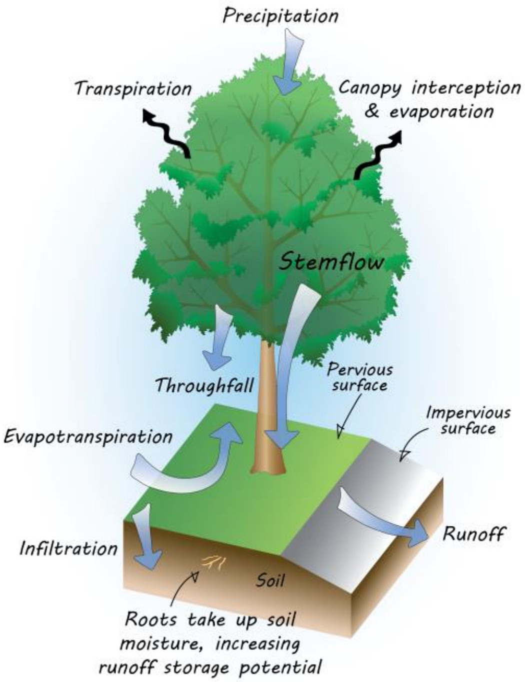


Figure 6. Stormwater benefit process.

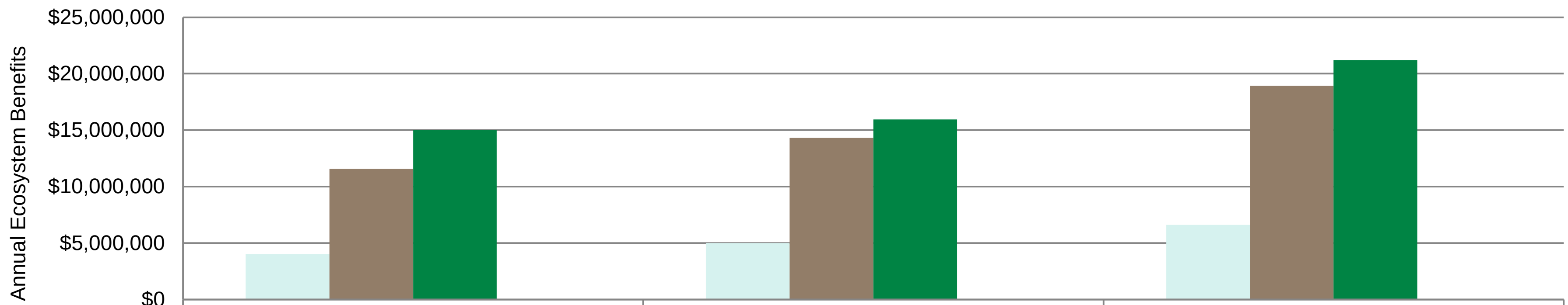
Air Quality: The publically accessible software model called i-Tree Vue uses National Land Cover Data (NLCD) satellite-based imagery to assess a project area's land cover. The software supports analysis of pollution removal from different land classes (including tree canopy). Recent innovations with the latest version of i-Tree Vue have allowed for the adjustment of the NLCD tree canopy and impervious cover values overall within the software model to generate the overall ecosystem service estimated values. Reports quantify the monetary and unit values of pollution reduction.

Carbon: The software model i-Tree Vue can again provide the solution to evaluating the carbon sequestration and storage services provided by the project area's UTC. Along with the air quality analysis, the software was calibrated with the current land cover and impervious surface percentages to model the urban forests' carbon benefits. Results demonstrate the amount of UTC directly correlated to current and future increases in carbon reduction.

Stormwater: A stormwater assessment was completed using the TR-55 hydrologic equations created by the USDA for modeling stormwater runoff. These equations are commonly used to assess stormwater runoff in urban watersheds by generating a curve number. This number is correlated with hydrologic soil groups which identify a soil's permeability. In addition, the curve number also uses current land cover as an input. To calculate runoff, the equation uses rainfall data, potential maximum retention, and initial abstraction. CITYGreen for ArcView® 3.x software was utilized to quantify the monetary and unit values of pollution reduction and stormwater.

Data analysis shows Lexington’s existing UTC provides an estimated $30,594,735 in annual benefits and savings to the community. Figure 7 lists the total ecosystem benefits and illustrates projected ecosystem benefits based on Lexington’s current canopy cover extent of 24.56% and the potential benefits from increasing that cover by 5% and 15%. Increasing canopy cover by 5% to 30% is a realistic, short-term achievable goal. Increasing canopy cover by 15% meets American Forests recommended 40% canopy cover for metropolitan areas east of the Mississippi River.

Increasing Lexington’s UTC by 5% will produce an increase in benefits and values of nearly 15%. Achieving 30% canopy cover reaches 55% of Lexington’s maximum potential for canopy cover given existing conditions. Canopy cover at 40% will produce an increase in benefits and values of nearly 53%. Achieving 40% canopy cover reaches 73% of Lexington’s maximum potential for canopy cover given existing conditions.



	Existing UTC - 24.56%	Short-term Goal - 30%	American Forests Goal - 40%
Air Pollution	$4,028,507	$4,987,218	$6,595,599
Carbon	$11,557,552	$14,308,034	$18,922,386
Stormwater	$15,008,676	$15,942,816	$21,198,900
Total	$30,594,735	$35,238,068	$46,716,885

Figure 7. Ecosystem benefits provided by Lexington’s urban tree canopy at various UTC percentages.

Lexington's entire urban forest removes 1,122,300 pounds of pollutants from the air annually, a benefit valued at $4,028,507. Additionally, the community's urban forest stores approximately 490,732 tons of carbon and each year sequesters approximately 16,178 tons of carbon dioxide; these benefits are valued at $11,188,694 (storage) and $368,858 (annual carbon sequestration). Trees also intercept over 258,246,548 cubic feet of runoff every year, a benefit valued at $15,008,676. Table 4 illustrates the total ecosystem benefits that the existing UTC provides to Lexington as well as the estimated benefits provided if the UTC is increased to 30% or 40%.

Table 4. Ecosystem Benefits Provided by Lexington's UTC[1]

Ecosystem Factor	Lexington 2012 UTC 24.56%		Lexington at UTC of 30%		Lexington at UTC of 40%	
	Units	Value	Units	Value	Units	Value
Air Pollution (pounds)						
CO_2	16,000	$10,274	20,000	$12,719	26,400	$16,820
NO_2	134,400	$604,342	166,600	$748,165	220,000	$989,448
O_3	498,400	$2,239,766	617,000	$2,772,789	81,600	$3,667,016
SO_2	129,600	$142,651	160,600	$176,599	212,000	$233,553
PM_{10}	343,800	$1,031,474	425,600	$1,276,946	563,000	$1,688,762
Subtotal	1,122,200	$4,028,507	1,389,800	$4,987,218	1,103,000	$6,595,599
Carbon (tons)						
Storage	490,732	$11,188,694	607,517	$13,851,395	803,442	$18,318,480
Sequestration	16,178	$368,858	20,027	$456,639	26,487	$603,906
Subtotal	506,910	$11,557,552	627,544	$14,308,034	829,929	$18,922,386
Stormwater (cubic feet)	258,246,548	$15,008,676*	245,969,777	$15,942,816*	230,337,477	$21,198,900*
Subtotal	258,246,548	$15,008,676**	245,969,777	$15,942,816**	230,337,477	$21,198,900**
Total		$30,594,735		$35,238,068		$46,716,885

[1] Air pollution and carbon values are derived using the latest version of i-Tree Vue 4 and stormwater values are calculated in CITYGreen.

* Stormwater values are calculated based on the cost of building man-made structures to hold peak run off flows.

** Annual stormwater costs are derived by taking the actual cost of the man-made structures financed at 6% interest for 20 years.

Forest Fragmentation

Urban forests provide numerous environmental and socioeconomic benefits, but the benefits to wildlife may not always be fully appreciated. The urban ecosystem is extremely complex and diverse; existing in a multitude of layers formed by small, functional ecosystems that together form a larger system. The overall health of the urban ecosystem depends highly on the ability of the trees, plants, wildlife, insects, and humans to interact collectively as a whole. However, a key factor in declining urban health is urban build-up and sprawl, which can lead to the removal and decrease of canopy across a community. Often this effect causes canopies to be fragmented and leads to the degradation of ecosystem health, which in turn leads to a decline in habitat quality and canopy connectivity. This decline results in changes and imbalance to microclimates and increases the risk and susceptibility to invasive species.

As a part of the UTC assessment, Davey Resource Group analyzed Lexington's existing UTC for fragmentation. This analysis focused on how tree canopy is spatially distributed throughout the Urban Service Area and provided an index displaying the degree of fragmentation (Figure 8). Often, the health and diversity of the overall canopy can be greatly improved by creating linkages between multiple patches of forest. The analysis found that Lexington's urban forest includes the following:

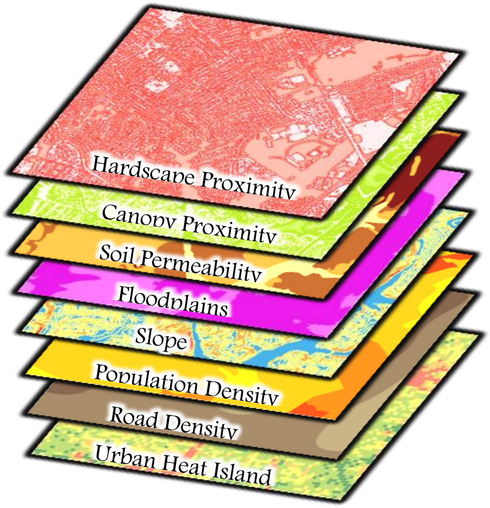
- **113 acres of Core Canopy.** Tree canopy that exists within and relatively far from the forest/non-forest boundary (i.e., forested areas surrounded by more forested areas).
- **131 acres of Perforated Canopy.** Tree canopy that defines the boundary between core forests and relatively small clearings (perforations) within the forest landscape.
- **1,608 acres of Edge Canopy.** Tree canopy that defines the boundary between core forests and large non-forested land cover features. When large enough, edge canopy may appear to be unassociated with core forests.
- **11,606 acres of Patch Canopy**. Tree canopy that comprises a small forested area that is surrounded by non-forested land cover.

Figure 8. Forest fragmentation identified by canopy structure.

UTC-Based Planting Plan

Delineation between viable and unviable planting areas through the use of UTC data provides a general idea for how much canopy coverage can increase within given boundaries. The assessment of Lexington's Urban Service Area indicates there are possibly 16,253 acres of land that could potentially be planted with trees.

Some planting sites would provide more tree benefits than other sites. For instance, Lexington's UTC analysis included consideration of environmental factors and natural resources to develop a planting priority for sites at greatest risk of soil loss or degradation. An explanation of the eight environmental and social factors used to prioritize future planting sites is provided in Appendix C.



To identify planting areas that will return the greatest and most diverse amount of benefits to LFUCG, Davey Resource Group assessed a number of environmental and social features, including existing canopy and land cover, soil permeability (where available), riparian areas, urban heat island, slope, road density, and population density. Each of these features was used to create individuals grids that were assigned a value between 0 and 4. By overlaying these grid maps and adding the values at any given point, a priority planting scale was developed based on the level of need (Figure 9). Planting trees in areas of high and very high need can reduce the risk of soil loss and degradation from storm and flood events as well as reduce urban heat island.

The analysis identified the following acres of preferred planting sites based on risk*:

- Very High – 1,223 acres
- High – 4,833 acres
- Moderate – 5,868 acres
- Low – 3,689 acres
- Very Low – 427 acres

* Planting areas less than 100 square feet were eliminated from this analysis due to irregularly shaped polygons. These locations were omitted because they were found to not have enough suitable planting space. Equals a 240-acre difference in planting area.

Figure 9. Priority planting site results.

Prioritized Planting Plan

Future planting projects can be discussed and planned by LFUCG with the information contained in prioritized, preferred planting sites isolated by the UTC assessment. Approximate numbers and tree size suggestions are included for each prioritized area with an emphasis on maximizing the population of large canopy tree species. Tree size assignment results are presented in Table 5.

Figure 10 illustrates the GIS data layer and associated attributes of the prioritized planting plan. Tree planting areas can be viewed or used as polygons or as points for planning purposes depending on the level of detail required. When viewing either polygons or points, the attribute table will indicate whether the species recommended for a given area is a small, medium, or large tree. The attribute table will also include information organized by identified geographical areas. Those areas identified by LFUCG include land use, council district, block group, neighborhood association, priority level, and urban heat island. Additional attributes identified include presence as a street tree, presence in a riparian area, and ownership.

The GIS data layer was provided along with this report on CD ROM.

Table 5. Prioritized Planting Plan
Tree Size Assignments

Tree Size	Count
Large	108,704
Medium	114,438
Small	161,245
Total	384,387*

**Public trees = 62,809*

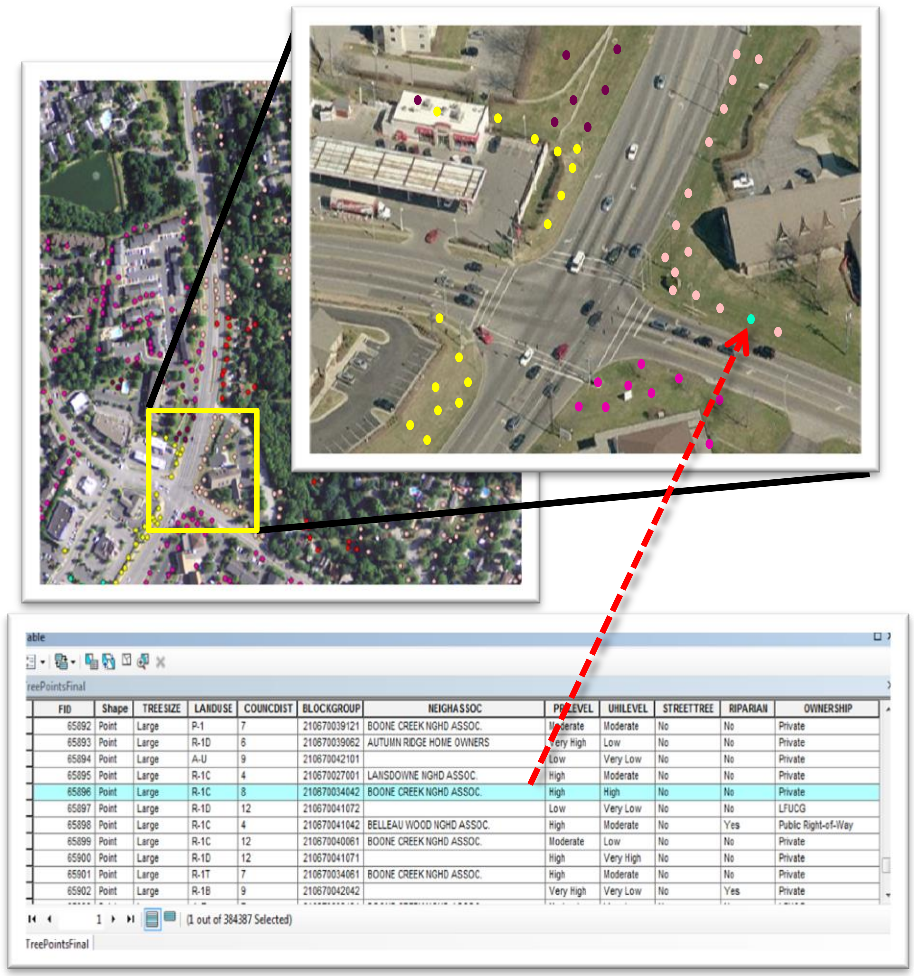


Figure 10. Preferred tree planting sites with their associated attributes.

Tree Canopy Calculator

Acreage within the Lexington Urban Service Area identified as preferred planting areas was analyzed to determine approximate tree counts and costs needed to populate these areas with new trees. The Urban Tree Resource Analysis and Cost Estimator (UTRACE) utilized the UTC data to estimate the trees required and costs to increase and maintain canopy.

UTRACE identifies the existing percentage of canopy cover and allows the user to set the desired canopy cover percentage in order to estimate the number of tree plantings that are biophysically possible to plant within the available planting space. It then estimates budget implications.

The canopy calculator has components which account for the number of trees plantable by crown diameter size—small, medium, or large—based on the total plantable acreage available. The tool also allows for the canopy percentage to be classified by land use categories or other unique boundaries and generates graphical representations of the results of each scenario. The percentage distribution by crown diameter size and further classification by land use categories results in the best plan both biophysically and economically.

Utilizing baseline percentages from the UTC analysis, this tool generated possible planting scenarios to attain the desired canopy goal. This analysis considered the preferred planting area as the target, assumed a mortality rate of 10%, and used a desired tree size distribution of 10% at 15-feet crown diameter, 40% at 30-feet crown diameter, and 50% at 40-feet crown diameter.

Table 6 shows a scenario for estimated costs and trees required to increase canopy by 2% within each watershed by planting in all preferred plantable areas. Table 7 shows a scenario for estimated costs and trees required to increase canopy by 2% within each council district by planting in all preferred plantable areas. UTRACE can be customized and is fully adjustable to allow LFUCG to plan and consider additional planting strategies. Definitions of the UTRACE inputs and results are provided in Appendix D. The UTRACE application was provided along with this report on CD ROM.

Table 6. A Sample Watershed Planting Strategy to Estimate Trees and Costs to Increase Canopy

Watersheds	Possible UTC	Existing UTC Acres	Existing UTC (%)	Preferred Plantable Acres	Total Preferred UTC (%)	Number of Trees Plantable	Change in UTC (%)	Projected UTC (%)	Number of Trees Required at 10% Mortality Rate	Estimated Tree Planting Cost*
Cane Run	3,636.51	1,556.14	20.97	2,414.12	32.53	119,144	2	22.97	8,058	$3,223,191
Town Branch	1,391.48	519.63	17.74	1,079.72	36.86	53,287	2	19.74	3,180	$1,272,045
Steeles Run	48.03	34.23	39.60	4.41	5.10	218	2	41.60	94	$37,533
North Elkhorn Creek	57.73	18.44	22.06	12.10	14.47	597	2	24.06	91	$36,311
Town Branch	1,523.19	1,382.62	24.77	1,318.62	23.62	65,078	2	26.77	6,061	$2,424,372
David Creek	196.31	64.09	21.96	79.51	27.25	3,924	2	23.96	317	$126,732
Wolf Run	2,027.75	1,671.69	27.61	1,744.03	28.81	86,073	2	29.61	6,574	$2,629,546
North Elkhorn Creek	3,218.23	1,278.62	19.42	1,746.92	26.54	86,216	2	21.42	7,147	$2,858,840
South Elkhorn Creek	2,371.14	1,800.54	27.29	2,159.37	32.73	106,571	2	29.29	7,163	$2,865,007
West Hickman Creek	3,861.69	3,374.58	29.38	3,339.03	29.07	164,791	2	31.38	12,470	$4,988,017
East Hickman Creek	3,521.34	1,703.00	22.83	2,326.98	31.19	114,843	2	24.83	8,100	$3,240,015
Total	21,853.41	13,403.58		16,224.82		800,742			59,254	$23,701,609

* Estimated costs were calculated by using monetary values given by the City of Lexington. Tree costs were $300 for small trees, $400 for medium trees, and $500 for large trees.

Table 7. A Sample Council District Planting Strategy to Estimate Trees and Costs to Increase Canopy

Council Districts	Possible UTC	Existing UTC Acres	Existing UTC (%)	Preferred Plantable Acres	Total Preferred UTC (%)	Number of Trees Plantable	Change in UTC (%)	Projected UTC (%)	Number of Trees Required at 10% Mortality Rate	Estimated Tree Planting Cost*
1	1,618.80	952.72	21.61	1,439.67	32.66	71,052	2	23.61	4,716	$1,914,528
2	3,351.51	1,258.94	17.97	2,233.62	31.88	110,236	2	19.97	7,494	$3,042,493
3	634.99	636.85	24.41	601.68	23.06	29,695	2	26.41	2,791	$1,132,963
4	1,091.22	1,083.73	31.92	995.96	29.33	49,153	2	33.92	3,632	$1,474,700
5	1,321.68	1,409.97	30.34	1,139.65	24.53	56,245	2	32.34	4,971	$2,018,158
6	2,390.39	1,301.12	22.52	1,614.12	27.94	79,662	2	24.52	6,181	$2,509,419
7	1,907.94	1,012.97	21.72	1,704.65	36.56	84,129	2	23.72	4,988	$2,025,044
8	1,014.60	819.10	28.90	920.04	32.46	45,407	2	30.90	3,032	$1,231,134
9	1,658.58	1,149.86	26.60	1,329.03	30.74	65,592	2	28.60	4,625	$1,877,757
10	1,539.37	1,159.54	26.37	1,496.73	34.04	73,868	2	28.37	4,704	$1,909,777
11	1,134.45	1,011.74	29.82	977.29	28.80	48,232	2	31.82	3,630	$1,473,659
12	4,221.37	1,621.83	22.61	1,799.89	25.09	88,830	2	24.61	7,674	$3,115,784
Total	21,884.89	13,418.38		16,252.32		802,100			58,438	$23,725,416

* Estimated costs were calculated by using monetary values given by the City of Lexington. Tree costs were $300 for small trees, $400 for medium trees, and $500 for large trees.

Conclusion

Trees are a unique "technology" because they produce multiple benefits at the same time. The primary reason for planting a tree does not limit the overall benefit it provides. For example, a tree planted to shade a window still provides other benefits, such as removing particulate matter from the air and increasing property values. More information on the benefits of the urban forest is included in Appendix F.

Lexington's existing UTC covers 24.56% of the total land area. During the last 18 years there has been a 5% increase of canopy cover.

The UTC of Lexington's Urban Service Area is a vital asset to Fayette County, providing a value of $30.6 million in environmental and socioeconomic benefits. Air quality improvement accounts for 13%, carbon sequestration and storage account for 38%, and stormwater management accounts for 49% of total benefits.

The maximum potential UTC based on all the possible area available for planting in the Urban Service Area is 55%. Increasing UTC from 25% to 30% will provide an increase in benefits and values by nearly 15%. Increasing UTC from 25% to 40% will provide an increase in benefits and values by nearly 53%.

The management of trees in an urban forest can be challenging. Balancing the recommendations of experts, the needs of residents, the pressures of local economics and politics, the concerns for public safety and liability issues, the physical aspects of trees, the forces of nature and severe weather events, and the desires for all of these factors to be met simultaneously is an overwhelming task. LFUCG must carefully consider each specific issue and balance these pressures with a local knowledgeable and an understanding of trees and their needs. If a balance is achieved, Lexington's unique livability will grow stronger and the health and safety of its trees and residents will be maintained.

As more communities focus attention on environmental sustainability, community forest management has become increasingly dependent on GIS for UTC mapping and analysis. Understanding the importance of existing UTC is a key measure for identifying various types of community forestry management opportunities.

Urban forestry research and applications aid in determining a balance between growth and preservation by identifying and assessing existing forestry opportunities. GIS-based analysis of UTC is a crucial step toward allowing urban planners, foresters, and elected officials to work in the direction of achieving balance between development and conservation.

With the completion of this UTC assessment, LFUCG can now use the data to set goals towards increasing the amount of UTC within Lexington's Urban Service Area. Reaching the maximum potential UTC will be a challenge; however, preserving existing UTC, establishing realistic UTC goals, and harnessing the maximum amount of ecosystem benefits by planting large-growing trees are prudent and responsible endeavors.

Glossary

bare soil land cover: The land cover areas mapped as bare soil typically include vacant lots, construction areas, and baseball fields.

canopy: Branches and foliage which make up a tree's crown.

canopy cover: As seen from above, it is the area of land surface that is covered by tree canopy.

canopy spread: A data field that estimates the width of a tree's canopy in five-foot increments.

existing UTC: The amount of UTC present within the city boundary.

geographic information systems (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a piece of an organization's overall information system framework. GIS links location to information (such as people to addresses, buildings to parcels, or streets within a network) and layers that information to give you a better understanding of how it all interrelates.

greenspace: A land use planning and conservation term used to describe protected areas of undeveloped landscapes.

impervious land cover: The area that does not allow rainfall to infiltrate the soil and typically includes buildings, parking lots, and roads.

i-Tree Canopy: The i-Tree Canopy tool allows users to easily photo-interpret Google aerial images of their area to produce statistical estimates of tree and other cover types along with calculations of the uncertainty of their estimates. A simple, quick, and inexpensive means for cities and forest managers to accurately estimate their tree and other cover types.

i-Tree Tools: State-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide.

i-Tree Vue: The i-Tree Vue tool makes use of freely available National Land Cover Data (NLCD) maps to assess land cover, including tree canopy, and some of the ecosystem services, carbon storage and sequestration, and air quality, provided by the current urban forest. The effects of planting scenarios on future benefits can also be modeled using Vue.

land cover: Physical features on the earth mapped from satellite or aerial imagery such as bare soils, canopy, impervious, pervious, or water.

nitrogen dioxide (NO_2): Nitrogen dioxide is a compound typically created during the combustion processes and is a major contributor to smog formation and acid deposition.

open water land cover: The land cover areas mapped as water typically include lakes, oceans, rivers, and streams.

ozone (O_3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms. It is a product of the photochemical process involving the Sun's energy. Ozone exists in the upper layer of the atmosphere as well as at the Earth's surface. Ozone at the Earth's surface can cause numerous adverse human health effects. It is a major component of smog.

particulate matter (PM_{10}): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

pervious land cover: The vegetative area that allows rainfall to infiltrate the soil and typically includes parks, golf courses, and residential areas.

possible UTC: The amount of land that is theoretically available for the establishment of tree canopy within the city boundary.

riparian: Of or relating to or located on the banks of a river or stream.

right-of-way (ROW): A strip of land generally owned by a public entity over which facilities, such as highways, railroads, or power lines, are built.

street tree: A street tree is defined as a tree within the right-of-way.

species: Fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.

sulfur dioxide (SO_2): A strong-smelling, colorless gas that is formed by the combustion of fossil fuels. Sulfur oxides contribute to the problem of acid rain.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. Characteristically, it has one main stem, although many species may grow as multi-stemmed forms.

tree benefit: An economic, environmental, or social improvement that benefited the community and resulted mainly from the presence of a tree. The benefit received has real or intrinsic value associated with it.

urban forest: All of the trees within a municipality or a community. This can include the trees along streets or rights-of-way, parks and greenspaces, and forests.

urban tree canopy (UTC) assessment: A study performed of land cover classes to gain an understanding of the tree canopy coverage, particularly as it relates to the amount of tree canopy that currently exists and the amount of tree canopy that could exist. Typically performed using aerial photographs, GIS data, or Lidar.