URBAN TREE CANOPY

ASSESSMENT

LEXINGTON, KENTUCKY

AUGUST | 2022

FAYETTE URBAN COUNTY GOVERNMENT LEXINGTON KENTUCKY 1775

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AN ASSESSMENT OF URBAN TREE CANOPY IN LEXINGTON, KENTUCKY

> **To be without trees would, in the most literal way, to be without our roots.**
>
> **-Richard Mabey**

PREPARED BY

PlanIT Geo, Inc., Arvada, Colorado

PREPARED FOR

Lexington-Fayette Urban County Government

COMPLETED

August 2022

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12,649
ACRES OF CANOPY

23%
OF LEXINGTON WAS COVERED BY TREE CANOPY IN 2020

EXECUTIVE SUMMARY

PURPOSE OF THIS ANALYSIS

The city of Lexington is the second largest city in the state of Kentucky. Located within Fayette County, Lexington is approximately 86 square miles, or 55,040 acres, in size. The urban forest in Lexington is a valuable asset providing residents and visitors with many environmental, social, and economic benefits. This assessment mapped urban tree canopy (UTC), possible planting area (PPA), and tree canopy changes from 2012 to 2020 and analyzed how they are distributed throughout Lexington's Urban Service Area and its property ownership type, zoning type, city council districts, watersheds, and census tracts.

PROJECT METHODOLOGY

The results, based on 2020 and 2012 imagery from the USDA's National Agriculture Imagery Program (NAIP), provide a current and historical look at land cover in Lexington and will allow the City to revise and develop existing and new strategies to protect and expand the urban forest. This study used modern machine learning techniques to create land cover data that are more reproducible and will allow for a more even comparison the next time tree canopy and land cover are assessed.

LEXINGTON'S URBAN FOREST

In 2020, Lexington had 23% urban tree canopy cover and 33% possible planting area, not including any surface water bodies within the City. The City's total land cover contained 23% tree canopy, 33% non-canopy vegetation; 3% soil/dry vegetation; 40% impervious surfaces, and 1% water. The 12,649 acres of tree canopy in Lexington provide a multitude of economic, environmental, and social benefits, valued at just over $6.5 million annually, as well as $111 million in carbon storage.

Of the nine property ownership types in Lexington, Lexington-Fayette Urban County Government-owned property had the highest canopy coverage at 32%. However, privately owned land contained the most canopy, overall, containing 9,384 acres or 74% of all canopy in the City. Privately owned lands also contained the greatest potential for canopy expansion, offering 12,983 acres (35% PPA by area and 73% of the City's total plantable space).

URBAN TREE CANOPY CHANGE

Results from this assessment found that canopy cover changed from 20% to 23% from 2012 to 2020 (+3% or 1,736 acres) within the Urban Service Area. Canopy on state, Lexington-Fayette Urban County Government (LFUCG), and Lexington-Fayette Urban County Housing Authority lands increased by 5% within each. Federal lands were the only property type that experienced a decrease in canopy cover, with loss of 4%, or 7 acres. Canopy cover increased within all of Lexington's 12 city council districts except for District 1 which lost 8 acres of canopy between 2012 and 2020.

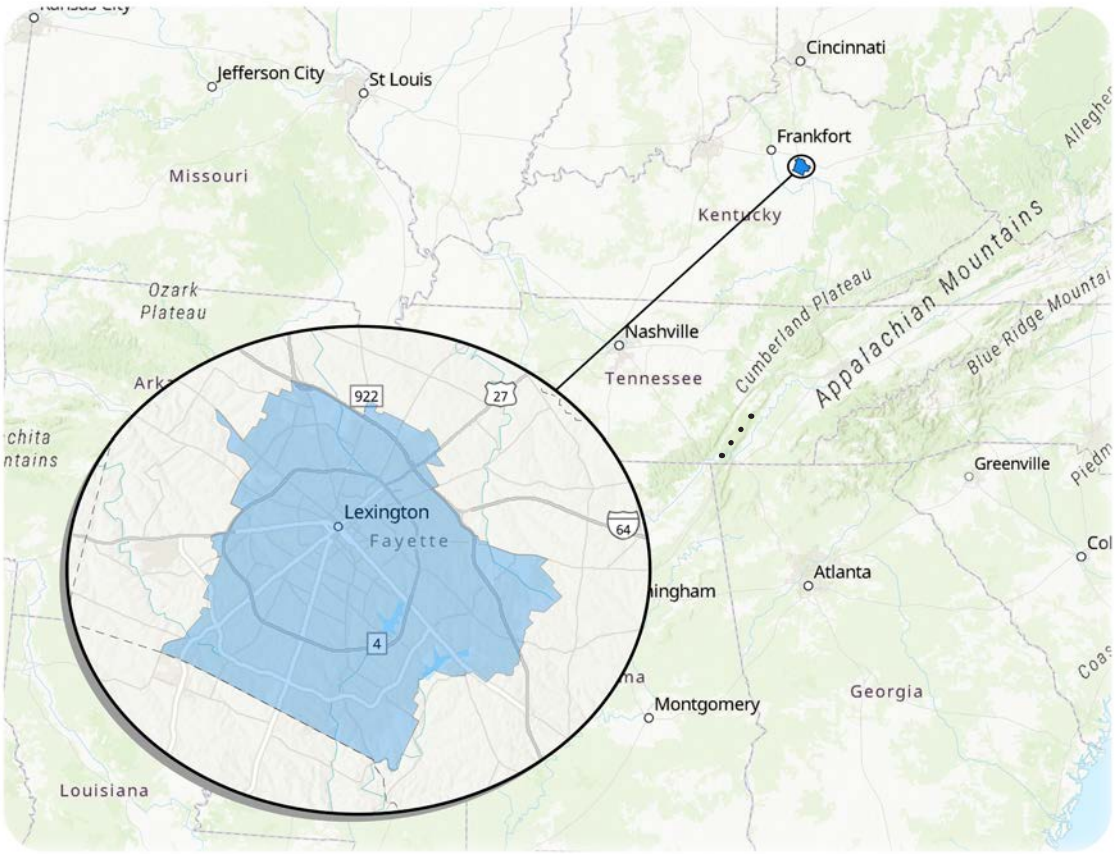


Figure 1. The Lexington Urban Service Area occupies approximately 86 square miles in central Kentucky.

RECOMMENDATIONS

The results of this analysis can be used to develop a continued strategy to protect and expand Lexington's urban forest. This study revealed that Lexington's citywide canopy has grown by over 1,700 acres. With 17,668 acres of possible planting area, LFUCG has the opportunity to continue to increase urban tree canopy coverage on both public and private property. Nearly 75% of the city's PPA falls on privately-owned property. With partnerships, education, and outreach programs to private landowners, the City of Lexington can aim for larger gains in the citywide canopy numbers. It is important for the City to use this assessment to inform future investments in the urban forest so that all those who live, work, and play in Lexington can benefit from the urban forest. The City must proactively work to protect the existing urban forest and replenish the canopy with additional trees. Through management actions, strategic plantings, and protections for existing canopy informed by the UTC, PPA, and change metrics included in this report, Lexington has an opportunity to expand its current urban tree canopy to its fullest potential.

23%
URBAN TREE CANOPY

33%
POSSIBLE PLANTING AREA

40%
IMPERVIOUS SURFACE

Figure 2. Based on an analysis of 2020 high-resolution imagery, Lexington contains 23% tree canopy, 33% areas that could support canopy in the future, and 40% total impervious areas.

PROJECT

METHODOLOGY

Land cover, urban tree canopy, and possible planting areas were mapped using the sources and methods described below. These data sets provide the foundation for the metrics reported at the selected geographic assessment scales.

DATA SOURCES

This assessment utilized high-resolution (60-centimeter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in 2020 to derive the land cover data set. The NAIP imagery was used to classify all types of land cover.

MAPPING LAND COVER

The land cover data set is the most fundamental component of an urban tree canopy assessment. Tree canopy and land cover data from the EarthDefine US Tree Map (https://www.earthdefine.com/treemap/) provided a five class land cover data set. The US Tree Map is produced using a modern machine learning technique to extract tree canopy cover and other land cover types from the latest available 2020 NAIP imagery. These five classes are shown in Figure 3 and described in the Glossary found in the Appendix.

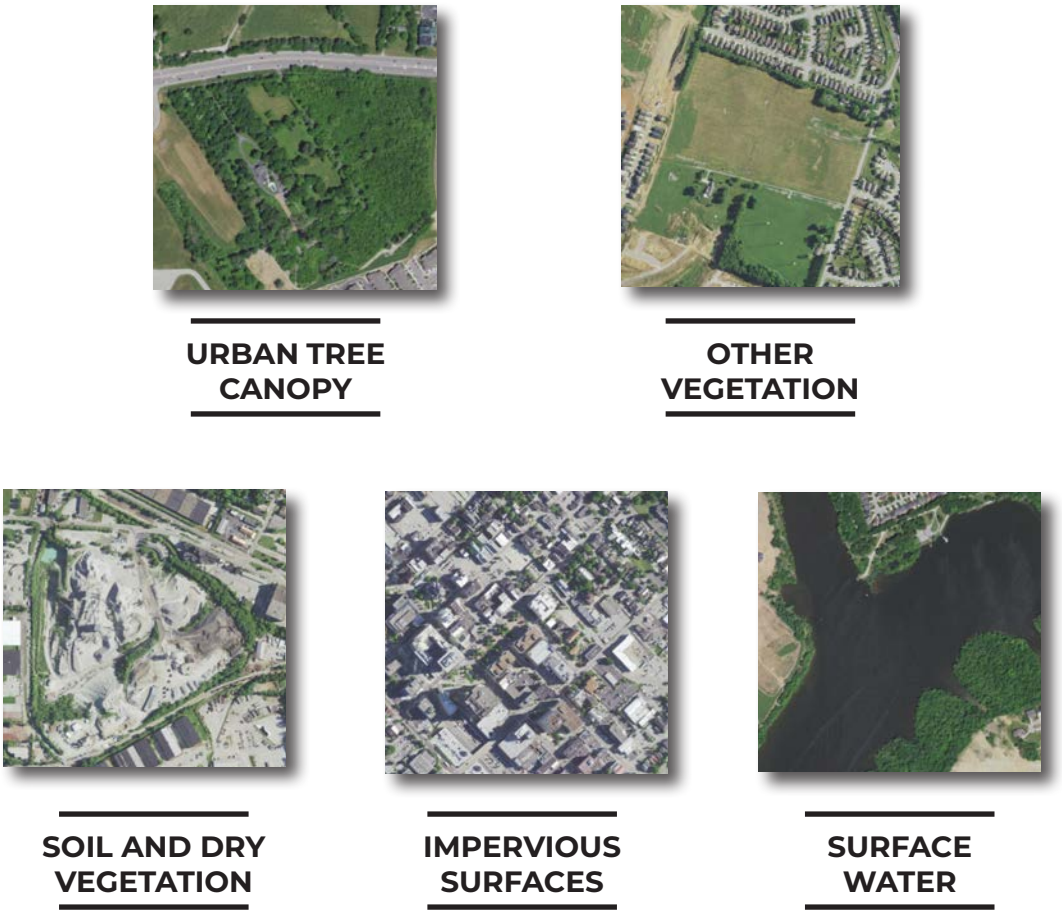


Figure 3. Five (5) distinct land cover classes were identified in the 2020 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Lexington's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in Lexington that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting.

Possible planting areas were derived from the non-canopy vegetation layer. Unsuitable areas, or areas where it was not feasible to plant trees due to biophysical or land use restraints (e.g. golf course playing areas, recreation fields, utility corridors, etc.) were manually delineated and overlaid with the existing land cover data set (Figure 4). The final results were reported as PPA Vegetation, Unsuitable Vegetation, Unsuitable Impervious, Unsuitable Soil, and Water.

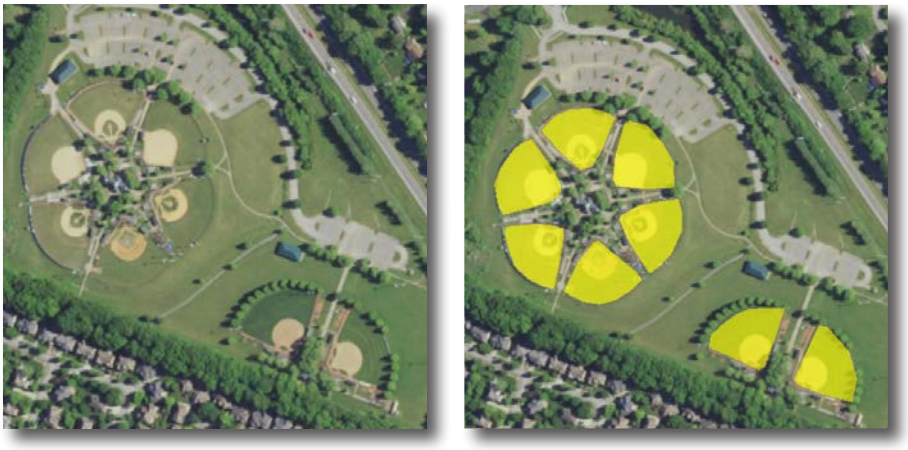


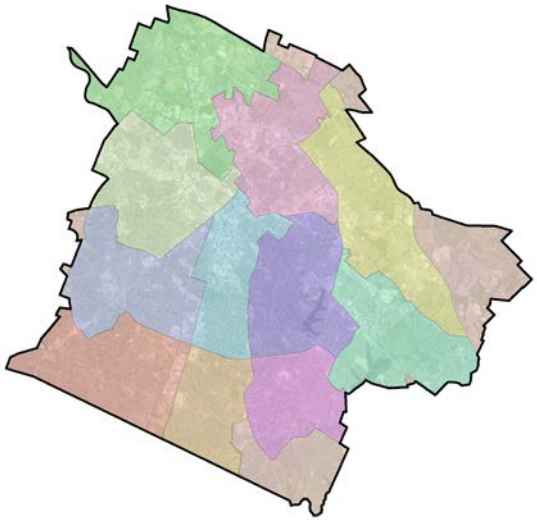
Figure 4.
Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.

DEFINING ASSESSMENT LEVELS

In order to best inform the City of Lexington's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries. These boundaries include the city boundary, city council districts, HUC-12 watersheds, census tracts, property ownership, and zoning.

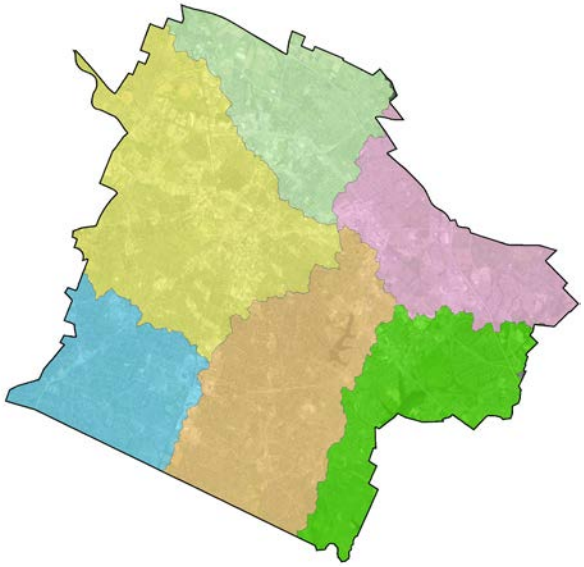
URBAN SERVICE AREA

The Lexington **urban service area** is the one (1) main area of interest over which all metrics are summarized.



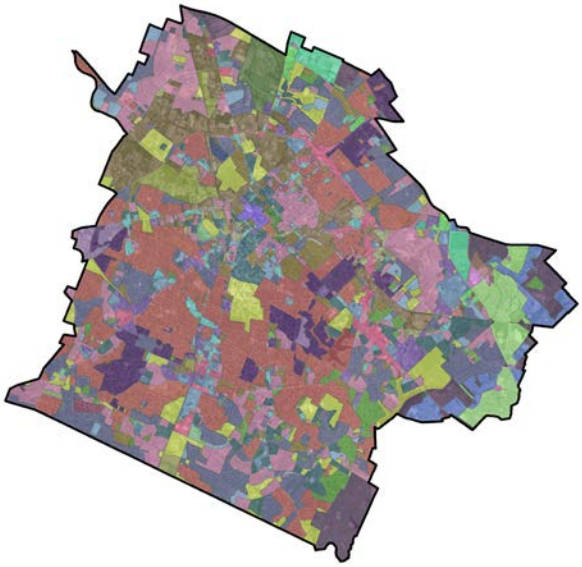
CITY COUNCIL DISTRICTS

Twelve (12) **city council districts** were assessed to inform the council members and citizens residing in each individual voting district.



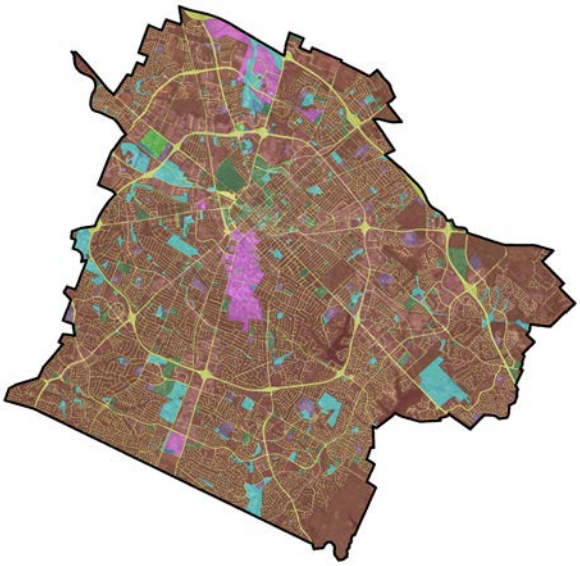
HUC-12 Watersheds

Since trees play an important role in stormwater management, six (6) USGS HUC-12 watersheds were assessed.



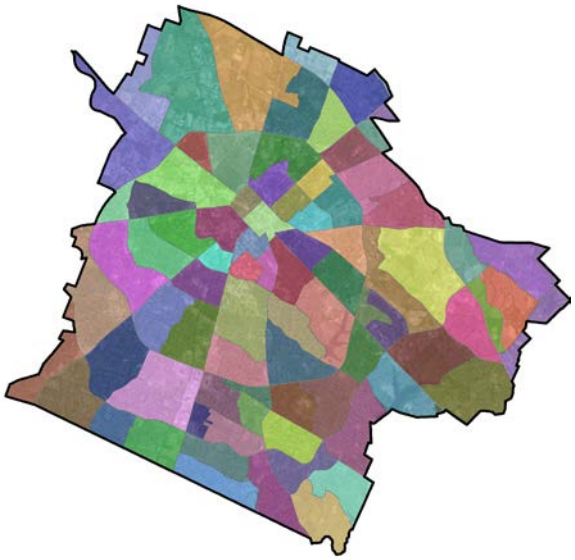
Zoning

Thirty-six (36) **zoning types** were assessed to further dissect urban tree canopy on different types of land use.



Property Ownership

Property ownership summarizes parcels by ownership type, including public schools, local government-owned parcels, University of Kentucky, Lexington-Fayette Urban County Housing Authority, and privately owned lands.



Census Tracts

Eighty-one (81) **census tracts** were assessed to show the relationship between tree canopy and socio-demographics and highlight potential environmental justice issues.

Figure 5. Six (6) distinct geographic boundaries were explored in this analysis: the urban service area, city council districts, watersheds, zoning, property ownership, and census tracts.

STATE OF THE CANOPY AND KEY FINDINGS

The results and key findings of this study, including the land cover map and canopy change analysis results, are presented below. These results can be used to design a strategic approach to identifying existing canopy and future planting areas. Land cover percentages are based on the total area of interest while urban tree canopy, possible planting area, and unsuitable percentages are based on land area. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification.

In 2020, tree canopy constituted 23% of Lexington's land cover; other vegetation was 33%; soil/dry vegetation was 3%; impervious was 40%; and water was 1%. These land cover results are presented below in Table 1 and Figure 6.

Table 1. Land cover classes in acres and percent in Lexington's Urban Service Area.

Lexington, KY	Acres	% of Total
Urban Service Area	54,648	100%
Tree Canopy	12,649	23%
Non-Canopy Vegetation	18,258	33%
Impervious Surfaces	12,775	40%
Soil & Dry Vegetation	1,373	3%
Water	593	1%

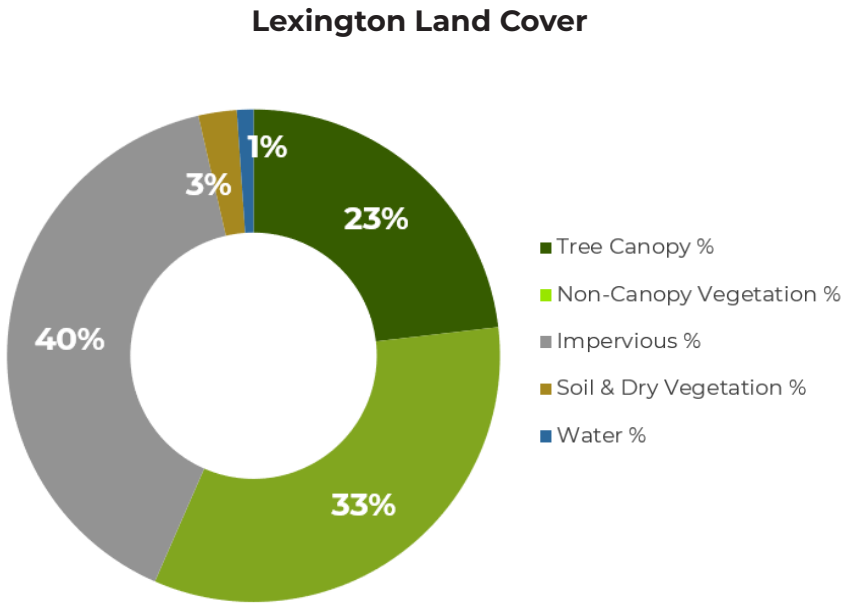


Figure 6. Land cover classification results (percentages based on total area of the Urban Service Area).

Figure 7. Distribution of land cover throughout the Urban Service Area.

CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover data as a foundation to determine possible planting areas (PPA) throughout Lexington's Urban Service Area (USA). Note that the results of this study are based on land area, which excludes water bodies, as opposed to total area. Results of this study indicate that within the USA, 12,649 acres are covered with urban tree canopy, making up 23% of the city's 54,055 land acres; 17,668 acres are covered with other vegetation where it would be possible to plant trees, making up 33% of the city; and the other 23,738 acres were considered unsuitable for tree planting, making up 44% of the city. The unsuitable areas include recreational sports fields, race tracks, golf course playing areas, utility corridors, areas of bare soil and dry vegetation, and impervious surfaces.

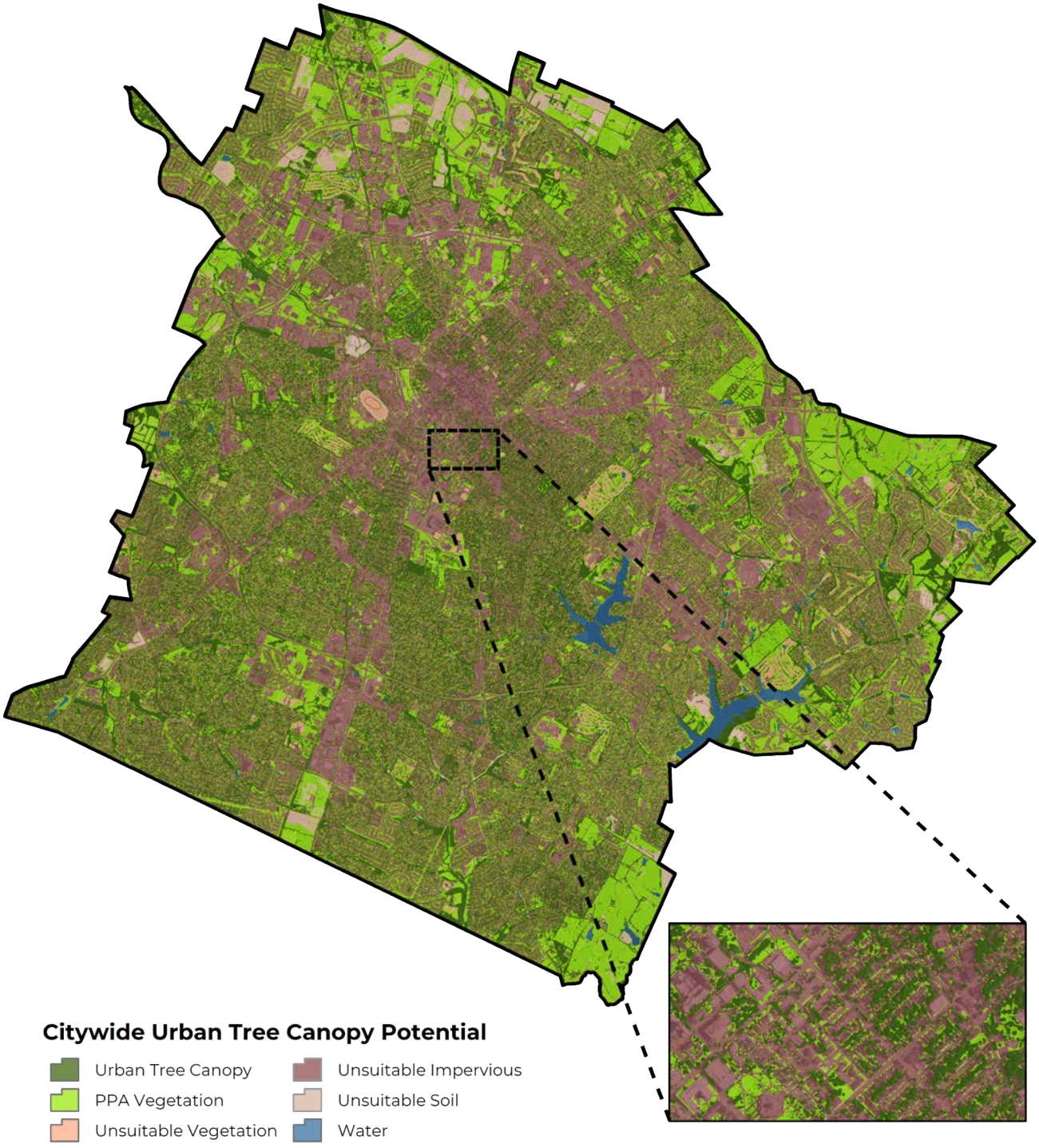


Figure 8. Distribution of existing and potential urban tree canopy throughout the Urban Service Area.

The city's 12,649 acres of urban tree canopy were further divided into subcategories based on whether the canopy was overhanging pervious or impervious surfaces. Tree canopy overhanging an impervious surface can provide many benefits through ecosystem services such as localized cooling provided by shading and increased stormwater absorption. Results indicated that Lexington's UTC was predominantly overhanging pervious surfaces at 88%, while 12% was overhanging impervious surfaces.

Table 2. Urban tree canopy assessment results by acres and percent (percentages based on land acres).

Lexington Urban Service Area	Acres	%
Total Area	54,648	100%
Land Area	54,055	99%
Urban Tree Canopy	12,649	23%
Total Possible Planting Area	17,668	33%
Total Unsuitable Area	23,738	44%

CITYWIDE URBAN TREE CANOPY CHANGE

Over the eight-year study period, there was an increase in Lexington's urban tree canopy. Tree canopy increased by 1,736 acres citywide, yielding a 3% raw increase since 2012 (16% relative to 2012 acreage). This increase in canopy can be attributed to crown growth of maturing trees and growth of newly planted trees since 2012. Current levels of urban tree canopy in Lexington can continue to be improved with careful planning and planting efforts. See Table 4 for more details.

Table 3. Detailed urban tree canopy classifications.

Lexington Urban Service Area	Acres	%
Overhanging Pervious Surfaces	11,127	88%
Overhanging Impervious Surfaces	1,522	12%
Totals	**12,649**	**100%**

Lexington Urban Tree Canopy Potential

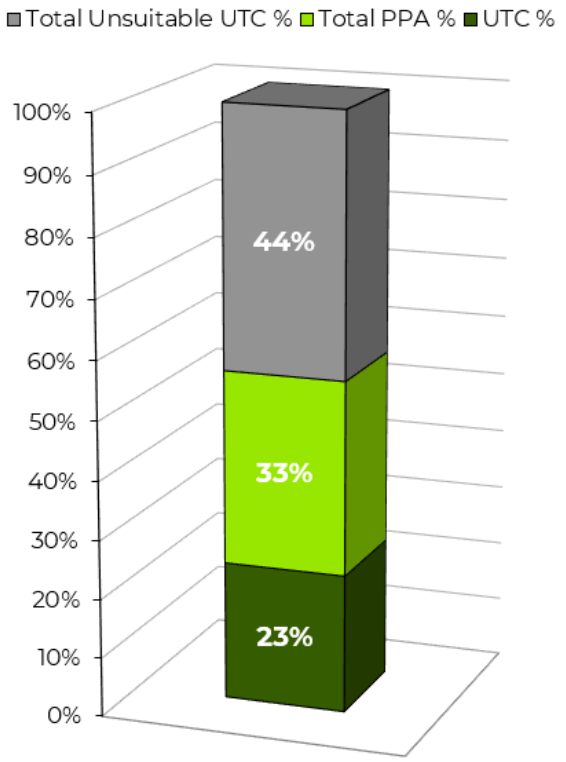


Figure 9. Urban tree canopy, possible planting area, and area unsuitable for UTC in the Lexington Urban Service Area.

Table 4. Urban tree canopy change in the Lexington Urban Service Area.

Lexington Urban Service Area	*Total Area*	*Land Area*	*2012*		*2020*		*UTC Change*	
	Acres	*Acres*	Acres	%	Acres	%	Acres	%
Urban Tree Canopy	54,648	54,055	10,914	20%	12,649	23%	1,736	3%

URBAN TREE CANOPY BY PROPERTY OWNERSHIP

UTC and PPA were assessed across Lexington's property ownership types. Privately-owned land made up 69% of the USA and contributed the greatest amounts of UTC (74%) and PPA (73%) towards the citywide totals. The average UTC % within this ownership type was 25%, higher than the citywide average. The highest UTC % was found on lands owned by the Lexington-Fayette Urban County Government (LFUCG) with 32%. These areas contributed 7% to the total citywide UTC. Fayette County Public Schools and University of Kentucky had the lowest percentages of UTC, with 11% and 13%, respectively. Possible planting area was highest in LFUCG-owned land which contained 47% PPA. These areas could make prime targets for city-led planting efforts. The next highest PPA was within Fayette County Public Schools and Federal, which both contained 43% PPA. Over 1,300 acres of PPA also exist within the right-of-way making up 7% of all PPA within the city.

URBAN TREE CANOPY CHANGE BY PROPERTY OWNERSHIP

Dividing the urban tree canopy change results by the defined property ownership categories offered some additional insights as to how Lexington's canopy has changed on private versus public lands. All but one property ownership type experienced tree canopy gains between 2012 and 2020. Federal properties experienced a 4% decrease, or a loss of seven acres, over the eight year study period. A 5% increase in canopy cover occurred in three ownership types: LFUCG, Lexington-Fayette Urban County Housing Authority, and State. Privately-owned areas gained 1,326 acres, translating to a 4% increase.

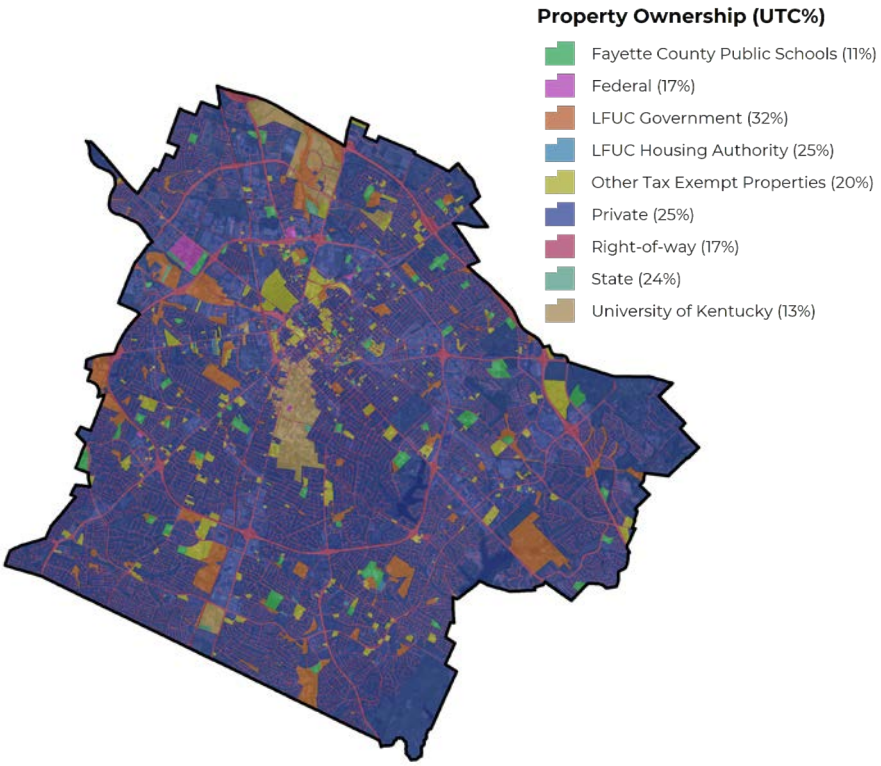


Figure 10. Property ownership and urban tree canopy percentages in Lexington.

Table 5. Urban tree canopy change by property ownership type in Lexington.

Property Ownership Type	*Land Area*		*2012*		*2020*		*UTC Change*	
	Acres	*Dist.*	Acres	%	Acres	%	Acres	%
Fayette County Public Schools	986	2%	100	10%	105	11%	5	1%
Federal	179	0%	38	21%	30	17%	-7	-4%
Lexington-Fayette Urban County Government	2,912	5%	799	27%	931	32%	132	5%
Lexington-Fayette Urban County Housing Authority	101	0%	21	21%	26	25%	5	5%
Other Tax Exempt Properties	2,107	4%	372	18%	427	20%	55	3%
Private	37,070	69%	8,059	22%	9,384	25%	1,326	4%
Right-of-Way	9,021	17%	1,331	15%	1,517	17%	187	2%
State	105	0%	20	19%	25	24%	5	5%
University of Kentucky	1,575	3%	174	11%	203	13%	29	2%

URBAN TREE CANOPY BY CITY COUNCIL DISTRICTS

Urban tree canopy metrics were also assessed for Lexington's 12 city council districts. In 2020, District 5 had the highest percentage of urban tree canopy with 30% of the district's area, or 1,290 acres. District 5's UTC accounted for 10% of Lexington's total tree canopy. District 12 contributed the highest percentage of citywide canopy, with 1,400 acres, but it is also the largest district comprised of several areas on the outskirts of the USA. District 12 also contained 52% PPA, the highest of any district, and contributed 18% of total PPA for the USA. District 2 had the lowest UTC % with 18%. However, it did contain the second highest PPA with 2,221 acres, or 38%.

URBAN TREE CANOPY CHANGE BY CITY COUNCIL DISTRICTS

Nearly all city council districts (11 out of 12) experienced tree canopy gain between 2012 and 2020. The greatest tree canopy gain occurred in District 10, where 336 acres were added for a 7% increase. District 4 also experienced a 7% increase, and gained 198 acres of tree canopy. The only tree canopy loss occurred in District 1. This area lost eight acres, for a percent decrease of 0.2%.

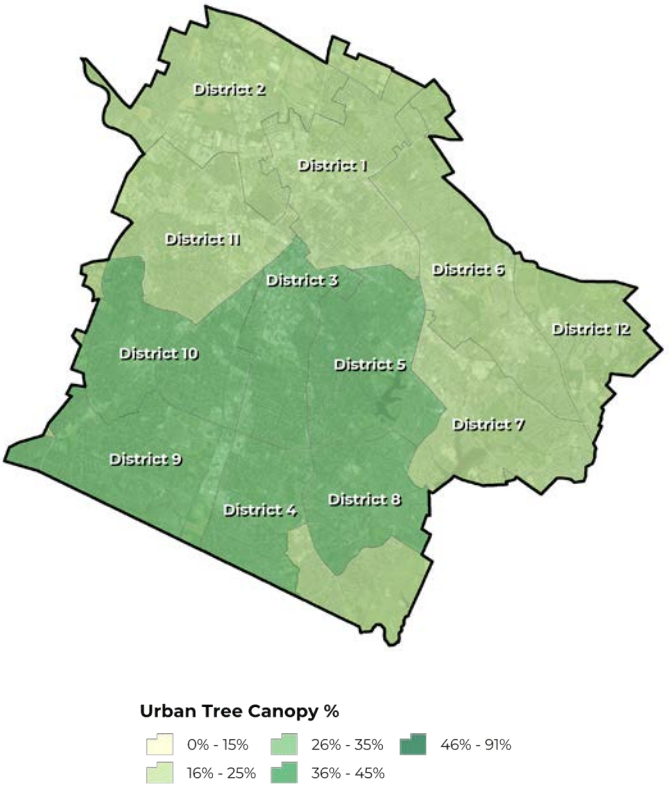


Figure 11. City council districts and urban tree canopy percentages in Lexington.

Table 6. Urban tree canopy, possible planting area, and tree canopy change by Lexington's 12 city council districts.

City Council Districts	*Land Area*		*Urban Tree Canopy*			*Possible Planting Area*			*UTC Change*	
	Acres	*Dist.*	Acres	%	Dist.	Acres	%	Dist.	%	Acres
1	4,806	9%	912	19%	7%	1,412	29%	8%	0%	-8
2	5,897	11%	1,037	18%	8%	2,221	38%	13%	2%	111
3	3,259	6%	859	26%	7%	685	21%	4%	3%	110
4	2,807	5%	790	28%	6%	818	29%	5%	7%	198
5	4,287	8%	1,290	30%	10%	1,061	25%	6%	4%	161
6	5,219	10%	1,019	20%	8%	1,778	34%	10%	1%	46
7	4,173	8%	801	19%	6%	1,421	34%	8%	1%	57
8	3,050	6%	825	27%	7%	966	32%	5%	3%	106
9	4,740	9%	1,277	27%	10%	1,517	32%	9%	6%	303
10	4,673	9%	1,317	28%	10%	1,219	26%	7%	7%	336
11	4,917	9%	1,118	23%	9%	1,355	28%	8%	3%	157
12	6,219	12%	1,400	23%	11%	3,212	52%	18%	3%	157
Totals	**54,047**	**100%**	**12,646**	**23%**	**100%**	**17,662**	**33%**	**100%**	**3%**	**1,734**

URBAN TREE CANOPY BY ZONING

UTC and PPA were assessed for Lexington's 35 zoning types. Seven summary zoning classes were created by aggregating the more detailed zoning types: Agricultural, Commercial (Downtown), Commercial (Other), Industrial, Mixed Use, Office/Professional, and Residential. Residential areas had the highest distribution of land area and contributed the greatest amounts of both UTC and PPA towards the citywide totals, making up 78% of the city's UTC and 65% of all PPA in Lexington. These areas also had greater than citywide average canopy cover with 28%. Agricultural zones contributed the second highest amounts of citywide UTC and PPA distributions at 11% and 18%. Canopy cover within this zone was the same as the citywide average at 23%. Although agricultural land may be occupied with cropland, trees may still be planted around the borders and along the rights-of-way and driveways leading to farmlands. All other aggregated zoning types had canopy cover that was well below the citywide average. Office/Professional had 14%, Industrial had 13%, Commercial - Other had 8%, Commercial - Downtown had 7%, and Mixed Use had 6%. These areas only make up less than one-quarter of the USA, though, and contain 10% of citywide canopy and 17% of citywide PPA. Industrial areas had the third-largest distribution of land area, relatively low canopy cover at 13%, and a large amount of plantable space with 10% of the citywide PPA. Industrial zones contained 1,726 acres of planting space that could be utilized to mitigate urban heat by providing shade in these primarily impervious areas. Collaborative planting efforts between LFUCG and private industries could yield impactful results.

Table 7. Urban tree canopy and possible planting areas by zoning categories.

Zoning Category	*Urban Tree Canopy*			*Possible Planting Area*		
	Acres	*%*	Dist.	Acres	%	Dist.
Agricultural (A-R, A-U)	1,338	23%	11%	3,105	53%	18%
Commercial - Downtown (B-2, B-2A, B-2B)	19	7%	0%	13	4%	0%
Commercial - Other (B-1, B-3, B-5P, B-6P)	387	9%	2%	595	16%	3%
Industrial (I-1, I-2, B-4, ED)	670	13%	6%	1,726	29%	10%
Mixed Use (MU 1/2/3)	9	6%	0%	40	26%	0%
Office/Professional (P-1, P-2)	305	14%	2%	738	34%	4%
Residential (R-1A/1B/1C/1D/1E, R-1T, R-2/3/4, M-1P, PUD 1/2, EAR 1/2/3, CC, CD)	9,922	28%	78%	11,451	32%	65%

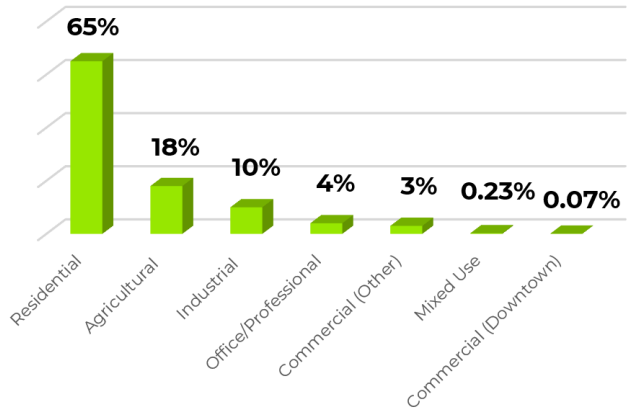


Figure 12. Distribution of PPA across Lexington's zoning type categories.

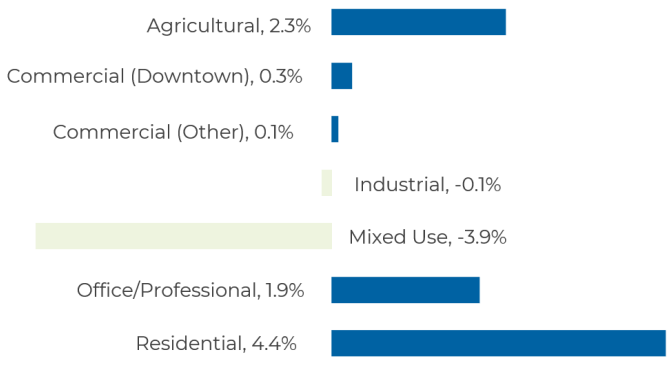


Figure 13. Tree canopy percent change from 2012 -2020 by zoning type category.

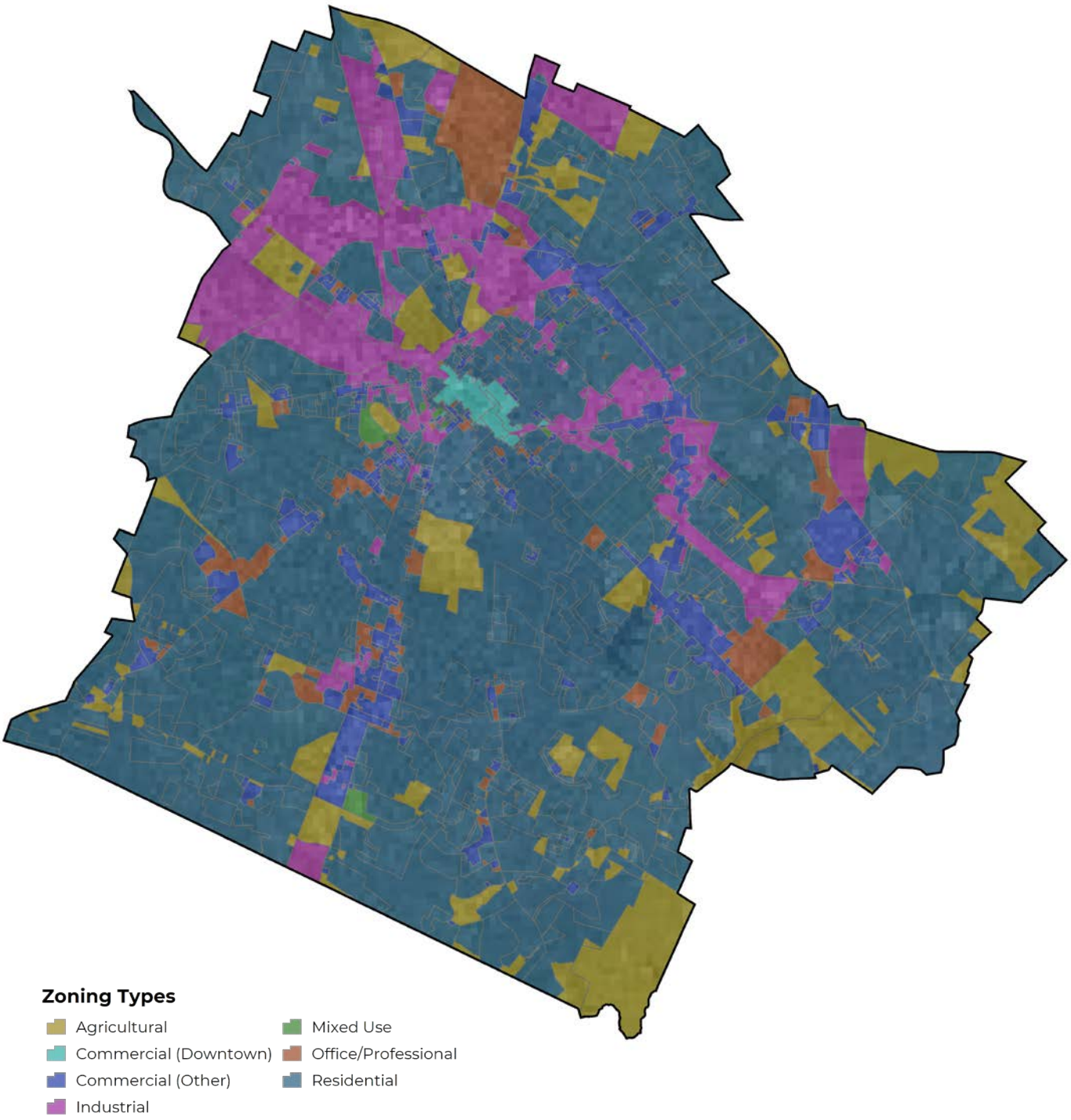


Figure 14. Urban tree canopy by Lexington's zoning types.

URBAN TREE CANOPY CHANGE BY ZONING

Dividing the urban tree canopy change results by the City's zoning categories offered some additional insights as to how Lexington's canopy has changed over time. While individual canopy losses and gains occurred in all zoning classes, the overall canopy losses occurred in two zoning types: Industrial and Mixed Use. Industrial areas had the greatest reduction in canopy (-8 acres), and Mixed Use experienced the largest percent reduction in the canopy (-4% or -6 acres). Commercial (Downtown) and Commercial (Other) sustained a less than 1% gain. Agricultural and Office/Professional both increased their canopy by 2% in eight years. Canopy in Residential areas experienced the largest increase with a 4% gain (1,570 acres).

URBAN TREE CANOPY BY HUC-12 WATERSHEDS

Due to their benefits for regulating runoff, reducing flooding, and maintaining a healthy water cycle, urban tree canopy metrics were also assessed by watersheds. Trees planted within these areas can help to intercept and absorb stormwater runoff that may otherwise carry unhealthy pollutants into surface water bodies. Six watersheds extend along Lexington's urban service area. Both Shannon Run-South Elkhorn Creek and West Hickman Creek had the highest tree canopy per land area with 28% UTC. Headwaters North Elkhorn Creek had the lowest tree canopy percent with 18% UTC, but this watershed also contained the greatest proportion of PPA with 41%. Upper East Hickman Creek also had 41% PPA. Town Branch, which includes Wolf Run, had the highest PPA acreage and distribution across all of Lexington's watersheds. It contained 3,941 acres of PPA, translating to 22% of the entire urban service area's PPA.

URBAN TREE CANOPY CHANGE BY HUC-12 WATERSHEDS

Five of the six watersheds experienced increases to tree canopy acreage. Shannon Run-South Elkhorn Creek had the largest percent increase of tree canopy, sustaining a 7% gain. The second highest gain occurred in West Hickman Creek, where tree canopy increased by 5%. Cane Run was the only watershed that decreased in tree canopy over the study period, losing 20 acres, or <1%.

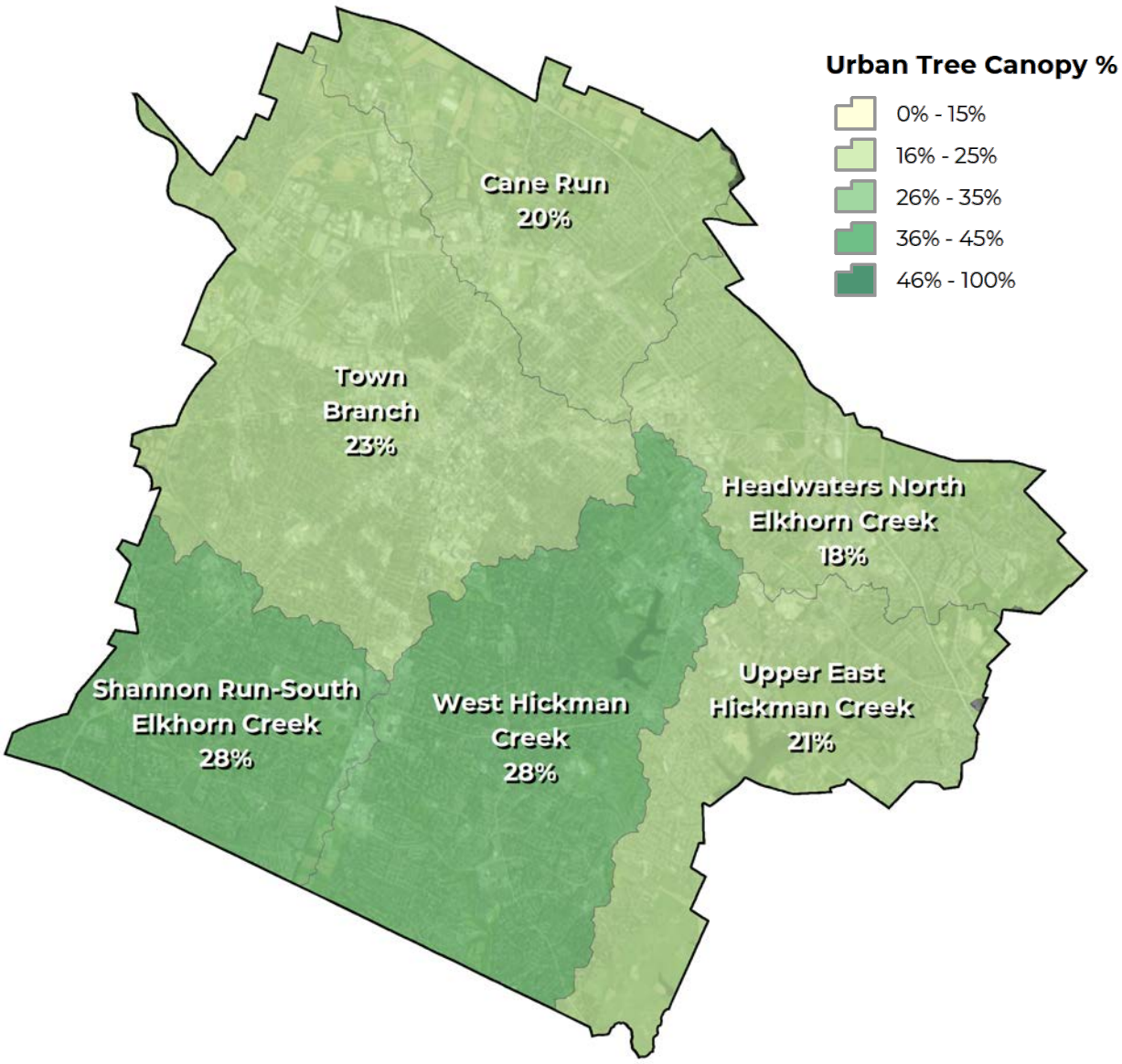


Figure 15. Urban tree canopy by Lexington's HUC-12 watersheds.

URBAN TREE CANOPY BY CENSUS TRACTS

UTC and PPA were assessed at the census tract level. Census tracts contain clusters of census blocks and block group boundaries. This is the largest geographic unit of measure at which the U.S. Census publishes statistical data within a state and represents between 1,200 and 8,000 people, with an optimum size of 4,000 people. Census tracts are particularly valuable for assessing the equitable distribution of tree canopy throughout the city, as the tracts are linked to all demographic and socio-economic data. Results indicated that 27 of Lexington's 80 census tracts contained less than 20% canopy cover, nearly half (37) contained between 20 and 30%, and the other 16 contained greater than 30%. Only one census tract exceeded 40% tree canopy. Most census tracts had between 20-40% PPA. Eleven census tracts exceeded 40% PPA. All of these tracts are located along the edges of the USA and contain large parks or pastures that could support additional trees now or in the future with potential zoning changes.

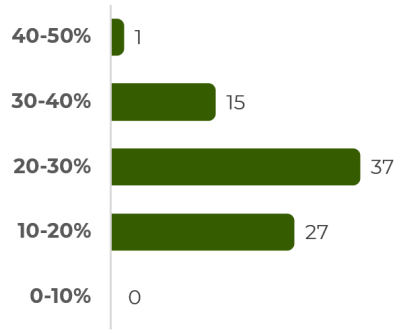


Figure 16. Number of census tracts with percent canopy cover ranges.

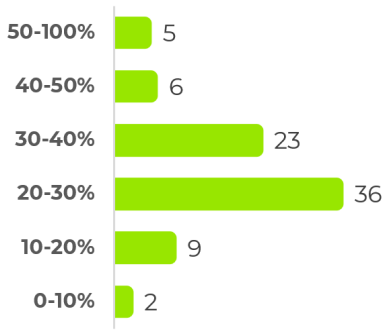


Figure 17. Number of census tracts with percent possible planting area ranges.

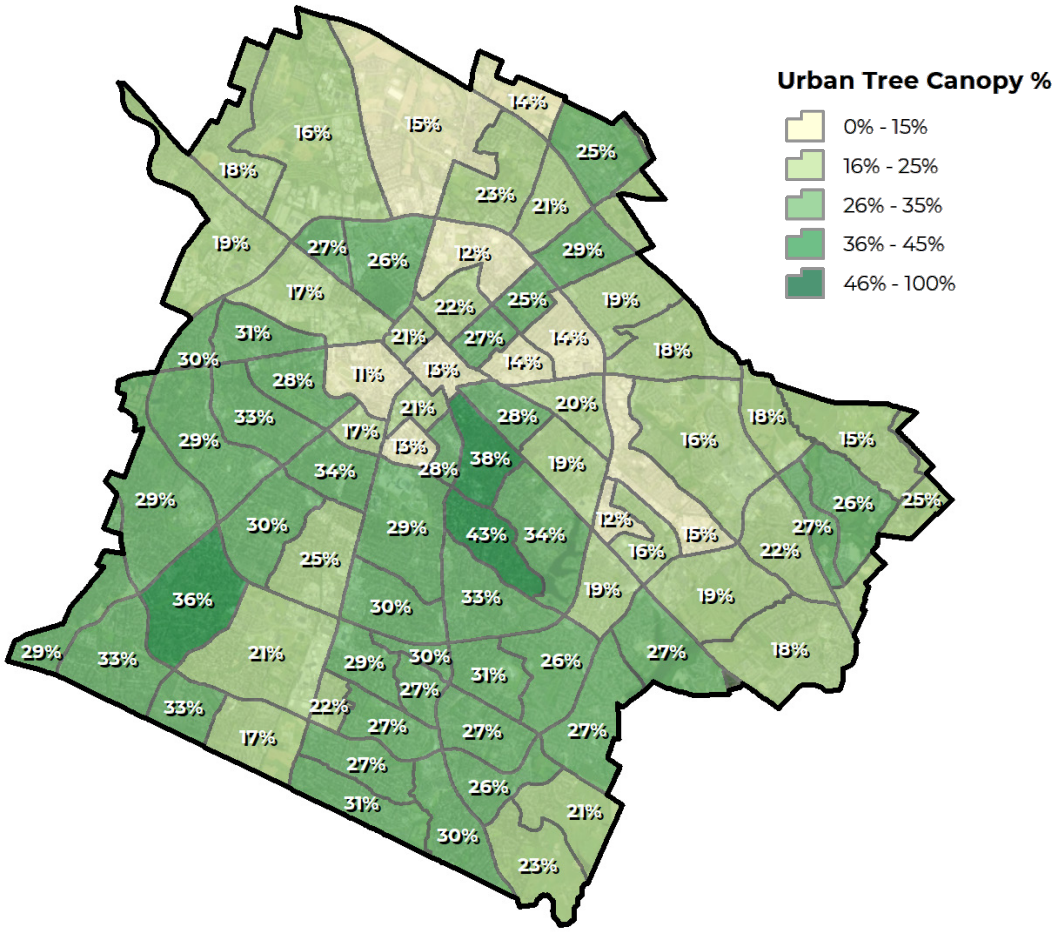


Figure 18. Urban tree canopy by Lexington's census tracts.

URBAN TREE CANOPY CHANGE BY CENSUS TRACTS

Of Lexington's 80 census tracts, three experienced a UTC gain of 10% or more. Two tracts experienced the greatest loss of tree canopy with 4% decreases over the study period. Losses in canopy were generally concentrated northeast of Lexington's downtown area. The greatest gain in canopy cover occurred in census tracts bordering the urban service area's western and southern boundaries.

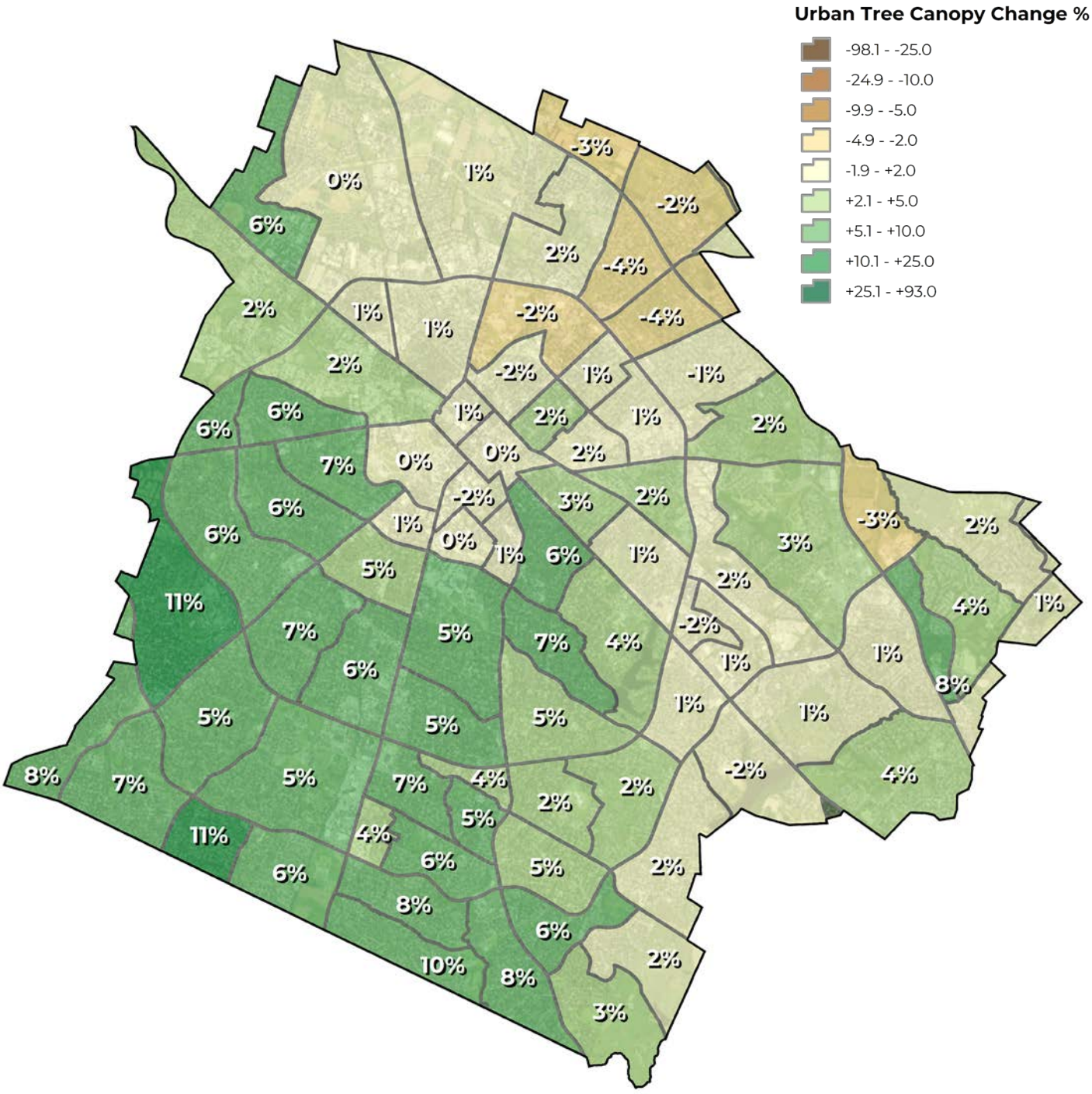


Figure 19. Urban tree canopy change by Lexington's census tracts.

ASSESSMENT OF

ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by the urban tree canopy in Lexington. The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction, and stored carbon. The following values were calculated using the USDA Forest Service's i-Tree Landscape tool with Lexington's total acres of urban tree canopy as the input data.

AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperature, and improve public health by reducing air pollutants which cause death and illness. The existing tree canopy in Lexington removes approximately 775,000 pounds of air pollution annually, valued at over $2.5 million.

STORMWATER AND WATER QUALITY

Trees and forests mitigate stormwater runoff which minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian land, and absorbs pollutants, thus improving water quality and habitats. The tree canopy in Lexington absorbs 170 million gallons of water per year. Extrapolated citywide, this means that Lexington's existing canopy provides over $1,520,000 annually in stormwater benefits.

CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a forest, the rate and amount increase with age. Lexington's trees store approximately 1.3 billion pounds of carbon, valued at over $111 million, and each year the tree canopy absorbs and sequesters approximately 28 million pounds of carbon dioxide, valued at over $2.4 million.

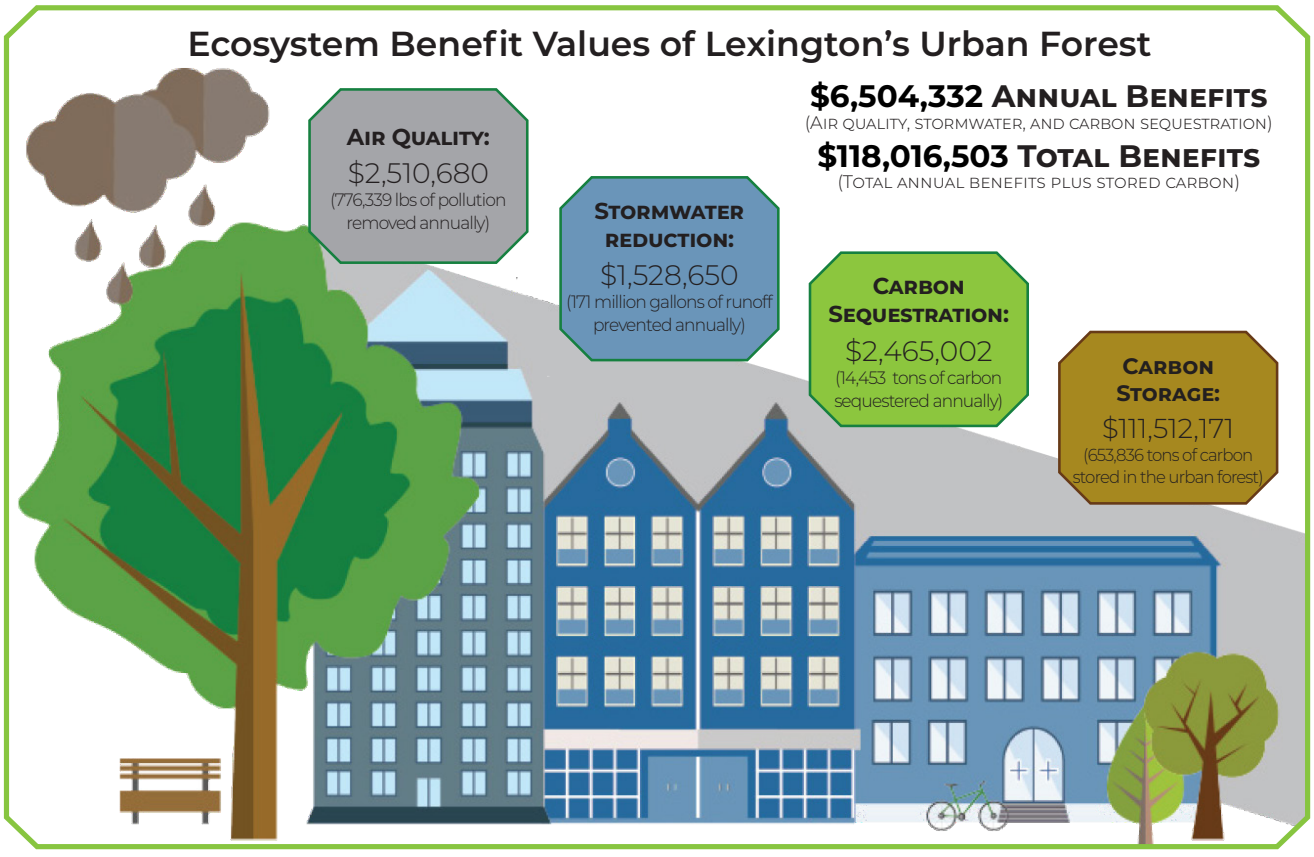


Figure 20. Eco-benefits of Lexington's urban forest.

BENEFITS BY GEOGRAPHIES

In addition to assessing the value of ecosystem services provided by Lexington's generalized complete urban forest, values were also calculated for individual features of several geographies.

Table 8. Total annual and carbon storage value of ecosystem benefits in HUC-12 watersheds within Lexington's urban service area.

HUC-12 Watersheds	Total Annual Value $	Carbon Storage Value $
Cane Run	743,530	12,747,295
Headwaters North Elkhorn Creek	637,295	10,925,966
Shannon Run-South Elkhorn Creek	927,345	15,898,683
Town Branch	1,765,249	30,263,952
Upper East Hickman Creek	776,256	13,308,358
West Hickman Creek	1,646,863	28,234,304
Totals	**6,496,538**	**111,378,558**

Note: Watershed boundaries do not cover the entirety of the USA boundary, and therefore, watershed monetary values are less than the citywide totals.

WATERSHEDS

Of the six watersheds, Town Branch had the highest total annual and carbon storage values followed by West Hickman Creek. Headwaters North Elkhorn Creek had the lowest total annual value of $637,295 but still maintained over ten million dollars in carbon storage.

CITY COUNCIL DISTRICTS

Council District 12 had the greatest total value of ecosystem benefits and carbon storage across all of Lexington's city council districts. Council District 12 contributed $719,880 in total annual value and $12,341,836 in carbon storage. Council District 4 had the lowest UTC acres and, therefore, contributed the least amount of benefits with $406,369 in annual value and $6,966,906 in carbon storage.

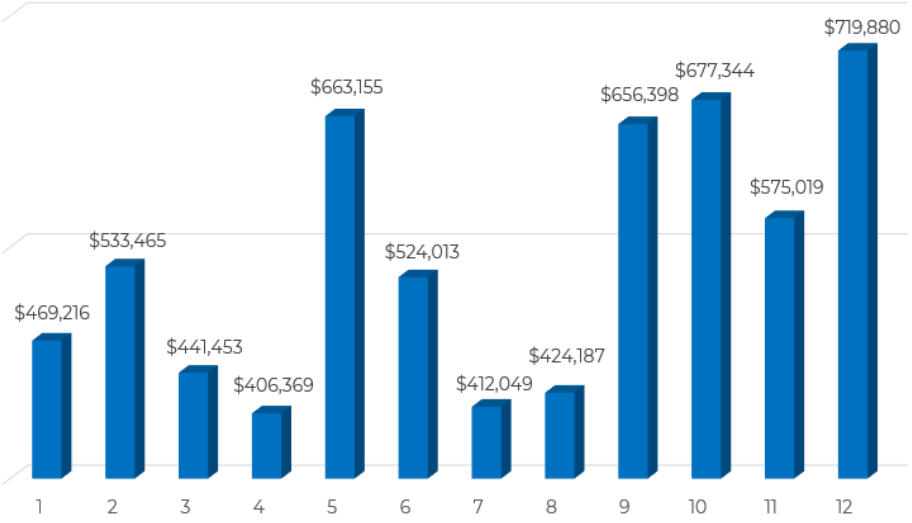
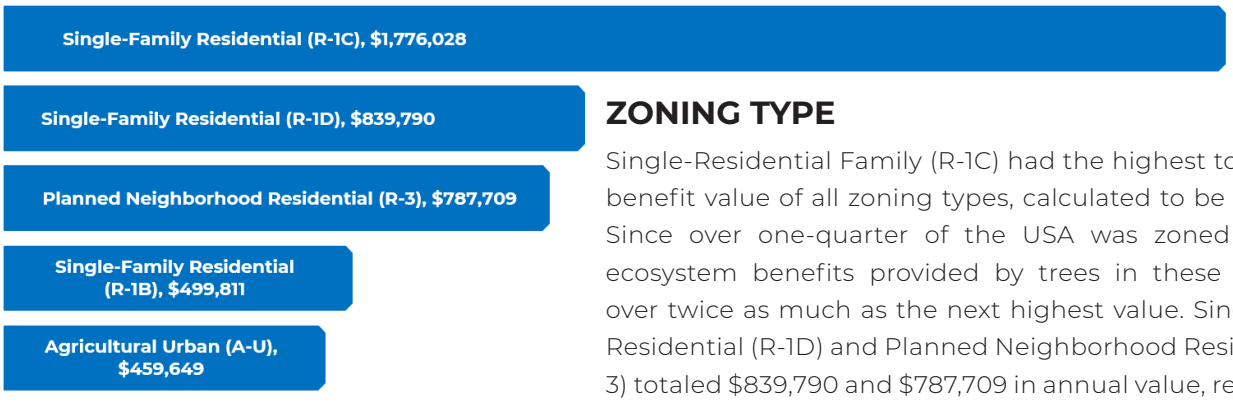


Figure 21. Total annual value of ecosystem benefits for city council districts.



ZONING TYPE

Single-Residential Family (R-1C) had the highest total annual benefit value of all zoning types, calculated to be $1,776,028. Since over one-quarter of the USA was zoned R-1C, the ecosystem benefits provided by trees in these areas was over twice as much as the next highest value. Single-Family Residential (R-1D) and Planned Neighborhood Residential (R-3) totaled $839,790 and $787,709 in annual value, respectively.

Figure 22. Five highest ecosystem benefit total annual values by zoning types.

NATURESCORE

RESULTS

NATURESCORE

The urban forest of Lexington offers much more than greener views and cooling shade. It creates meaningful environmental, economic, and social benefits for the community, valued at $6.5 million/year in addition to the over $112 million in stored carbon. An additional benefit of tree canopy is its impact on the health and well-being of nearby residents. We quantify this relationship by using NatureScore™.

WHAT IS NATURESCORE?

NatureScore, created by NatureQuant, is a measure of nature and human health created through the use of machine learning to identify correlations between environmental data sets and health outcomes. Through these correlations, NatureScore determines what beneficial nature is, where it is present, and where it is lacking. NatureScore is a critical tool for planning, creating, and maintaining a vibrant, healthy, and verdant community rich with beneficial nature. The score incorporates satellite-collected infrared measurements, land classifications, park features, tree canopies, human modifications, air, noise, and light pollutions, and computer vision elements to find the greatest correlations of nature with the predictive health impacts to rank each area with a "NatureScore". A Leaf Score describes whether a given area is lacking in nature or whether nature is abundant relative to other areas of the city.

The map below shows each of Lexington's census block groups and whether they are nature deficient (red), nature utopias (green), or somewhere in between. The blue dots are added to show the percent tree canopy cover with bigger sizes representing higher canopy cover levels. Many areas with lesser access to nature also have low canopy cover.

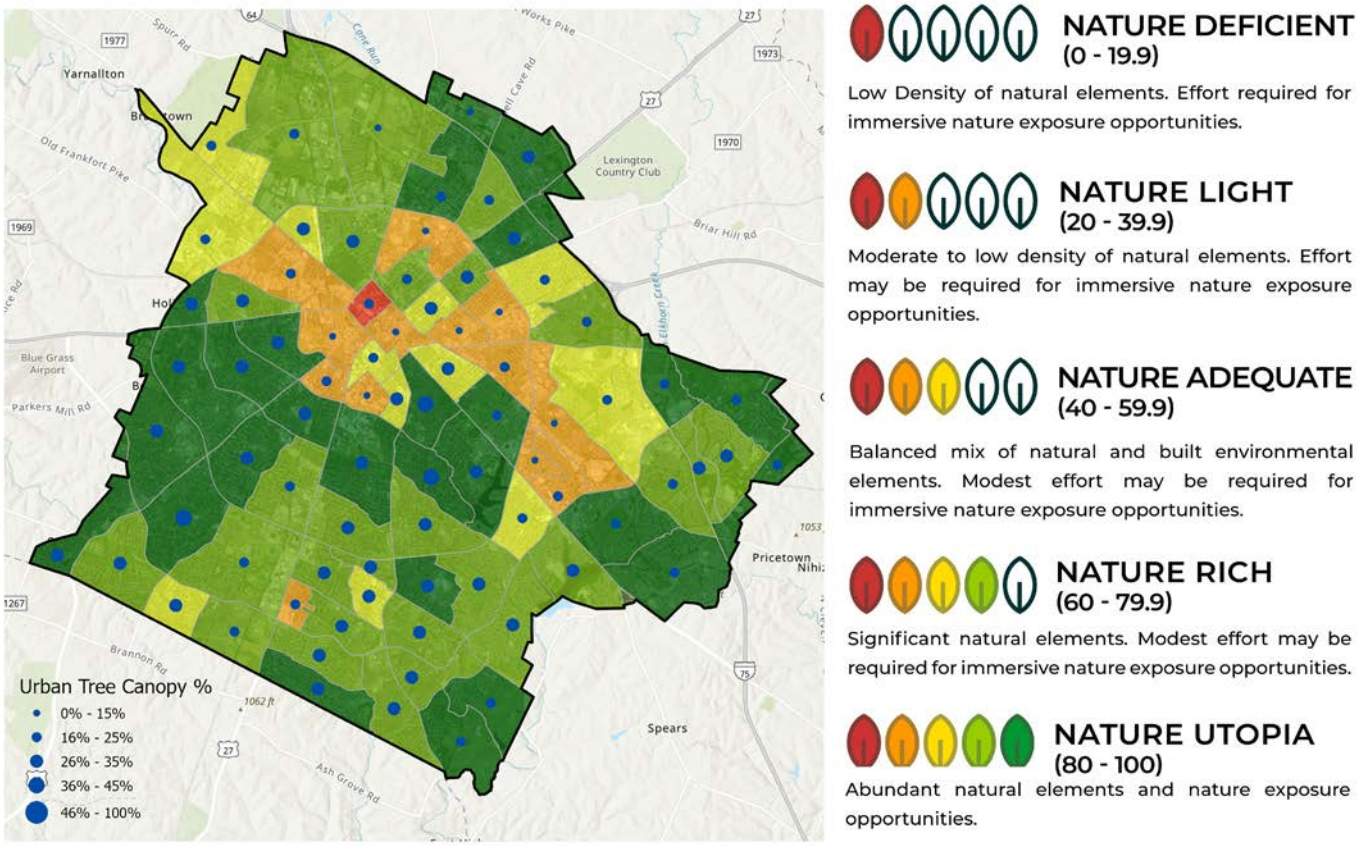


Figure 23. Tree canopy cover and NatureScore by census tracts.

A majority of the areas categorized as nature deficient or nature light are located inside of New Circle Road, specifically in the northern half. Increasing access to nature in these areas can have profound impacts on longevity as well as rates of obesity, diabetes, cardiovascular disease, and cancers among residents. Increasing tree canopy cover is one way to bring more nature to these highly developed areas.

Spending time near any greenspace or bluespace has been shown to correlate with improvements in public health. "Greenspace" is typically defined as undeveloped land with natural vegetation, but it also exists in many other forms, like urban parks, public open spaces, street trees, and landscaped plant-life. "Bluespace" is typically defined as the sea and ocean coasts, rivers, lakes, canals, waterfalls, and even some human-made water features. By targeting nature deficient or nature light areas with tree planting and the addition of other natural elements to the landscape, the City can provide lasting investment in the health of its citizens.

RESULTS

Lexington's Urban Service Area has an overall NatureScore of 63, or a Leaf Score of 4 (Nature Rich). The majority of census tracts are either Nature Utopia or Nature Rich. However, there are areas making up about 11% of the city that are categorized as nature deficient or nature light where nature is lacking. Special attention should be paid to preserving any green spaces located in these areas. Of Lexington's 12 city council districts, the highest nature score was found in District 12, and the lowest was District 1 with a score of 50. District 12 had near the citywide average canopy cover but also contained large greenspaces used for pasture or other agricultural purposes. Some of these areas are zoned for economic development, so the City should focus on preserving nature in these areas as much as possible. District 5 had the highest tree canopy coverage but only the fifth highest NatureScore. District 2 had the lowest canopy cover and a NatureScore of 59, but District 1 had the second lowest canopy cover and the lowest NatureScore by over five points.

Table 9. Urban tree canopy, NatureScore, and Leaf Score rating for Lexington's city council districts.

City Council Districts	*Urban Tree Canopy (acres)*	*NatureScore*	*Leaf Score*
1	912	50	Nature Adequate
2	1,037	59	Nature Adequate
3	859	56	Nature Adequate
4	790	61	Nature Rich
5	1,290	64	Nature Rich
6	1,019	56	Nature Adequate
7	801	58	Nature Adequate
8	825	65	Nature Rich
9	1,277	67	Nature Rich
10	1,317	67	Nature Rich
11	1,118	55	Nature Adequate
12	1,400	80	Nature Utopia

NatureScore serves to augment the results of the tree canopy assessment by providing additional insights into the future health of Lexington's residents. It shows that while canopy is a strong measure of the abundance and quality of green spaces, it is not the only measure to be aware of. The preservation of mature tree canopy, planting of new trees, and inclusion of green and bluespaces into development plans are all critical to maintaining the City's NatureScore and associated health impacts on its residents.

TREE PLANTING

PRIORITIZATION

PRIORITIZATION CRITERIA DESCRIPTIONS

Urban tree canopy provides a multitude of direct and indirect benefits. To provide the most complete understanding of where those benefits are lacking, tree planting priorities were identified based on environmental, socio-demographic, and public health data sets.

Tree planting prioritization ranking is needs-based and designed to rank city council districts and census tracts on each area's need for a particular benefit that trees can provide. Rankings are sorted from highest priority (dark blue) to lowest priority (light yellow) and were calculated for each individual criteria as well as overall to show where multiple needs overlap. Viewing combined ranks show where tree canopy benefits can have the greatest impact by addressing multiple needs.

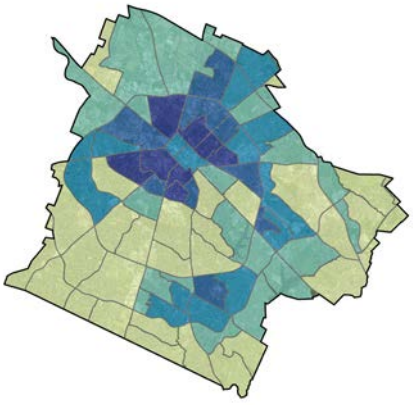
HUMAN HEALTH

- **Asthma:** Trees clean the air that we breathe and, in turn, improve public health. Planting trees can be a cost-effective way of improving a city's overall public health. This indicator shows the percentage of residents 18 years or older with asthma. This criteria prioritizes areas with greater numbers of residents with asthma.

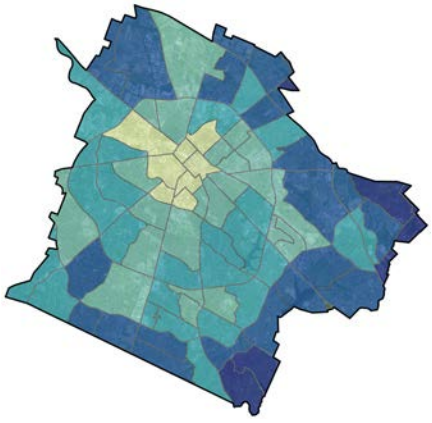
LAND USE

- **Private Yards:** Mature native trees can improve aesthetics, reduce crime, and increase home and property values. This criteria shows the presence of plantable space in private residential areas. Census tracts with more acres of private yards were highlighted as higher priority planting areas.

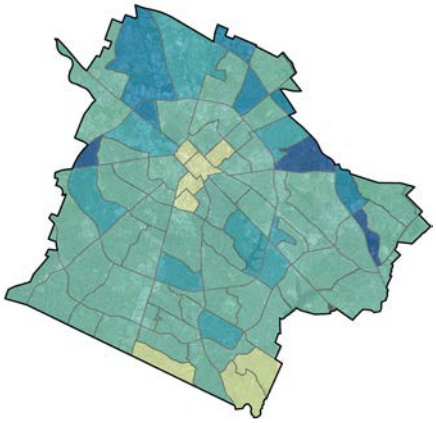
- **Proximity to Streets:** Trees planted along roads provide valuable benefits to improve air quality, reduce stormwater, and calm traffic. This criteria highlights areas with a greater amount of plantable space within the right-of-way as high priority for tree planting.



Asthma by Census Tracts



Private Yards by Census Tracts



Proximity to Streets by Census Tracts

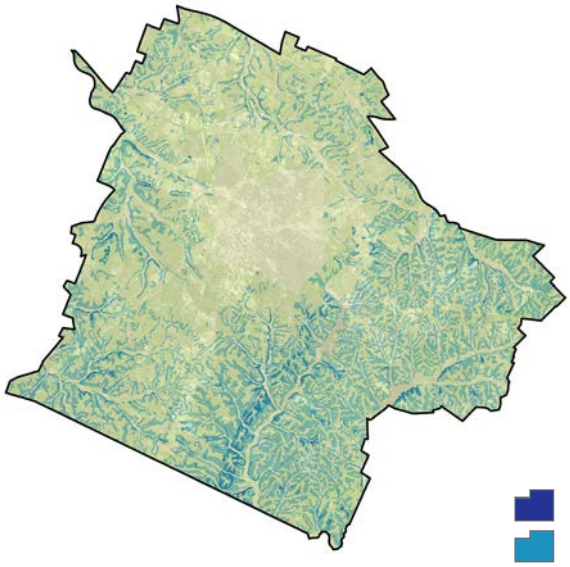
ENVIRONMENTAL

- **Topography:** Tree canopy planted on slopes can reduce erosion impacts. Tree roots stabilize soil and promote infiltration of water and nutrients, reducing the volume and rate of sediment, water, and pollutant loads downstream. This criteria highlights areas of steeper slopes for priority plantings.

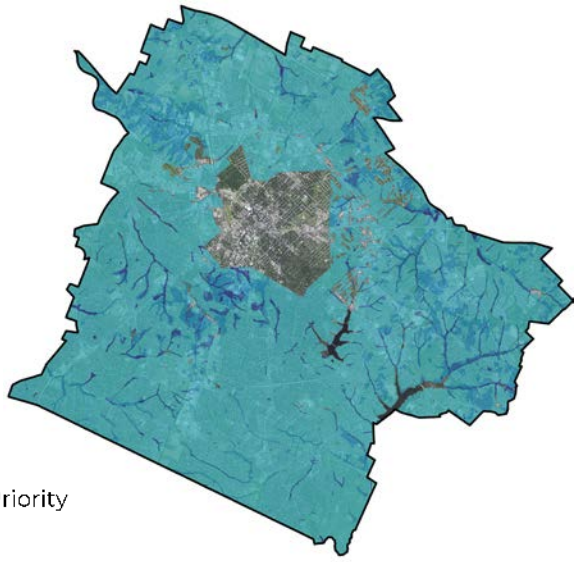
- **Soil Type:** Soil permeability promotes a healthy root system by aiding in moisture retention while allowing sufficient drainage to prevent root rot. Areas of well-drained soil were considered high priority for planting. Heavily developed areas were not classified by the Kentucky Soil Survey and, therefore, no soil data exists for the downtown area. This indicator shows that a majority of the USA is made of up well-drained to moderately-well drained soil.

- **Stormwater Reduction:** This indicator uses available planting area within 100 feet of all surface water bodies and impervious surfaces to identify areas with plantable space that will reduce stormwater runoff. Areas close to water bodies and impervious surfaces were considered high priority planting areas.

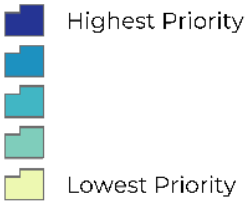
- **Urban Heat Island:** The average relative heat severity value within each feature. Urban heat severity data from the Trust for Public Land derived using the thermal band of a Landsat 8 satellite image were used. Areas with hotter surface temperatures were considered high priority for tree planting.

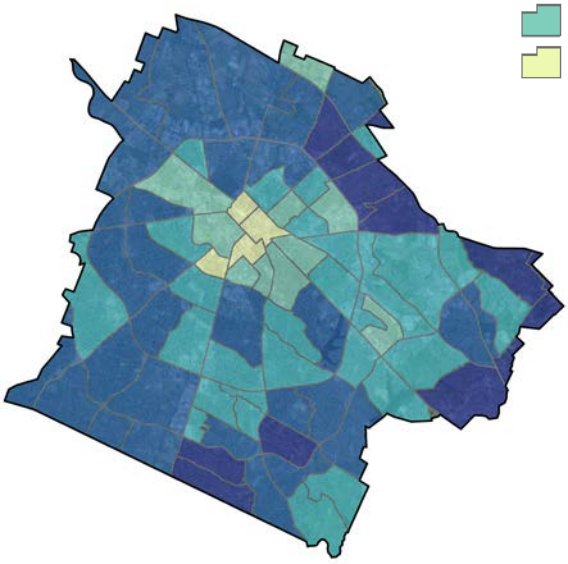


Topography

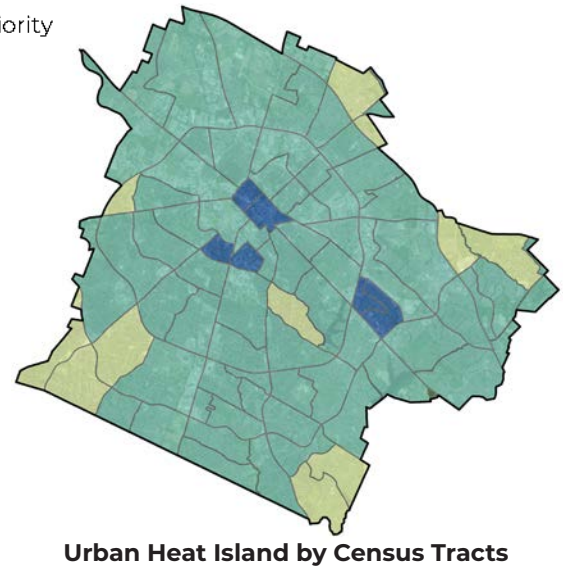


Soil Type





Stormwater Reduction by Census Tracts



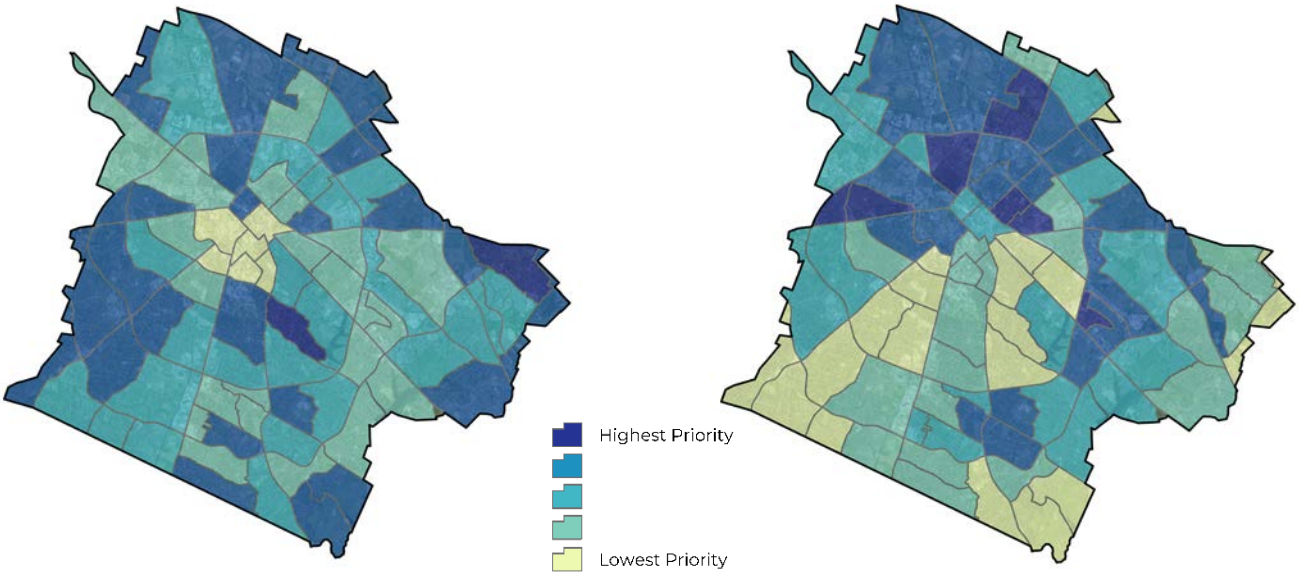
Urban Heat Island by Census Tracts

TREE PLANTING PRIORITIZATION

SOCIO-DEMOGRAPHIC

- **Vulnerable Populations:** Trees provide many environmental and health benefits to its residents. This indicator shows the ratio of residents under the age of 18 or over the age of 65 compared to the working-age population. This criteria highlights areas with larger ratios of vulnerable populations.

- **People of Color Populations:** Tree canopy is often negatively correlated with the percentage of residents of color. Planting trees in communities with higher percentages of people of color can support environmental equity. The greater percent of people of color within a census tract, the higher the planting priority.

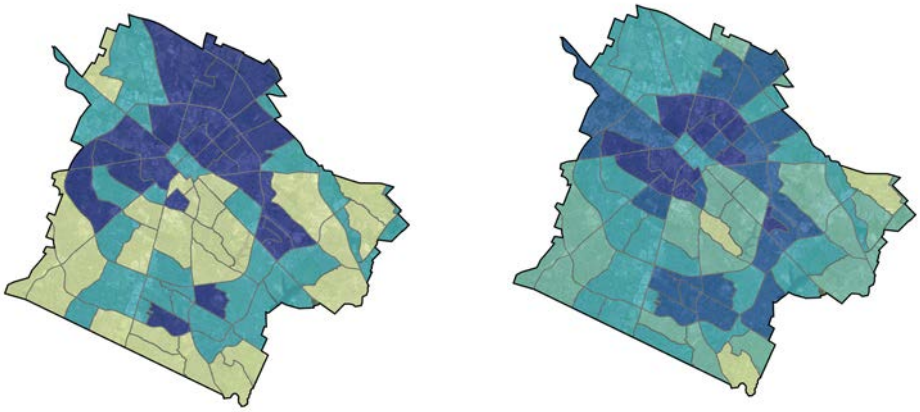


Vulnerable Populations by Census Tracts

People of Color by Census Tracts

- **Educational Attainment:** The presence of trees aligns with improved educational performance and social connections. This criteria shows educational attainment, or the highest level of education completed, as reported by the U.S. Census American Community Survey 5-year estimates. Areas with lower educational attainment were considered high priority for planting.

- **Average Income:** Income inequality often occurs with environmental inequality where lower-income residents live in highly impervious areas with limited numbers of trees, parks, and other greenspaces. This criteria highlights the average individual income. This criteria prioritizes areas with lower average income.



Educational Attainment by Census Tracts

Average Income by Census Tracts

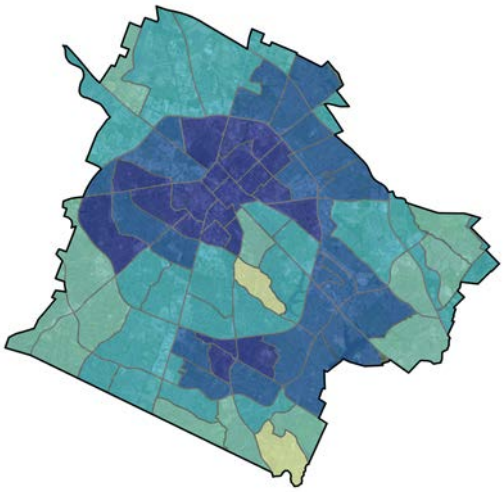
SOCIO-DEMOGRAPHIC

- **Median Household Income:** The presence of trees often aligns with increased socioeconomic status. This criteria shows the median household income. Census tracts with lower household income should be prioritized for planting efforts.

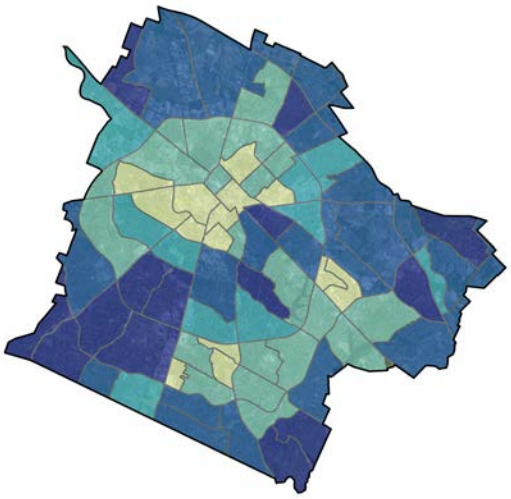
- **Owner-Occupied:** Homeowners have control over their properties and may choose to plant trees, while renters may not have permissions or the economic resources to do so. This indicator highlights the percentage of homeowners compared to renters. This criteria prioritizes areas with greater numbers of residents residing in owner-occupied homes.

- **Single Family Homes:** In densely populated areas, homes are being replaced by multi-story apartment buildings, which may leave little to no area for vegetated green space. This indicator highlights the presence of single family homes compared to all other housing options. This indicator highlights areas with a larger presence of single family homes.

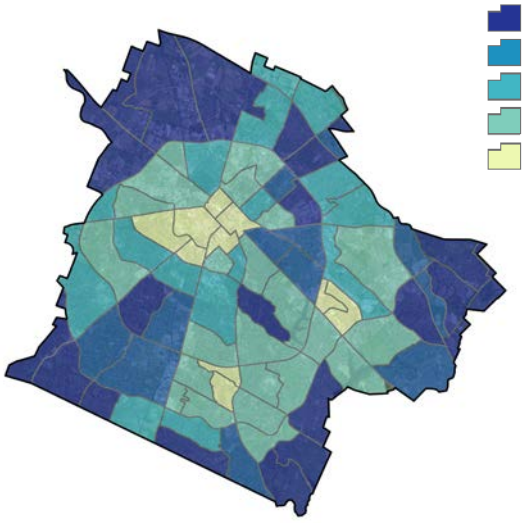
- **Median Home Value:** Mature native trees can increase home and property values. This criteria highlights the median home value and prioritizes areas with lower median home value.



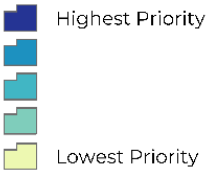
Median Household Income by Census Tracts

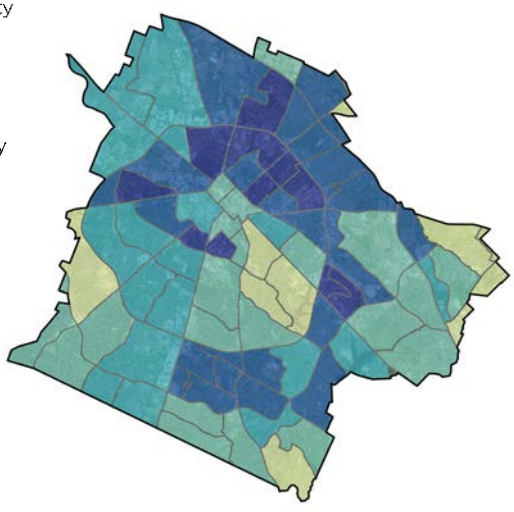


Owner-Occupied by Census Tracts



Single Family Homes by Census Tracts

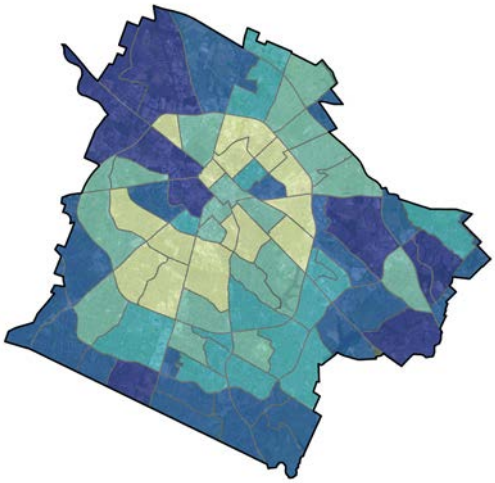




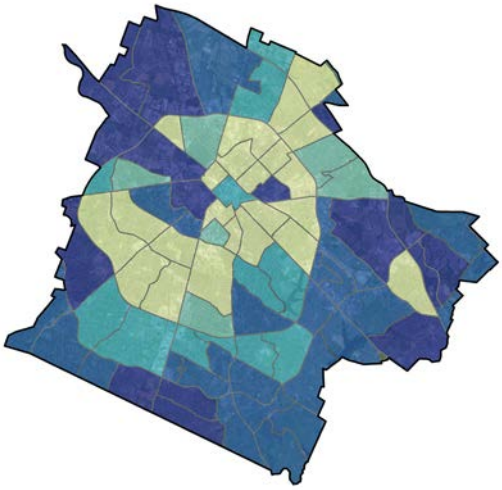
Median Home Value by Census Tracts

- **Average Building Age:** Trees can reduce cooling costs in the summer by providing shade and also reduce heating costs in the winter by blocking wind. Building materials have evolved over time to provide better insulation, but trees may have also been removed to make way for new developments. This criteria shows the average building age, and prioritizes areas containing more recently built homes for tree planting.

- **Median Year Built:** Trees can reduce cooling costs in the summer by providing shade and also reduce heating costs in the winter by blocking wind. Building materials have evolved over time to provide better insulation, but trees may have also been removed to make way for new developments. This criteria shows the median year built and prioritizes planting in census tracts with homes that were more recently built.

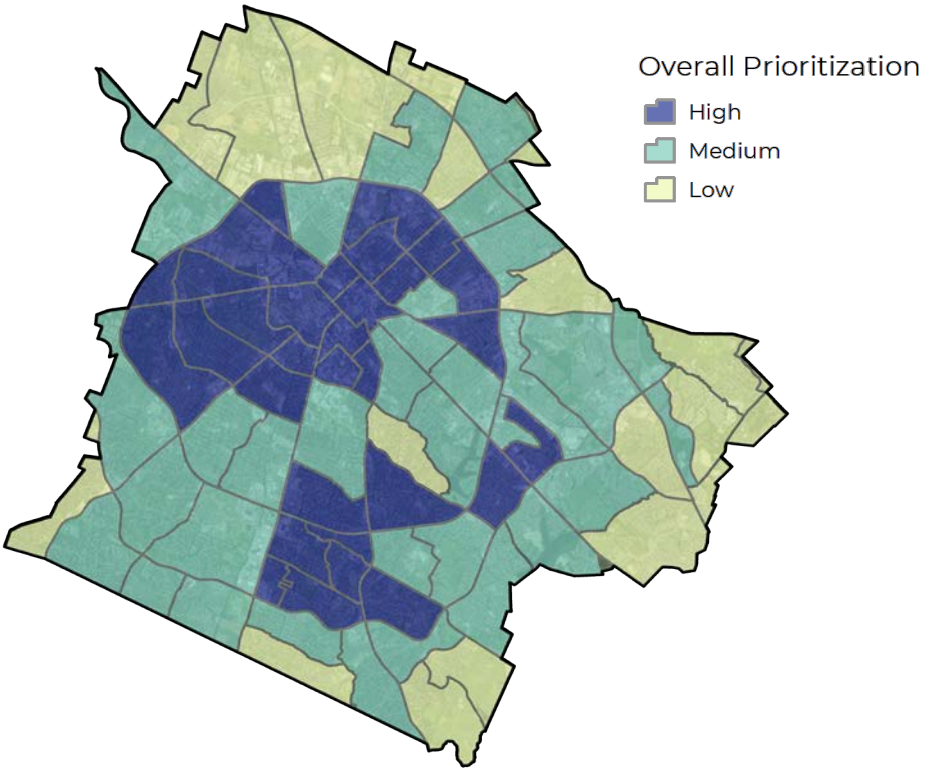


Average Building Age by Census Tracts



Median Year Built by Census Tracts

- **Overall:** The overall suitability for tree planting score based on an equally weighted formula that includes all planting prioritization categories. Weight of priority criteria can be adjusted and customized with CANOPY app.



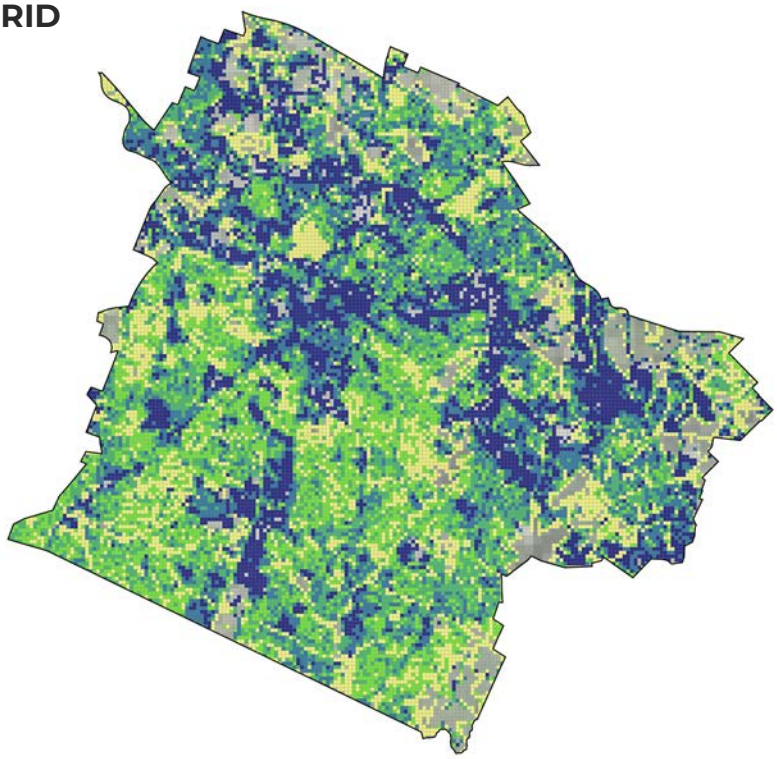
Overall Prioritization by Census Tracts

PRIORITIZATION BY 100M X 100M GRID

Impervious to Urban Tree Canopy Ratio:
A 100-meter grid was created across the USA to target more specific locations for tree planting based on the ratio between impervious surface coverage and tree canopy cover. Zonal statistics were performed on each grid cell to calculate this impervious to tree canopy ratio. The grid cells are displayed in quantiles, where the top 20% of grid cells (dark blue) represent high impervious to UTC ratios, or high priority areas, and the bottom 20% of grid cells (yellow) represent low impervious to UTC ratios, or low priority areas.

Stormwater Reduction:
This indicator uses available planting area within 100 feet of all surface water bodies and impervious surfaces to identify areas with plantable space that will reduce stormwater runoff.

Urban Heat Island:
The average relative heat severity value within each grid cell. Urban heat severity data from the Trust for Public Land derived using the thermal band of a Landsat 8 satellite image were used.



Percent Impervious-UTC Ratio by 100m Grid Cells

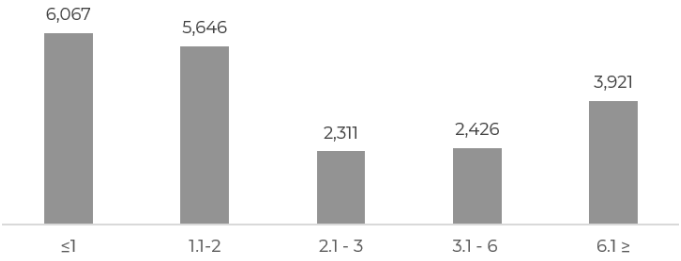
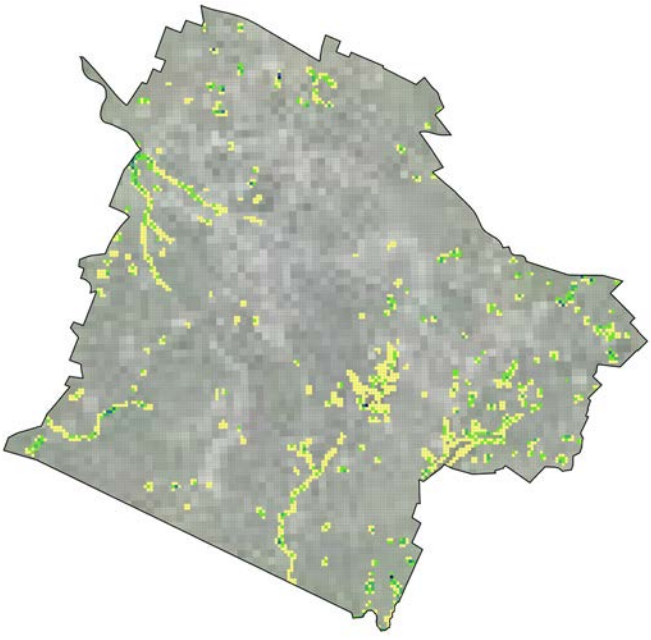
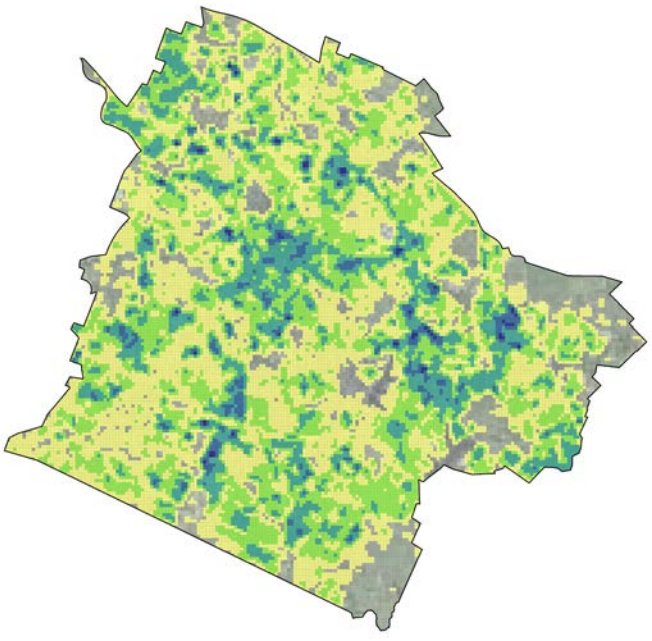


Figure 24. Frequency distribution of impervious to tree canopy ratios by 100-meter grid cells.



Stormwater Reduction by 100m Grid Cells



Urban Heat Island by 100m Grid Cells

URBAN TREE CANOPY GOAL SETTING

TREE PLANTING GOALS AND SCENARIOS

Multiple tree planting scenarios were considered to assist the City of Lexington in reaching future canopy goals. Tree planting scenarios were explored through the lens of property ownership types. The decision to evaluate scenarios this way was made with input from Lexington urban forestry and planning staff and the Lexington Tree Board. This approach will simplify implementation by identifying the types of properties and audiences to engage at the outset. These groups can be approached with the citywide canopy goals and planting efforts needed from each, providing an opportunity to play a part in this citywide initiative to make Lexington a healthier and more vibrant place to live. Tree canopy and plantable space information were used as inputs to a tree planting calculator to create planting scenarios towards four 20-year goals: no net loss, 30%, 35%, and 40% canopy. The calculator provided an accurate depiction of real-life scenarios by taking into account the estimated natural growth, regeneration, and loss of canopy due to mortality or development that would occur over the 20 years. Goals were set for every property ownership type to reach the citywide canopy goal, taking into consideration that the built environment and real world conditions can limit the amount of actual canopy increase.

Table 10. Assumptions for canopy goal setting

Category	Assumption
Time Period	20 years
New Tree Mortality Rate	10%
Annual Canopy Loss to Mortality	3%
Annual Acreage Loss to Development	10 acres
Annual Natural Regeneration Rate	3%
Annual Canopy Growth Rate	3%
Distribution of Small/ Med/Lg Trees to Plant	10% / 40% / 50%

Table 11. Canopy goal setting for Lexington's property ownership types.

Property Ownership Type	*Starting Data from 2020 Tree Canopy Assessment*			*Tree Planting Scenarios to Reach UTC Goals (based on assumptions)*							
				No Net Loss		*30%*		*35%*		*40%*	
	Existing UTC	*Possible UTC*	*Total Canopy Potential (existing + possible)*	*Canopy required to reach the citywide goal:*	*Plantings needed to meet 20 yr. goal*	*Canopy required to reach the citywide goal:*	*Plantings needed to meet 20 yr. goal*	*Canopy required to reach the citywide goal:*	*Plantings needed to meet 20 yr. goal*	*Canopy required to reach the citywide goal:*	*Plantings needed to meet 20 yr. goal*
Fayette County Public Schools	11%	44%	54%	11%	25	20%	723	25%	1,094	30%	1,466
Federal	17%	43%	60%	17%	109	18%	125	18%	125	20%	152
LFUCG	32%	47%	79%	32%	-	40%	1,578	45%	2,674	50%	3,771
LFUCG Housing Authority	26%	34%	59%	26%	118	30%	150	32%	165	35%	188
Other Tax Exempt Properties	20%	39%	60%	20%	-	25%	690	30%	1,483	35%	2,276
Private	25%	35%	60%	25%	-	34%	21,443	39%	35,404	45%	52,156
Right-of-Way	17%	43%	60%	17%	-	18%	635	22%	3,353	23%	4,032
State	24%	40%	64%	24%	116	25%	125	26%	133	28%	149
University of Kentucky	13%	38%	51%	26%	118	20%	833	25%	1,426	30%	2,019
Totals	**23%**	**33%**	**56%**	**23.3%**	**368**	**30.5%**	**26,302**	**35.3%**	**45,857**	**40.3%**	**66,209**

As shown in the table on the previous page, to reach a 30% tree canopy goal citywide, just over 26,000 trees would need to be planted over the next 20 years (approx. 1,300 per year). To reach a 35% tree canopy goal, almost 46,000 trees would need to be planted over the next 20 years (approx. 2,300 per year). To reach a 40% tree canopy goal, just over 66,000 trees would need to be planted over the next 20 years (approx. 3,300 per year). The majority of the planting work (70-80%) will need to happen on privately-owned residential land.

TREE CANOPY GOALS AND ZONING STANDARDS

It should also be noted that tree canopy goals and standards have been assigned in Lexington to each zoning type in Article 26 of the Lexington-Fayette County Zoning Ordinance (specifically Sec. 26-5 on Tree Canopy Standards):

Sec. 26-5. - Tree canopy standards. *It is a part of the intent of this Article to establish the minimum tree canopy to be achieved during development for different categories of land use. The following are those standards, expressed as a minimum percentage of the total developable area of a parcel of land:*
(1) *All residential and nonresidential uses in agricultural zones: Thirty percent (30%) of existing only. See Subsection (c) of this section, Agricultural Standard Exceptions;* **(2)** *All residential zones, including PUD-1, M-1P: Thirty percent (30%);* ***(3)*** *B-2, B-2A and B-2B zones: zero (0) percent;* ***(4)*** *P-1, P-2, B-1, B-3, B-5P, B-6P and CC zones: Twenty percent (20%);* ***(5)*** *B-4, I-1, I-2 and ED zones: Ten percent (10%);* ***(6)*** *All mixed use zones: Ten percent (10%).*

As shown in the table below, these goals have been met in the downtown Commercial zone (0% canopy required, 7% canopy currently) and in the Industrial zone (10% required, 13% currently). Additional tree canopy is needed to meet the goals in the Commercial/Office zones as well as the Residential zones.

It is also important to note that if these goals were met across all zoning types, this would result in a citywide canopy cover of approximately 23%-26% which matches the existing tree canopy today in Lexington. As Lexington is working toward a higher set of citywide goals, these tree canopy standards should only be considered as a "baseline" or minimum standard during development. Higher canopy cover targets must be achieved to reach long-term goals.

Table 12. Canopy goal setting for Lexington's zoning types based on LFUCG zoning tree canopy standards.

Zoning Type	*Zoning Area Size*		*2020 UTC*		*Zoning Tree Canopy Standard*			
	Land Area (Acres)	*% of USA*	Acres	%	Tree Canopy Standard Goal %	Total Acres Needed for Standard	Goal Reached?	Acres Still Needed
Agricultural (A-R, A-U)	5,899	11%	1,338	23%	30% of existing	Can't be determined	Can't be determined	Can't be determined
Commercial - Downtown (B-2, B-2A, B-2B)	291	1%	19	7%	0%	0	Yes	19 acres over goal
Commercial - Other (B-1, B-3, B-5P, B-6P)	4,315	8%	387	9%	20%	863	No	476
Industrial (I-1, I-2, B-4, ED)	5,318	10%	670	13%	10%	532	Yes	138 acres over goal
Mixed Use (MU 1, 2, 3)	153	0.3%	9	6%	10%	15	No	6
Office/Professional (P1, P2)	2,140	4%	305	14%	20%	428	No	123
Residential (Rs, M-1P, PUD 1/2, EAR 1/2/3, CC, CD)	35,939	67%	9,922	28%	30%	10,782	No	860

CONCLUSIONS AND RECOMMENDATIONS

The Lexington-Fayette Urban County Government has demonstrated that it values its natural resources and wants to maintain a healthy and sustainable urban environment. Recurring assessments of the city's tree canopy represent important steps in ensuring the long-term health of its urban forest. A greater percent of canopy cover can be achieved with proper planning, investment, and care of existing trees. The City should continue to monitor the health of the urban forest and implement the following recommendations to ensure the urban forest is considered during future city planning and development to sustain and enhance the benefits that trees provide to the community.

More than half of all tree canopy falls in single-family residential zones.

To preserve, protect, and maintain Lexington's tree canopy, the City should continue to have a tree canopy assessment performed at regular intervals through a TreePlotter CANOPY subscription or continuing regular projects. As the city grows, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Lexington with a wealth of environmental, social, and even economic benefits which relate back to greater community pride and interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to continue to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Lexington's urban forest.

1. Leverage the results of this assessment to promote the urban forest

The results of this assessment should be used to encourage investment in urban forest monitoring, maintenance, and management; to prepare supportive information for local budget requests/grant applications; and to develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues. The land cover, tree canopy, and urban tree canopy change data should be disseminated to diverse partners for urban forestry and other applications while the data are current and most useful for decision-making and implementation planning. The information from this study can help establish new canopy cover goals for the short- and long-term to continue to expand Lexington's urban forest to its known potential.

2. Use the urban tree canopy change data to identify areas to prioritize canopy expansion

The City and its various stakeholders can utilize the results of the UTC, PPA, and urban tree canopy change analyses to identify the best locations on City-owned and private property to focus future tree planting and canopy expansion efforts. Trees can play a large role in improving public health by improving air quality, reducing temperatures, and addressing climate change. The City can acquire parcels for public use as part of redeveloped neighborhoods to be used as carbon sinks to address community access to nature, climate, human health, and equity. Plantable space in the right-of-way is often found close to high concentrations of impervious surfaces. Focus on planting the right tree in the right place and planting large-species trees where appropriate to maximize ecosystem services. Planting trees near impervious surfaces can offset the urban heat island effect, stormwater runoff, and energy consumption. The priority planting analysis should be used to identify planting opportunities adjacent to high concentrations of impervious surfaces in these areas. Results revealed that 7% of plantable space is in the right-of-way, adjacent to impervious surfaces. The City can develop a proactive street tree maintenance program to take on the responsibility of planting and managing street

trees, ensuring healthy trees are distributed equitably across the city. Given the majority of tree loss was attributed to development, the City should evaluate city codes to increase tree preservation, create space for existing trees during the development process, and set aside space for new larger stature trees to be planted both on private property and within the public right-of-way to maximize the benefits of trees.

73%
OF ALL PLANTABLE SPACE IN LEXINGTON IS LOCATED ON PRIVATE LAND

3. Develop outreach programs towards private landowners

In Lexington, 73% of PPA is found in areas designated as private property. The City should focus on community outreach and education programs to better inform citizens and private landholders of the environmental, health, social, and financial benefits that trees provide and consider other strategies to help preserve existing trees and grow the tree canopy in the nearly 13,000 acres of plantable space on private properties. The City should explore options to develop grant programs for tree maintenance or removal of hazard or invasive trees within the city to remove barriers for overburdened communities which lack tree canopy. Tree giveaways, tree planting programs, and tree maintenance events can help to promote new tree plantings. To promote new plantings, expand the partnership with local contractors to plant more trees on redeveloped or newly developed property focusing on low-canopy and under served neighborhoods. The City should also continue to develop partnerships with Community Based Organizations and individual champions throughout neighborhoods to build stewardship at the community level. In addition, the City should continue to conduct volunteer tree planting and tree maintenance events to increase awareness levels in the community.

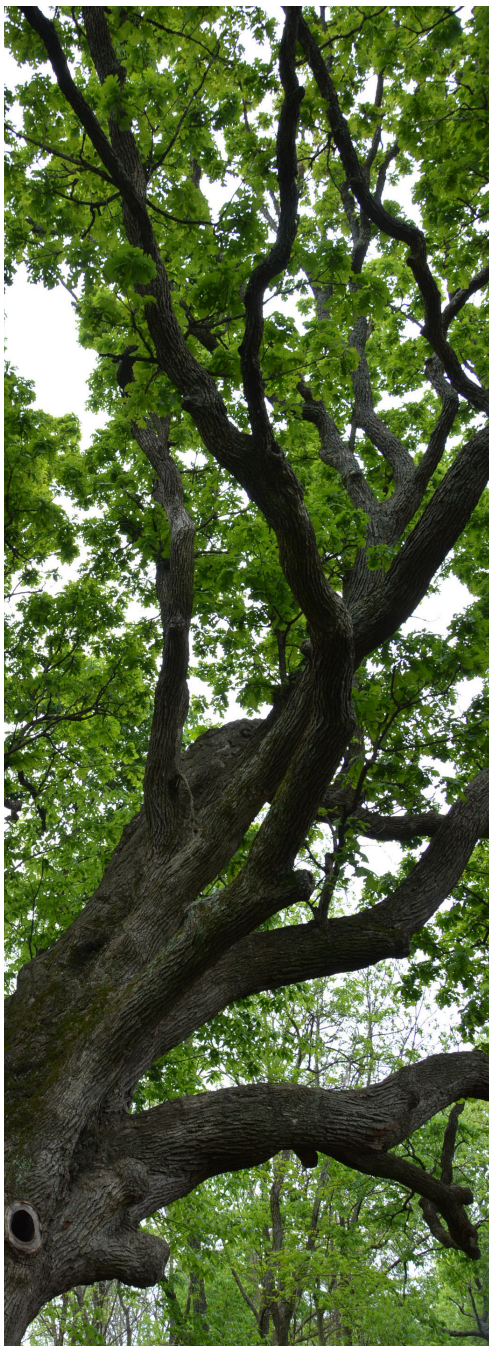


Figure 25. Bur oak *(Quercus macrocarpa)* - Lexington's official tree.

4. Use TreePlotter to identify areas in need of tree canopy, prioritize planting efforts, and continue to monitor the urban forest

To maximize impact, see greater return on investment, and provide the greatest number of benefits to the community, we recommend that the City focus planting and management efforts in areas with high weighted priority rankings. Planting priority maps and data, displayed in TreePlotter™ CANOPY, show land cover metrics and the areas of highest priority collectively and individually for all planting prioritization criteria. The City should also use the GIS data provided to create unique weighted scenarios to focus efforts in targeted areas that meet specific criteria. For instance, the City could find areas that have low UTC, high PPA, or would offer the greatest benefits to improving air quality and reducing summertime temperature. Focusing urban forest management resources on expanding and maintaining tree canopy in areas like these will have positive impacts on multiple factors that the City has deemed important. Efforts should focus on outreach to the residents of these neighborhoods, as well as local business and land owners, in order to promote new tree plantings and continued maintenance of existing trees. NAIP imagery is being collected this year (2022) in Kentucky, and the City's CANOPY subscription will be updated with new UTC, PPA, and canopy change metrics when they become available in mid- to late-2023.

REPORT

APPENDIX

ACCURACY ASSESSMENT

Classification accuracy serves two main purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Even with high resolution imagery, very small differences in classification methodology and image quality can have a large impact on overall map area estimations.

The classification accuracy error matrix illustrated in Table A1 contain confidence intervals that report the high and low values that could be expected for any comparison between the classification data and what actual, on the ground land cover was in 2020. This accuracy assessment was completed using high resolution aerial imagery, with computer and manual verification. No field verification was completed.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS:

1. One thousand sample points, or approximately 12 points per square mile area in Lexington (86 sq. miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the NAIP aerial photo and assigned one of five generalized land cover classes ("Ref_ID") mentioned above by a technician.
3. In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis. In this case, no points were dropped.
4. An automated script was then used to assign values from the classification raster to each point ("Eval_ID"). The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified points (where reference ID does not equal evaluation ID) and corresponding land cover are inspected for necessary corrections to the land cover.[1]
5. Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved.

SAMPLE ERROR MATRIX INTERPRETATION

Statistical relationships between the reference pixels (representing the true conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Lexington's landscape. The error matrix shown in Table A1 represent the intersection of reference pixels manually identified by a human observer (columns) and classification category of pixels in the classified image (rows). The blue boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the number of pixels manually referenced to the column class that were classified as another category in the classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (222 + 321 + 397 + 22 + 8 = 458 / 1000 = 97%), and the matrix can be used to calculate per class accuracy percentage's. For example, 222 points were manually identified in the reference map as Tree Canopy, and 225 of those pixels were classified as Tree Canopy in the classification map. This relationship is called the "Producer's Accuracy" and is calculated by dividing the agreement pixel total (diagonal) by the reference pixel total (column total). Therefore, the Producer's Accuracy for Tree Canopy is calculated as: (222/225 = .987), meaning that we can expect that ~99% of all 2020 tree canopy in the Lexington, KY study area was classified as Tree Canopy in the 2020 classification map.

Conversely, the "User's Accuracy" is calculated by dividing the total number of agreement pixels by the total number of classified pixels in the row category. For example, 222 classification pixels intersecting reference pixels were classified as Tree Canopy, but 19 pixels were identified as Vegetation and 2 were identified as impervious in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (222/234 = 0.948), meaning that ~95% of the pixels classified as Tree Canopy in the classification were actual tree canopy. It is important to recognize the Producer's and User's accuracy percent values are based on a sample of the true ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this land cover, and more importantly, tree canopy, were accurately mapped in Lexington in 2020. The largest sources of classification confusion exist between tree canopy and vegetation.

1 Note that by correcting locations associated with accuracy points, bias is introduced to the error matrix results. This means that matrix results based on a new set of randomly collected accuracy points may result in significantly different accuracy values.

Table A1. | Error matrix for land cover classifications in Lexington, KY (2020).

Classification Data	Reference Data: Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	222	10	2	0	0	234
Vegetation	2	321	2	0	0	325
Impervious	1	11	397	1	0	410
Soil / Dry Veg.	0	1	0	22	0	23
Water	0	0	0	0	8	8
Total	225	343	401	23	8	1,000

Overall Accuracy = 97%

Producer's Accuracy	
Tree Canopy	99%
Veg. / Open Space	94%
Impervious	99%
Bare Ground / Soil	96%
Water	100%

User's Accuracy	
Tree Canopy	95%
Veg. / Open Space	99%
Impervious	97%
Bare Ground / Soil	96%
Water	100%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Lexington's urban tree canopy coverage and how well aligned the derived land cover data are with interpretations by the human eye. The high accuracy of the 2020 data indicates that regardless of how and when it was achieved, the Urban Service Area's current tree canopy can be safely assumed to match the figures stated in this report (approximately 23%).

GLOSSARY/KEY TERMS

Land Acres: Total land area, in acres, of the assessment boundary (excludes water).

Non-Canopy Vegetation: Areas of grass and open space where tree canopy does not exist.

Possible Planting Area - Vegetation: Areas of grass and open space where tree canopy does not exist, and it is biophysically possible to plant trees.

Soil/Dry Vegetation: Areas of bare soil and/or dried, dead vegetation.

Total Acres: Total area, in acres, of the assessment boundary (includes water).

Unsuitable Impervious: Areas of impervious surfaces that are not suitable for tree planting. These include buildings and roads and all other types of impervious surfaces.

Unsuitable Planting Area: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

Unsuitable Soil: Areas of soil/dry vegetation considered unsuitable for tree planting. Irrigation and other modifiers may be required to keep a tree alive in these areas.

Unsuitable Vegetation: Areas of non-canopy vegetation that are not suitable for tree planting due to their land use.

Urban Tree Canopy (UTC): The "layer of leaves, branches and stems that cover the ground" (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of the urban forest. Tree canopy was generally taller than 10-15 feet tall.

Water: Areas of open, surface water not including swimming pools.

AUGUST | 2022

URBAN TREE CANOPY

ASSESSMENT

LEXINGTON, KENTUCKY

PLANIT GEO™
mapping a greener future

urbancanopy works, LLC