URBAN TREE CANOPY

ASSESSMENT

WINDSOR,
ONTARIO
JANUARY | 2020

THE CITY OF WINDSOR
ONTARIO, CANADA

PLANIT GEO™
mapping a greener future

AN ASSESSMENT OF
URBAN TREE CANOPY

WINDSOR, ONTARIO

> **A society grows great when old men plant trees whose shade they shall never sit in.**
> **-Greek Proverb**

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TREE CANOPY IN WINDSOR HAS INCREASED BY 7% SINCE 2002

EXECUTIVE SUMMARY

PURPOSE OF THIS ANALYSIS

The City of Windsor is located within Essex County located in Southwestern Ontario (Figure 1). It is approximately 147 square kilometers or 14,793 hectares of which 14,535 hectares are land. Across the City, trees along streets, in parks, yards, and natural areas constitute a valuable urban and community forest. This resource is a critical element of the region's green infrastructure, contributing to environmental quality, public health, water supply, local economies and city aesthetics. The primary goal of this assessment was to provide a baseline and benchmark of the City's current (2019) tree canopy, interpret the results across a range of geographic boundaries, and evaluate how the City's canopy has changed since 2002.

URBAN TREE CANOPY IN WINDSOR

Results of this study indicated that in 2019, the City of Windsor contained 19% urban tree canopy (or 2,798 hectares of the City's 14,793 total hectares); 32% non-canopy vegetation (4,762 hectares); 10% soil/dry vegetation (1,540 hectares); 37% impervious (5,435 hectares); and 2% water (258 hectares). Urban tree canopy (UTC) and possible planting area (PPA) results are based on land area which is equal to the total area minus water area (14,793 - 258 = 14,535 hectares). UTC cover was 19% (2,798 hectares), 28% (4,010 hectares) was suitable for future tree plantings, and 53% (7,728 hectares) was unsuitable due to its current land use or other constraint.

ASSESSMENT BOUNDARIES

This study assessed UTC and PPA at multiple geographic scales in order to provide actionable information to a diverse range of audiences. By identifying what resources and opportunities exist at these scales, the City can be more proactive in their approach to protect and expand their urban tree canopy. Metrics were generated at the following geographies: the citywide boundary (1); land ownership (3); zoning (9); wards (10); and IMS districts (25).

RECOMMENDATIONS

The results of this analysis can be used to develop a continuing strategy to protect and expand the urban forest in Windsor. The UTC, PPA, and canopy change metrics should be used as a guide to determine where the City has been successful in protecting and expanding its urban forest resource, while also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Windsor can use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

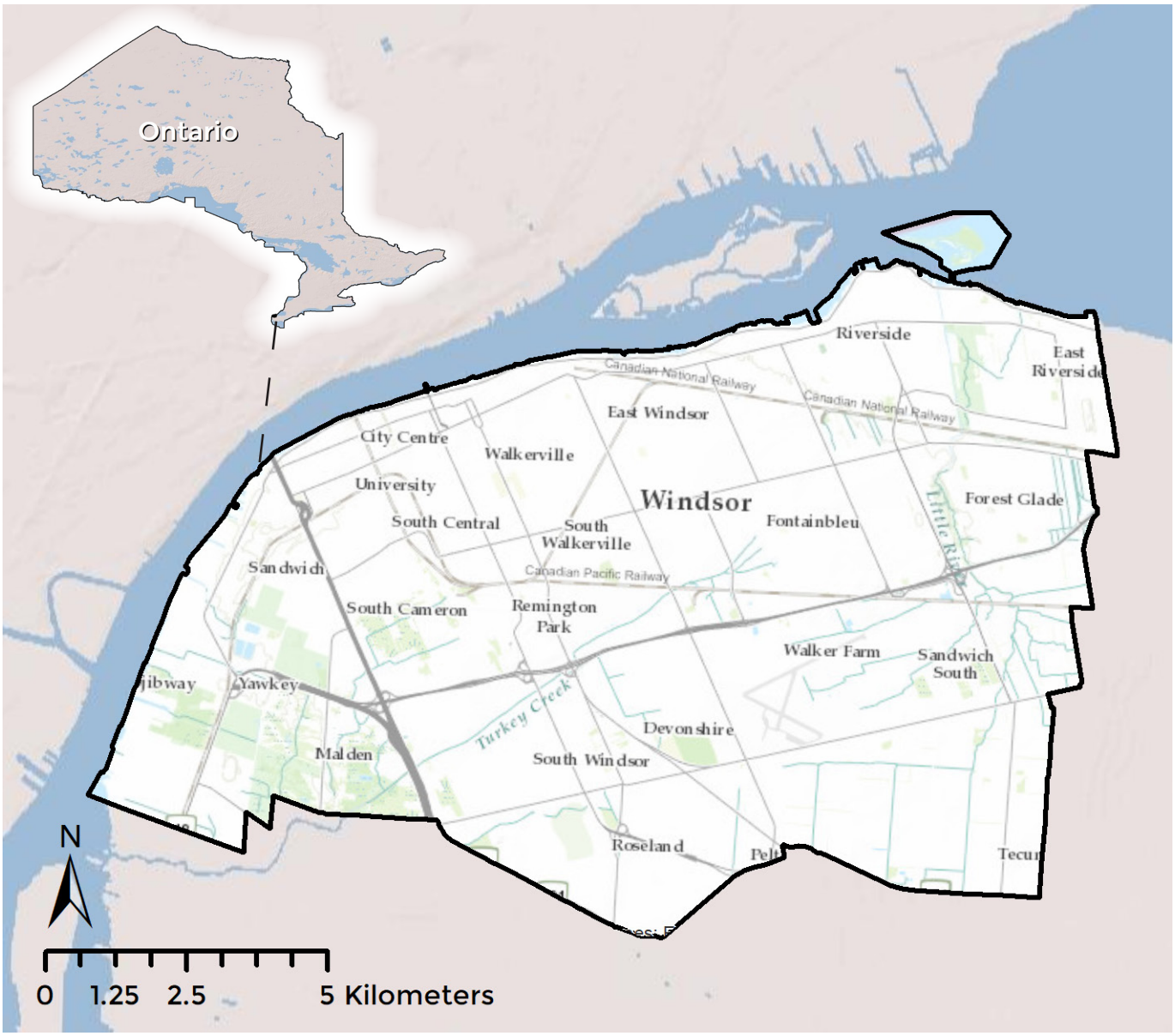


Figure 1. | Windsor occupies approximately 147 square kilometers in Southwestern Ontario.

19%
URBAN TREE CANOPY

28%
POSSIBLE PLANTING AREA

37%
IMPERVIOUS SURFACE

Figure 2. | Based on an analysis of 2019 high-resolution imagery, Windsor contains 19% tree canopy, 28% areas that could support canopy in the future (for a total possible canopy cover of 47%), and 37% total impervious areas.

PROJECT METHODOLOGY

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

DATA SOURCES

This assessment utilized high-resolution (1-meter), multispectral, Pleiades satellite imagery collected in July 2019 and LiDAR data from the CanElevation HRDEM series collected in 2017 to derive the land cover dataset. The Pleiades satellite imagery was used to classify all types of land cover, whereas the LiDAR data was mostly used to distinguish tree canopy from other types of vegetation.

MAPPING LAND COVER

An initial land cover dataset was to be created prior to mapping tree canopy. The land cover data set is the most fundamental component of an urban tree canopy assessment. An object-based image analysis (OBIA) software program called Feature Analyst was used to classify features through an iterative approach. In this process, objects' spectral signatures across four bands (blue, green, red, and near-infrared), textures, pattern relationships, and object height were considered. This remote sensing process used the satellite imagery and LiDAR to derive five initial land cover classes. These classes are shown in Figure 3 and described in the Glossary on page 27.

Figure 3. | Five (5) distinct land cover classes were identified in the 2019 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Windsor'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 Windsor 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 Non-Canopy Vegetation. 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, power line corridors, agricultural areas, 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 Total Unsuitable.

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

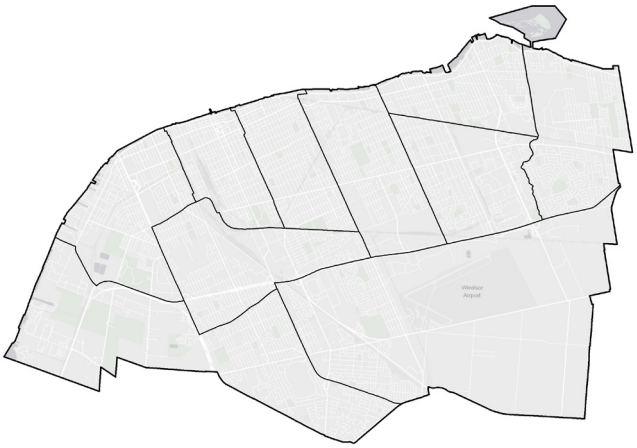
In order to best inform the City Council and various stakeholders in Windsor, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries (Figure 5). These boundaries include the city boundary, land ownership, zoning, wards, and IMS districts.

- The City of Windsor citywide boundary is the one (1) main area of interest over which all metrics are summarized.
- Tree canopy was analyzed for three (3) types of land ownership in Windsor to identify the amount of tree canopy in public and private spaces.
- Nine (9) unique zoning categories were assessed to provide detail on tree canopy within the current human uses of land across the city.
- Tree canopy was analyzed for the ten (10) wards which cover Windsor to identify the amount of tree canopy as it relates to the individual election districts and potentially to inform the council members and citizens residing in them.
- Twenty-five (25) IMS districts were assessed to provide information within a boundary utilized by and familiar to incident management planning.

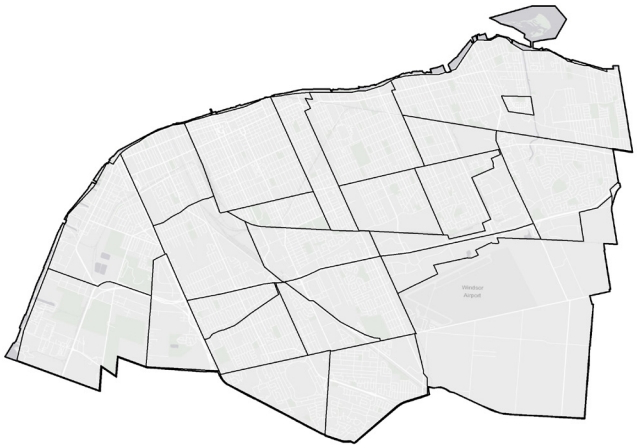
City Boundary

Land Ownership

Zoning



Wards



IMS Districts

Figure 5. | Five (5) distinct geographic boundaries were explored in this analysis: the full city boundary, land ownership, zoning, wards, and IMS Districts.

STATE OF THE CANOPY AND KEY FINDINGS

The results and key findings of this study, including the land cover map and canopy analysis results, are presented below. These results, or metrics, help inform 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 only. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification.

CITYWIDE LAND COVER

In 2019, tree canopy constituted 19% of Windsor's land cover; non-canopy vegetation was 32%; soil/dry vegetation was 10%; impervious was 37%; and water was 2%. These generalized land cover results are presented below in Table 1 and in Figure 6.

Table 1. | Land cover classification

City Boundary	City Boundary	Tree Canopy	Impervious Surfaces	Non-Canopy Vegetation	Soil & Dry Vegetation	Water
Hectares	14,793	2,798	5,435	4,762	1,540	258
% of Total	100%	19%	37%	32%	10%	2%

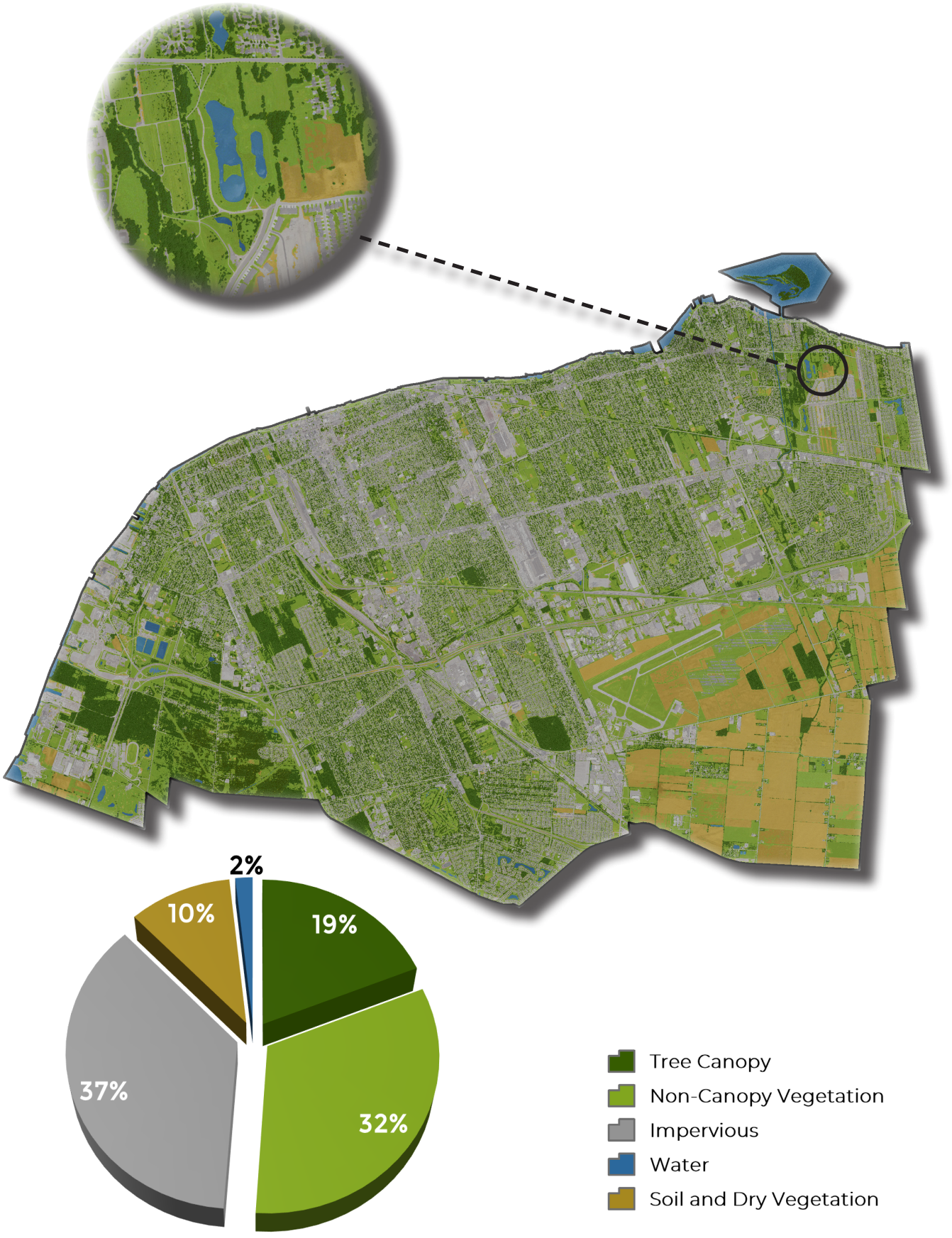


Figure 6. | Land cover classes for Windsor, Ontario based on 2019 satellite imagery and LiDAR. (Percentages based on total hectares within urban areas of the City.)

CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover map as a foundation to determine possible planting areas throughout the City. Additional layers and information regarding land considered unsuitable for planting were also incorporated into the analysis. Note that the results of this study are based on land area, which excludes water bodies, as opposed to total area, which includes water bodies (note the difference between Total Area and Land Area in Table 2).

Results of this study indicate that within the City of Windsor, 2,798 hectares are covered with urban tree canopy, making up 19% of the City's 14,535 land hectares; 4,010 hectares are covered with other vegetation where it would be possible to plant trees (PPA), making up 28% of the City (includes parks); and the other 7,728 hectares were considered unsuitable for tree planting, making up 53% of the City. The unsuitable areas include recreational sports fields, golf course playing areas, buildings, roads, agricultural lands and areas of bare soil and dry vegetation.

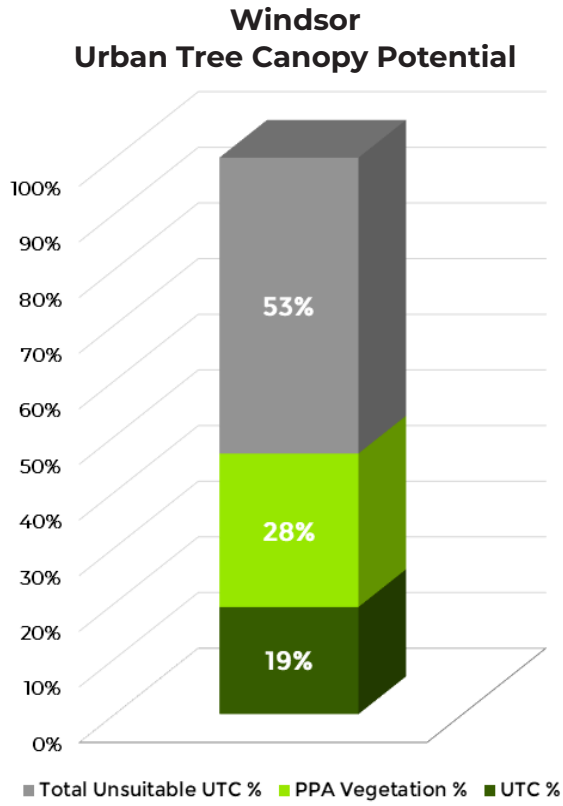


Figure 7. | Urban tree canopy, possible planting area, and area unsuitable for UTC in the City of Windsor.

Table 2. | Urban tree canopy assessment results by hectares and percent. (Percentages based on land area.)

City of Windsor	Hectares	%
Total Area	14,793	100%
Land Area	14,535	98%
Urban Tree Canopy	2,798	19%
Total Possible Planting Area	4,010	28%
Unsuitable Vegetation	752	5%
Unsuitable Impervious	5,435	37%
Unsuitable Soil	1,540	11%
Total Unsuitable Area	7,728	53%

Figure 8. | Urban tree canopy, possible planting area, and unsuitable areas for UTC in the City of Windsor.

URBAN TREE CANOPY BY LAND OWNERSHIP

UTC and PPA were assessed for three different types of land ownership in Windsor including private land, city-owned public land, and public right-of-way. Private land makes up 58% of the City's land area. UTC was not distributed evenly across land ownership type. The lowest UTC was found on private land (17%) while the highest UTC was found in city-owned public lands (26%). Possible planting area was more evenly distributed across land ownership type with the lowest found in public city-owned (26%) and the highest found in public right-of-way (29%). Private land contained the largest portion of Windsor's UTC and PPA with 58% and 67%. respectively.

Table 3. | Urban Tree Canopy assessment results by land ownership. UTC and PPA results include hectares, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each ownership type.

Land Ownership	Land Area		Urban Tree Canopy			Possible Planting Area		
	Hectares	*Dist.*	*Hectares*	*%*	*Dist.*	*Hectares*	*%*	*Dist.*
Private	9,684	67%	1,612	17%	58%	2,680	28%	67%
Public - City-Owned	2,041	14%	521	26%	19%	525	26%	13%
Public - Right-of-Way	2,810	19%	665	24%	24%	805	29%	20%
Totals	**14,535**	**100%**	**2,798**	**19%**	**100%**	**4,010**	**28%**	**100%**

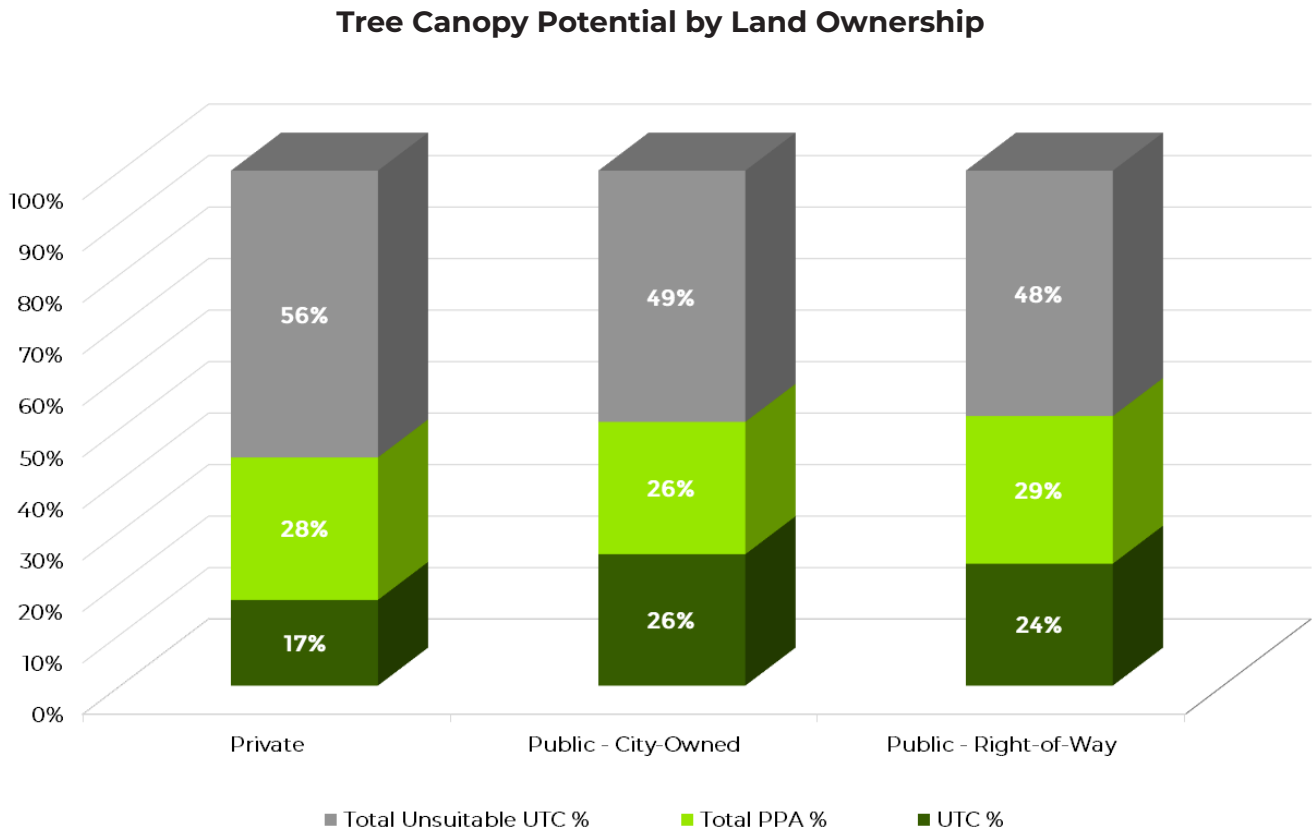


Figure 9. | Urban tree canopy, possible planting area, and area unsuitable for UTC by land ownership.

URBAN TREE CANOPY BY ZONING

To provide greater detail about how tree canopy in Windsor is distributed amongst different functions of land, UTC and PPA were assessed within local zoning types. UTC varied greatly between zoning types with the lowest UTC found in Agriculture (6%) and the highest found in Green Space (41%).Low Density Housing contained the largest portion of tree canopy in Windsor with nearly half (46%) of all of the City's tree canopy. PPA had greater variation with the lowest PPA found in Agriculture (8%) and the highest found in Vacant (64%). The greatest opportunity for future canopy expansion was in Low Density Housing which contained (38%) of all PPA in Windsor.

Table 4. | Urban Tree Canopy assessment results by zoning. UTC and PPA results include hectares, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each zoning type.

Zoning	Land Area		Urban Tree Canopy			Possible Planting Area		
	Hectares	*Dist.*	*Hectares*	*%*	*Dist.*	*Hectares*	*%*	*Dist.*
Agriculture	1,402	12%	82	6%	4%	113	8%	4%
Commercial	912	8%	65	7%	3%	169	19%	5%
Green Space	1,306	11%	534	41%	25%	498	38%	16%
Low Density Housing	3,534	30%	977	28%	46%	1,222	35%	38%
Medium Density Housing	652	6%	100	15%	5%	218	33%	7%
High Density Housing	300	3%	67	22%	3%	91	30%	3%
Institutional	1,228	10%	86	7%	4%	191	16%	6%
Manufacturing	2,384	20%	218	9%	10%	698	29%	22%
Vacant	7	0%	2	28%	0%	5	64%	0%
Totals	**11,725**	**100%**	**2,132**	**18%**	**100%**	**3,204**	**27%**	**100%**

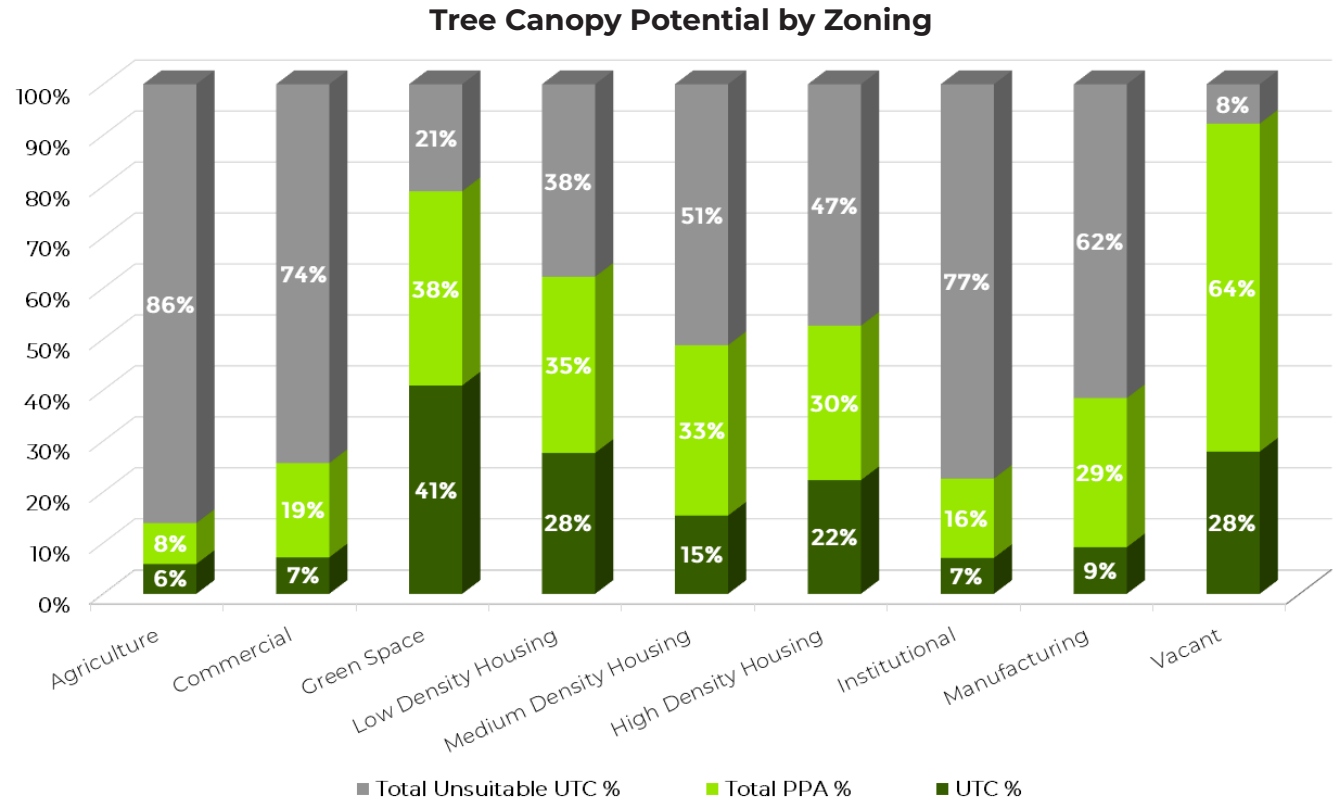


Figure 10. | Urban tree canopy, possible planting area, and area unsuitable for UTC by zoning.

URBAN TREE CANOPY BY WARDS

UTC and PPA were assessed for 10 wards across Windsor. UTC varied throughout wards in Windsor from 10% to 32%. The ward with the lowest UTC was Ward 9 with 10%. Ward 1 had the highest coverage with 32%. Ward 1, containing the Ojibway Prairie Complex, also contained the largest portion of the City's tree canopy with 28%. Ward 7 had the highest percentage of PPA throughout its area with 35% PPA, while Ward 1 contained the largest portion of the City's PPA with 21% of all Windsor's plantable space.

Table 5. | Urban Tree Canopy assessment results by wards. UTC and PPA results include hectares, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each ward.

Wards	Land Area		Urban Tree Canopy			Possible Planting Area		
	Hectares	*Dist.*	*Hectares*	*%*	*Dist.*	*Hectares*	*%*	*Dist.*
WARD 1	2,421	17%	782	32%	28%	828	34%	21%
WARD 2	1,135	8%	248	22%	9%	354	31%	9%
WARD 3	682	5%	111	16%	4%	151	22%	4%
WARD 4	799	5%	158	20%	6%	200	25%	5%
WARD 5	1,146	8%	171	15%	6%	341	30%	8%
WARD 6	820	6%	209	25%	7%	252	31%	6%
WARD 7	1,180	8%	229	19%	8%	417	35%	10%
WARD 8	1,066	7%	198	19%	7%	357	34%	9%
WARD 9	4,085	28%	405	10%	14%	724	18%	18%
WARD 10	1,201	8%	288	24%	10%	387	32%	10%
Totals	**14,535**	**100%**	**2,798**	**19%**	**100%**	**4,010**	**28%**	**100%**

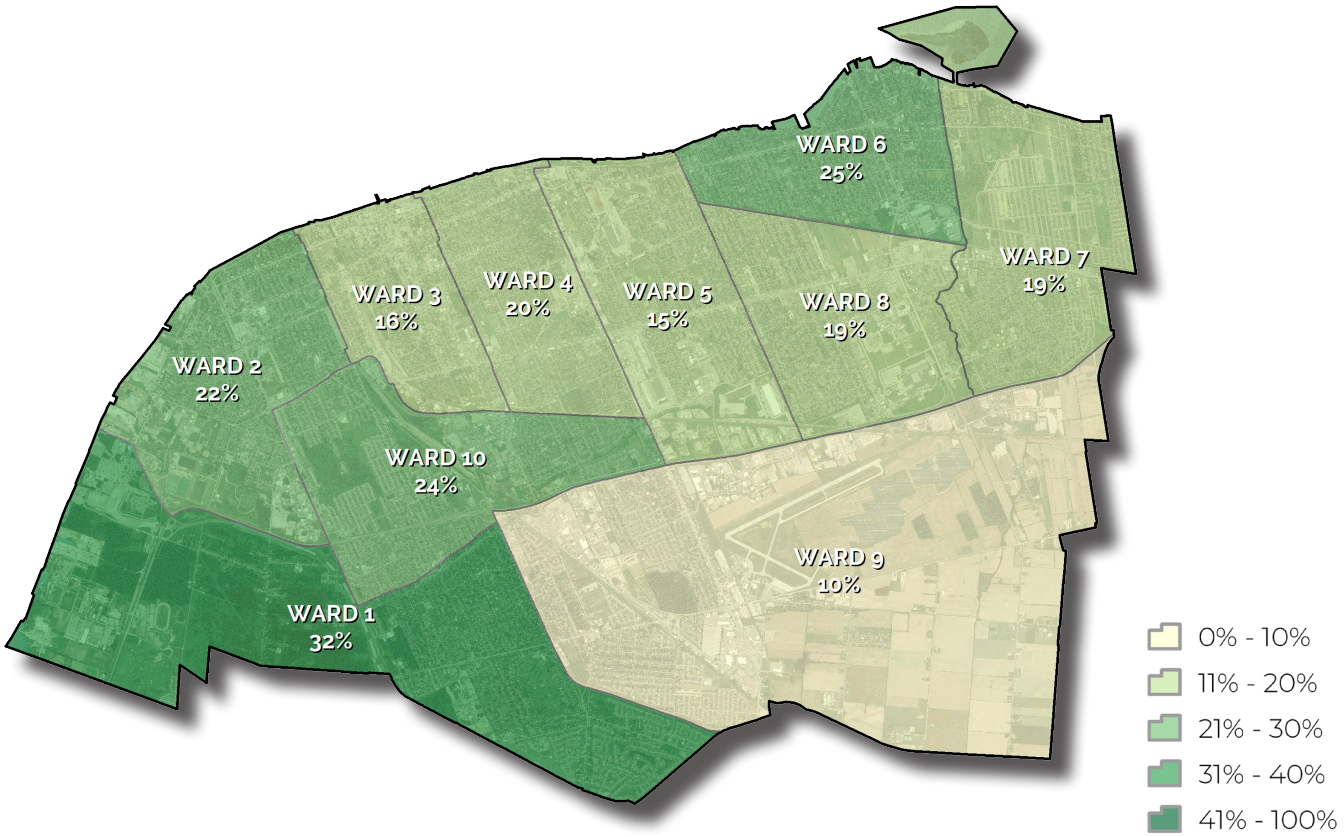


Figure 11. | Urban tree canopy in Windsor by wards.

URBAN TREE CANOPY BY IMS DISTRICTS

Windsor was divided into 25 Incident Management System (IMS) Districts to provide a standardized approach to emergency management. UTC and PPA were assessed within these districts. UTC varied greatly throughout Windsor's IMS districts with the lowest found in Industrial Park - South (3%) and the highest UTC found in Fazio (40%). At 11% each Ojibway and Riverside contained the greatest portion of all tree canopy in Windsor. PPA also varied greatly with Tecumseh (10%) containing the least and Industrial Park - North (41%) containing the most. The greatest opportunity for future tree plantings is found in Riverside which contained 12% of all PPA in Windsor.

Table 6. | Urban Tree Canopy assessment results by IMS districts. UTC and PPA results include hectares, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each IMS district.

IMS Districts	Land Area		Urban Tree Canopy			Possible Planting Area		
	Hectares	*Dist.*	*Hectares*	*%*	*Dist.*	*Hectares*	*%*	*Dist.*
Central	394	3%	46	12%	2%	106	27%	3%
Core - East	776	5%	114	15%	4%	161	21%	4%
Core - South	201	1%	53	26%	2%	60	30%	2%
Core - West	486	3%	101	21%	4%	138	28%	3%
Devonwood	510	4%	103	20%	4%	136	27%	3%
Fazio	408	3%	164	40%	6%	135	33%	3%
Ford	685	5%	129	19%	5%	202	29%	5%
Forest Glade	729	5%	127	17%	5%	261	36%	7%
Fountainebleu	366	3%	83	23%	3%	119	32%	3%
Industrial Park - North	355	2%	25	7%	1%	145	41%	4%
Industrial Park - South	252	2%	8	3%	0%	67	27%	2%
Jefferson	249	2%	58	23%	2%	71	29%	2%
Kenilworth	249	2%	61	24%	2%	80	32%	2%
Ojibway	922	6%	304	33%	11%	326	35%	8%
Remington Park	415	3%	65	16%	2%	126	30%	3%
Riverside	1,383	10%	296	21%	11%	467	34%	12%
Roseland - East	637	4%	112	18%	4%	200	31%	5%
Roseland - West	413	3%	121	29%	4%	141	34%	4%
Sandwich	765	5%	159	21%	6%	254	33%	6%
South Cameron	646	5%	177	27%	6%	215	33%	5%
South Windsor - North	217	2%	59	27%	2%	69	32%	2%
South Windsor - South	388	3%	145	37%	5%	114	29%	3%
Tecumseh	2,507	17%	146	6%	5%	256	10%	7%
Villages	39	0%	11	29%	0%	10	26%	0%
Walkerville	336	2%	74	22%	3%	76	23%	2%
Totals	**14,326**	**100%**	**2,739**	**19%**	**100%**	**3,933**	**27%**	**100%**

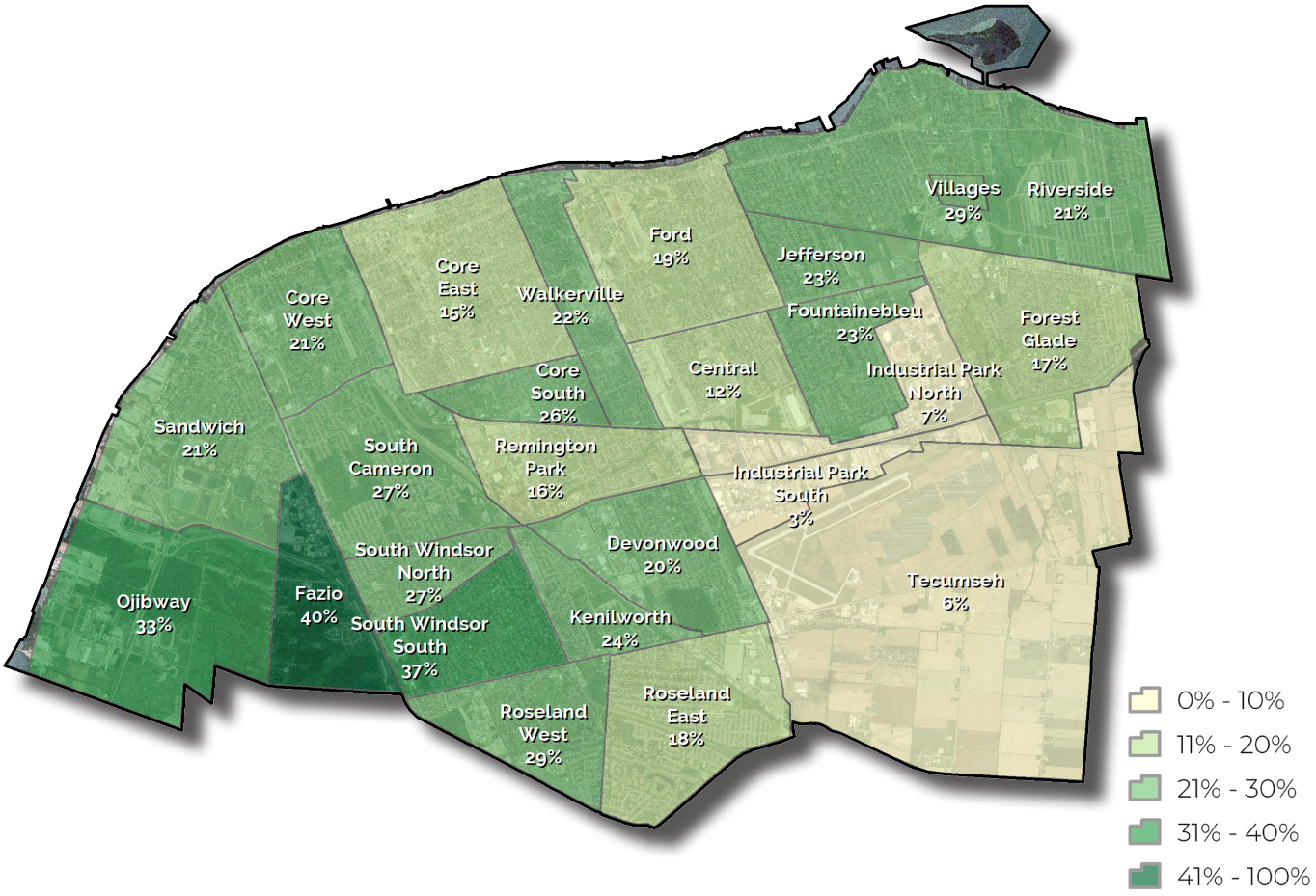


Figure 12. | Urban tree canopy in Windsor by IMS districts.

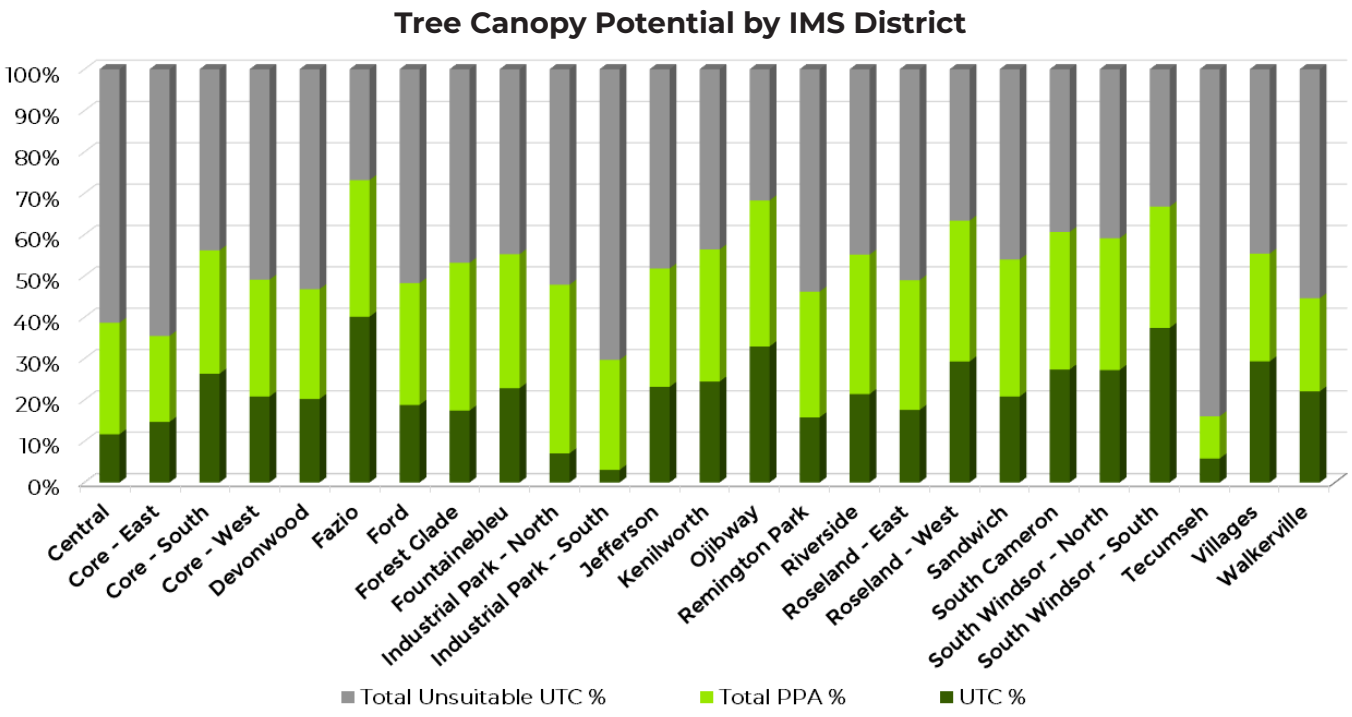


Figure 13. | Urban tree canopy, possible planting area, and area unsuitable for UTC by IMS Districts.

URBAN TREE CANOPY CHANGE ANALYSIS

In addition to assessing Windsor's current UTC based on 2019 imagery, this study also mapped and quantified UTC in 2002 and 2010 and measured the changes between each year. While the current assessment mapped detailed land cover using GIS polygons to represent tree canopy, the canopy change assessments were conducted using a point-based sampling method to limit costs while still following scientifically-based protocols.

METHODS

To assess changes in tree canopy between 2002 and 2010, a random point-based sampling method based on the i-Tree Canopy tool was used. The process was performed using the city boundary of Windsor. Random points were generated within the assessment boundary and manually assigned a value of "Tree" (1) or "Not a tree" (0) until a 1 percent standard error was reached. This required 1,100 points for both assessment years.

To calculate the percent tree cover and SE, let:
N = total number of sampled points (1,100)
n = total number of points classified as tree in 2002 (135), and
p = n/N (135/1,100 = 0.12)
q = 1 – p (1 - 0.12 = 0.88)
SE = √ (pq/N) (√ (0.12 x 0.88 / 1,100) = 0.098)
Thus, tree cover in Windsor in 2002 is estimated at 12% with a SE of 1%. Based on the SE formula, SE is greatest when p=0.5 and least when p is very small or very large (Table 1)

$$SE = \sqrt{\frac{p(1-p)}{n}}$$

Estimate of SE (N = 1100) with varying p.

p	SE
0.01	0.003
0.1	0.0090
0.3	0.0138
0.5	0.0150
0.7	0.0138
0.9	0.0090
0.99	0.003

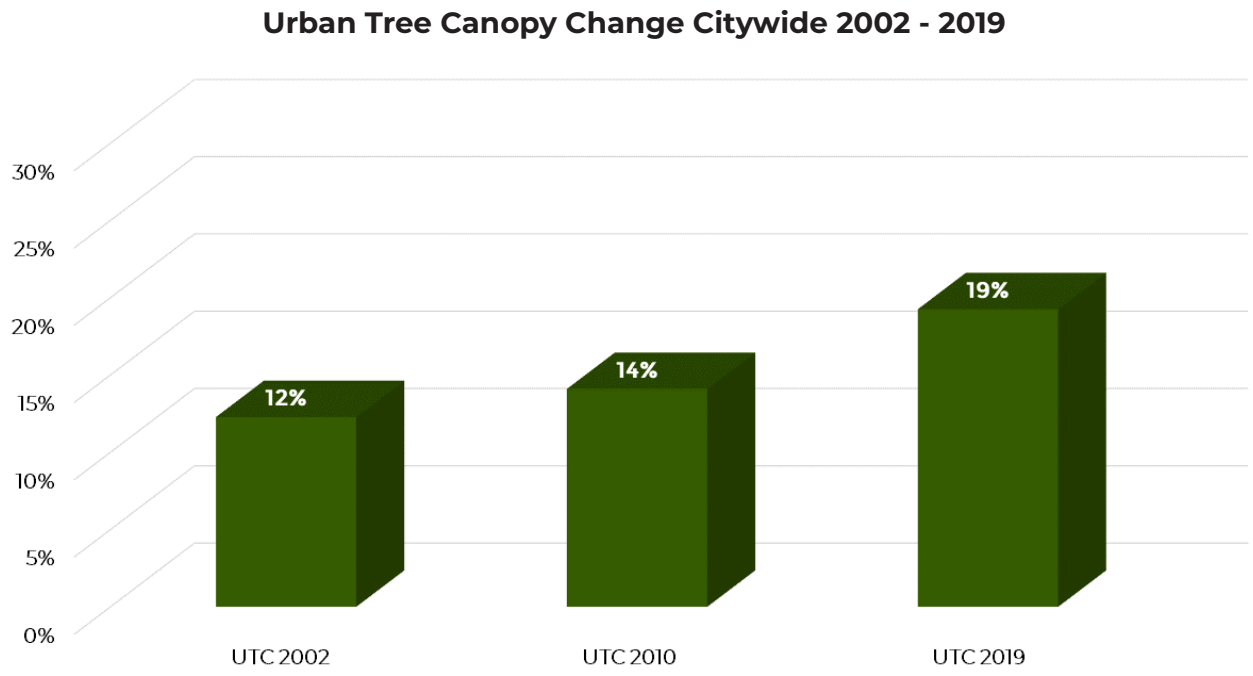


Figure 14. | Urban tree canopy change in Windsor.

RESULTS

The assessment produced citywide tree canopy percentages of 12% in 2002 and 14% in 2010. Canopy cover increased by 2% in between 2002 and 2010 despite emerald ash borer (EAB) detection and the City's subsequent removal of 7,000 ash trees. There was a 5% increase between 2010 and 2019 and a 7% increase between 2002 and 2019. Tree canopy has grown steadily for the last 17 years in Windsor. Tree canopy growth was slightly less in the eight years between 2002 and 2010, with most of the current canopy growth occurring since 2010 as shown in the example below (Figure 15). Current levels of urban tree canopy in Windsor can be maintained as long as future development does not call for the removal of established trees with large crown coverage and with careful planning and planting efforts derived from the tree planting scenarios section of this report. However, Windsor has thousands of mature trees well over 100 years old which may eventually succumb to old age, stress, and other environmental factors. This may cause a decline in canopy cover over the next 20 year period if planting efforts are insufficient.

Table 7. | Urban tree canopy change analysis results.

	UTC 2002	UTC 2010	UTC 2019	Change (2002 - 2010)	Change (2010 - 2019)	Change (2002 - 2019)
Citywide	12%	14%	19%	2%	5%	7%

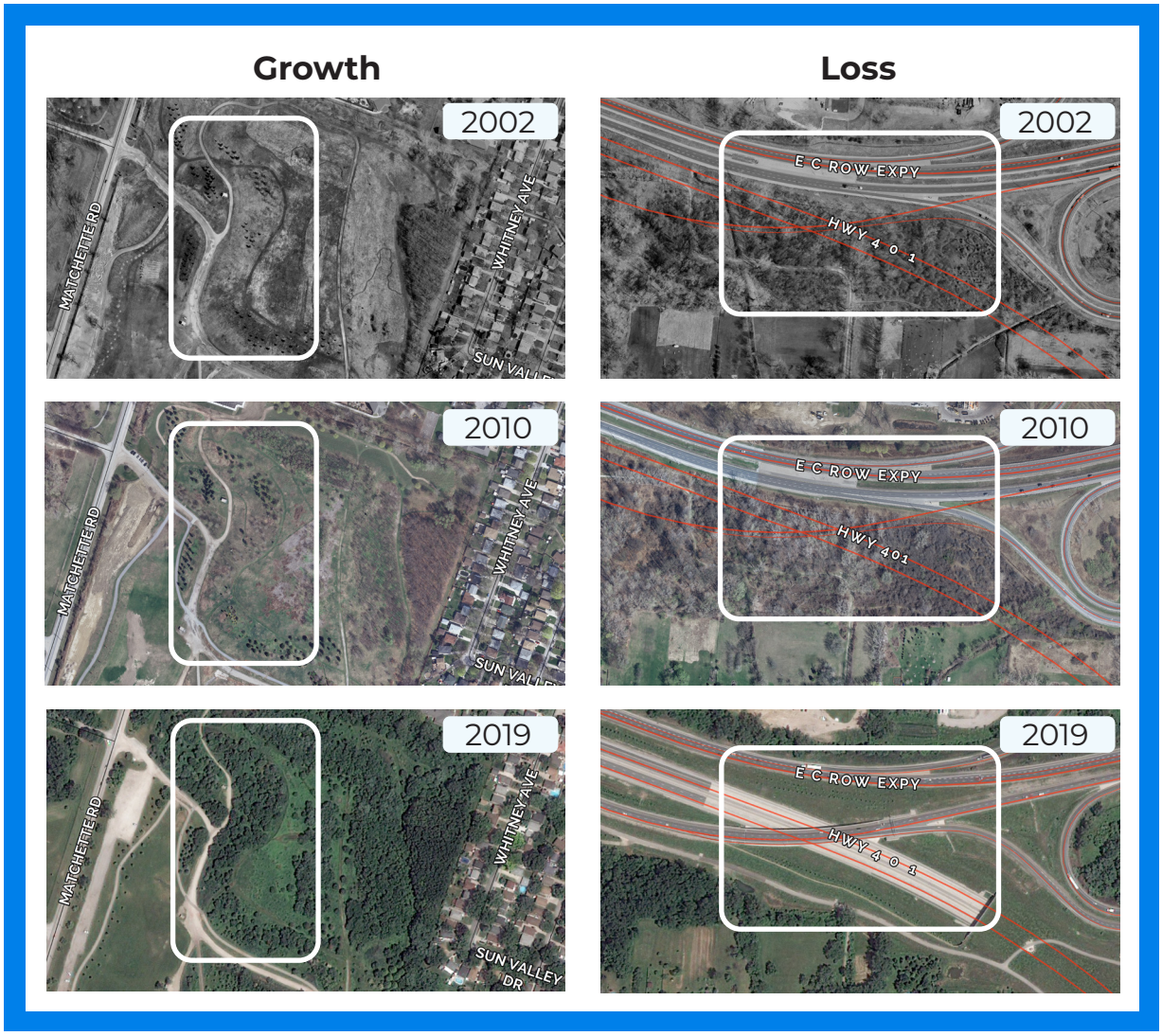


Figure 15. | Examples of urban tree canopy gain (left) and loss (right) in Windsor.

COMPARISON OF PLANTING SCENARIOS

A variety of possible planting scenarios were explored in order to assist the City in putting the UTC and PPA metrics derived in this study into action. These scenarios were designed to represent different approaches that the City could take when deciding where to plant new trees and to help synthesize the UTC and PPA data with their goals, priorities, and available resources. Using PlanIT Geo's Canopy Calculator tool, target canopy cover goals were established for a given area of interest, and the amount of canopy required to achieve those targets (in both hectares and number of trees planted) was calculated over a 30-year planning horizon. The calculator tool takes into account the estimated natural growth, regeneration, and loss of canopy due to mortality or development that would occur in that timeframe.

Planting scenarios were explored for the entire City of Windsor (14,535 ha land area with 2,798 ha of existing UTC). With input from City Administration and arborists, four scenarios were created representing a wide range of management approaches that the City could take over the next 30 years, from no new plantings to the maximum number of new plantings deemed realistic. The model's input parameters were also adjusted to reflect Windsor's unique urban forest structure. For example, the distribution of average crown sizes was calculated based on available inventory data from 2019. While some parameters were adjusted for each scenario (e.g. the number of trees planted), others remained constant throughout all possible scenarios (e.g. growth and mortality rates of trees). See the "Canopy Calculator Assumptions" box to the right and Table 8 below for more details about the planting scenario parameters.

CANOPY CALCULATOR ASSUMPTIONS

- **Planning horizon: 30 years**
- **Annual canopy growth of existing trees: 6%**
- **Annual natural regeneration: 3%**
- **New tree mortality rate: 3%**
- **Annual loss to mortality: 7%**
- **Annual loss to development: 0.4 ha**
- **Tree size distribution (average crown radius, percent of total tree population):**
  Small = 2m, 20%; Medium = 4m, 65%
  Large = 8m, 15%

Table 8. | Planting scenario descriptions and results. Note that in all four scenarios, the resulting natural regeneration equaled 49 ha (4% of initial UTC), canopy growth/mortality equaled -295 ha (-26%), and loss to development equaled -121 ha (11%) based on the constant input parameters. UTC in 2019 was 2,798 ha or 19%.

Scenario	Goal	UTC% in 2019	Planting Required		Net UTC Change		UTC% in 2049	
			hectares	no. of trees	hectares	%	hectares	%
No Action	Calculate the resulting UTC% in 2049 if no new tree plantings occur over the next 30 years.	19%	0	0	-367	-32%	765	13%
Maintain Existing UTC%	Calculate the number of tree plantings required to maintain the City's existing UTC% for the next 30 years. 2,186 trees per year would be required.	19%	363	65,578	-15	-1%	1,118	19%
Attainable Growth Option	Calculate the resulting UTC% in 2049 if the City plants 2,500 trees per year.	19%	403	72,750	36	3%	1,168	20%
Aggressive Growth Option	Calculate the resulting UTC% in 2049 if the City plants 5,000 trees per year.	19%	806	145,500	439	39%	1,571	27%

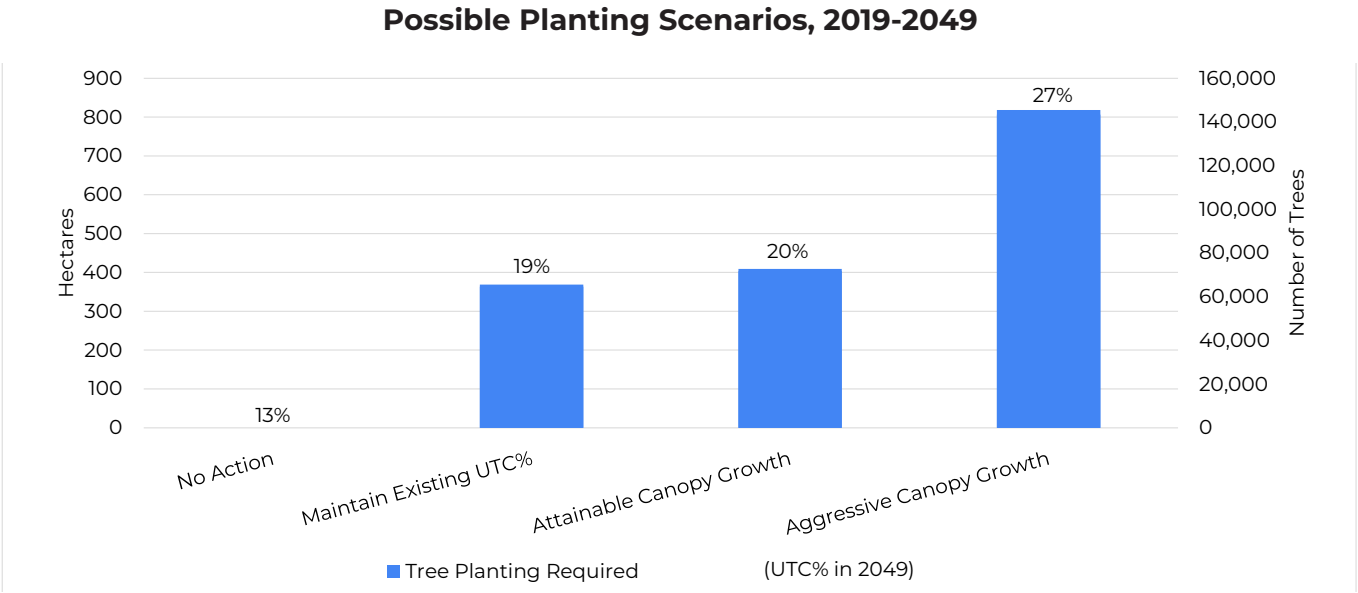


Figure 16. | After a 30-year planning horizon, Windsor's urban tree canopy in 2049 could vary from 13% if no new trees are planted to 27% if "aggressive growth" is implemented. Maintaining 2019 canopy levels (19%) requires approximately 2,200 new tree plantings per year.

In order to maintain the existing 19% tree canopy cover in Windsor, approximately 360 hectares or 66,000 individual trees would need to be planted throughout the 30-year planning horizon. If no new trees are planted, canopy could decline to 13% amidst natural mortality and losses to development.

Implementing the "attainable" growth option, meant to represent a realistic level of canopy increase for the City (2,500 trees per year), results in a slight increase in canopy from 19% to 20%. On the other hand, if a very "aggressive" planting schedule is implemented (5,000 trees per year), the City could hypothetically attain up to 27% canopy cover.

Therefore, the City can proceed with the knowledge that planting approximately 2,200 trees per year will maintain its canopy; 2,500 trees per year will increase canopy by 1%; and any additional plantings beyond that will continue to increase the City's canopy beyond 2019 levels.

To address the question of where to locate these new trees, the City can use the prioritization scores calculated as a part of this assessment. Wards and IMS districts received prioritization scores in the categories of low existing UTC%, high potential UTC%, air quality, public spaces, right-of-way, urban heat island, and an "overall" score that summarizes all the other categories. The map to the right displays these overall scores by IMS districts.

Districts with the greatest planting prioritization scores include Fazio, Industrial Park North & South, and Forest Glade.

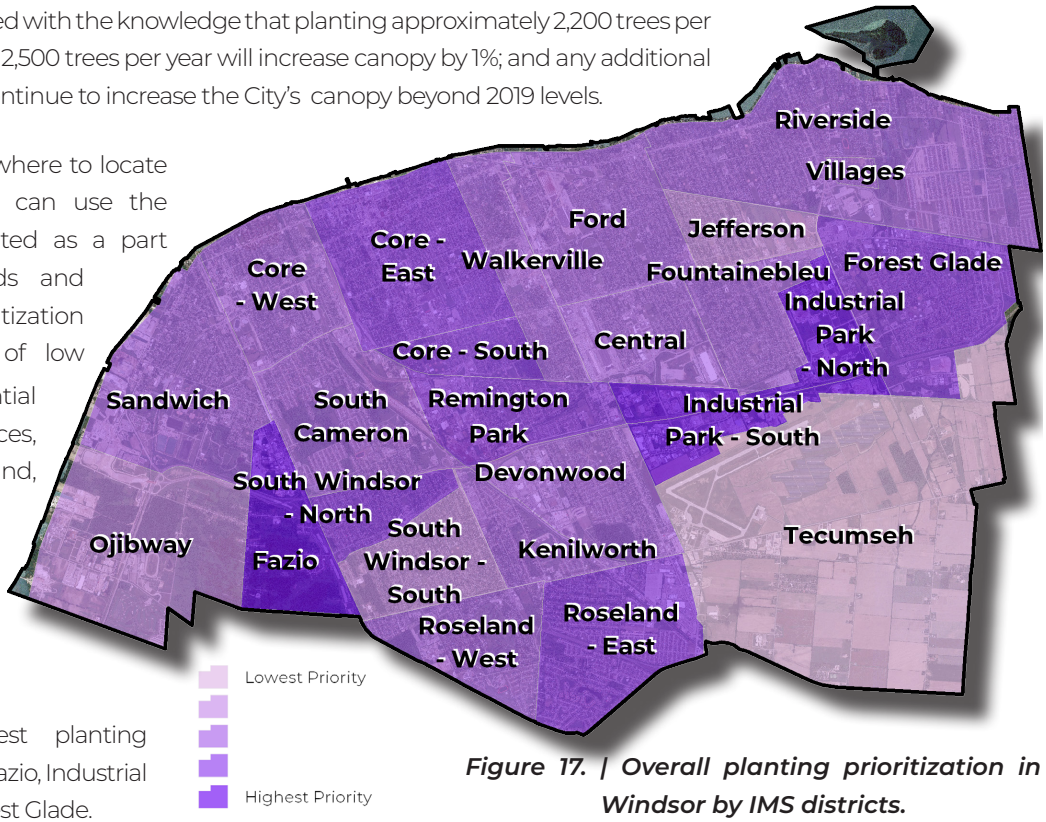


Figure 17. | Overall planting prioritization in Windsor by IMS districts.

QUANTIFYING ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by trees and forests in Windsor. i-Tree is a set of scientific-based tools collaboratively developed by the USDA Forest Service, Davey Tree Expert Company, The Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry.

Ecosystem service values from i-Tree Landscape were extracted using forests in Detroit, Michigan as a proxy for those in Windsor since ecosystem service values were only available in the U.S. Canopy cover from this tool is from a 30-meter national land cover dataset (NLCD) which often does not capture the full extent of canopy cover especially in urban areas. To make this value more representative of actual canopy cover in Windsor, canopy cover was adjusted to the total number of hectares found in this study and the ecosystem service values found in the tool were adjusted accordingly. All values were converted to metric units and Canadian dollars.

The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction, and stored carbon. The benefit values below represent a broad look at the value provided by all trees in Windsor, on public and private property. However, detailed information on individual trees such as species, age, health, and location (in the right-of-way versus a natural area or woodlot) were not accounted for in this study. Tree inventory data and other i-Tree tools can be used to look at the value provided by individual trees. The approach used in this study represents the best available technique for understanding the values provided by the entire urban forest in Windsor in 2019.

AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperatures, and improve public health by reducing air pollutants which cause death and illness. Benefit values were produced using “local tree cover, leaf area index, percent evergreen, weather, pollution, and population data to estimate pollution removal and values”. See more information on i-Tree’s website.

- The existing tree canopy in Windsor removes 195 metric tons of air pollution annually, valued at $1,963,845.

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. Benefit values were produced “using estimates of transpiration, precipitation interception, and avoided runoff using the i-Tree Eco Model and local leaf area indices and weather data”. See more information on i-Tree’s website.

- On average, each hectare of tree canopy in Windsor absorbs over 75,000 liters of water. This benefit of avoided runoff is valued at roughly $573 (CAD) per hectare/per year. Extrapolated citywide, this means that Windsor’s existing tree canopy provides $1,603,313 annually in stormwater benefits.

CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a temperate forest, the rate and amount increase with age. Benefit values were produced using factors such as local estimates of carbon accumulation from tree growth and estimates of carbon lost through decomposition due to tree mortality. See more information on i-Tree's website.

- Windsor's trees store approximately 247,297 metric tons of carbon, valued at $55,315,175, and each year the tree canopy absorbs and sequesters approximately 6,783 metric tons of carbon dioxide, valued at $1,517,409.

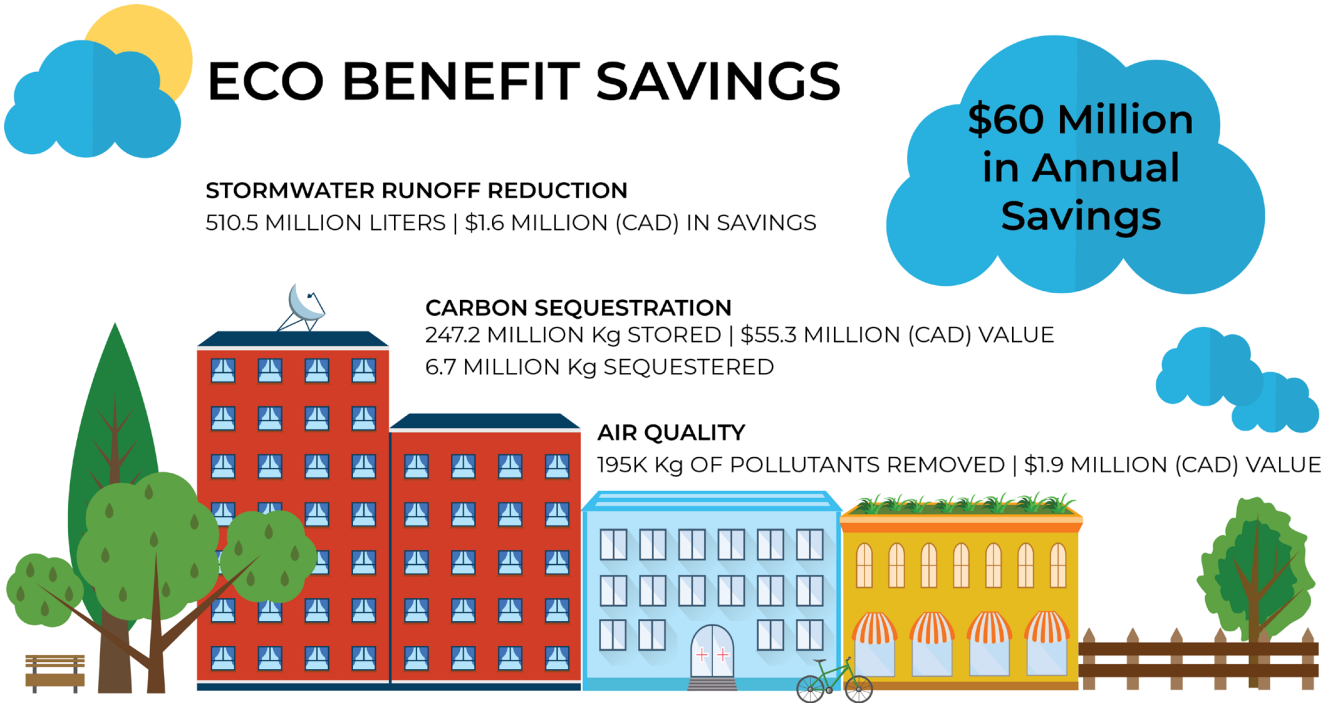


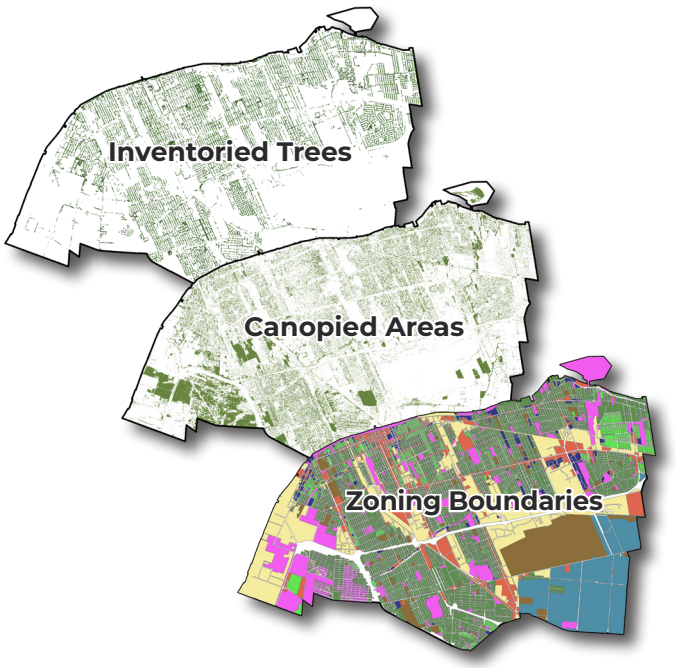
Figure 18. | Ecosystem services of Windsor's urban forest, in CAD.

URBAN FOREST INVENTORY ASSESSMENT

To get a complete picture of a community's urban forest, it must be observed from multiple angles. Whereas a geospatial tree canopy assessment provides a broad-scale view of where the City's existing trees and plantable areas are located, it does not offer information about the individual trees or planting sites themselves. Conversely, while a field inventory assessment provides information about the individual trees, such as their species, size/age, health, maintenance needs, or size and location of the planting space, it does not yield the total area of canopy or percentage of canopy coverage within a geographic area. For this reason, it is imperative that cities assess their urban forest from both the "top-down" with a canopy analysis and the "bottom up" with an inventory. By combining the urban tree canopy (UTC) data derived in this study with the City's inventory data collected in the field, new insights about Windsor's urban forest structure and composition were revealed that could not be obtained from either the UTC or inventory assessments alone.

METHODS

The first step in this process was to perform the UTC assessment using remote sensing and GIS tools as described in the "Project Methodology" section of this report (Page 6) to quantify Windsor's total tree canopy and its distribution throughout the City. At the same time, a field inventory assessment of all street and park trees managed by the City was performed to collect data regarding the trees' unique characteristics and management concerns. For each tree, ISA certified arborists from Urban Forest Innovations recorded the location (X/Y coordinates, City IMS Area, address, and planting space type); species (common and botanical names); size (DBH or "diameter at breast height," a standard measure of tree size at ~1.4-meters height, in cm.); as well as ratings for the tree's health, structure, and risk of failure (scales of 1-4), among other observations.



Once all field data was collected, it was analyzed throughout the full City boundary. The results are presented below. While these results can be viewed as a summary of the entire City's urban forest attributes, in reality, they only apply to the areas that were inventoried. An inventory of street and park trees within the City's care does not necessarily capture the characteristics of the complete urban forest, which includes an even larger number of trees on private property. For example, in Windsor, 46 percent of urban tree canopy is found in Low-Density Residential-zoned areas which likely include many trees in yards. Therefore, to create a more accurate depiction of Windsor's urban forest, the inventory results were split up into smaller categories and extrapolated to the full urban forest extent to model the distribution of tree characteristics in areas that could not be inventoried.

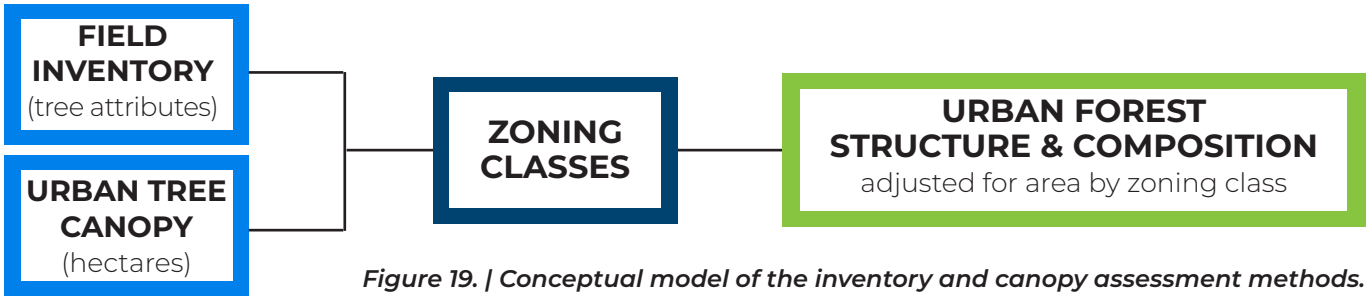


Figure 19. | Conceptual model of the inventory and canopy assessment methods.

The inventory results were next analyzed within unique types of land use found in Windsor to see how their particular attributes differed. To ensure consistency across methods, the same geographic boundaries from the canopy assessment (Zoning classes from the State of the Canopy and Key Findings section, Page 14) were used to subdivide the inventory results for further analysis. Finally, all inventory attributes separated by zoning class were multiplied by the area of canopy within that zoning class to get an estimated citywide area (in hectares and percent) of canopy coverage with specific inventory attributes (e.g. species and size). These results were then compared with the inventory results for the total City boundary to see how they differed when adjusted for canopy areas by zoning type.

LIMITATIONS

Because the tree canopy assessment and field inventory were performed separately rather than in conjunction, some other statistical methods of assessing species, size, or health of trees by area were unable to be performed. For example, i-Tree Eco is able to estimate values such as species composition by area, but that process requires the use of stratified field inventory sample plots that are generated within the tool prior to beginning the field inventory. Another option for quantifying canopy by species that was considered is an assessment of hyperspectral imagery (e.g. an image with many bands which then undergo "band algebra" to derive a more detailed land cover classification dataset), however, that was not possible within the scope of this project and the specific type of imagery (1-m multispectral Pleiades satellite imagery) and object-based image classification that was implemented.

For these reasons, it was determined that stratifying the inventory sample data by a sub-geography of interest from the canopy analysis (in this case, Zoning) and then combining the two assessments' results within those classes was the most logical and feasible approach. However, it is important to note that in order to estimate values for areas that could not be inventoried, this approach requires the assumption that all tree canopy within a given zoning class will share the same attributes, which may not necessarily be true. As the map to the right and chart below illustrate, some zoning types (such as low-density housing) had a relatively higher amount of inventoried trees-per-area, while others (such as green space) had fewer.

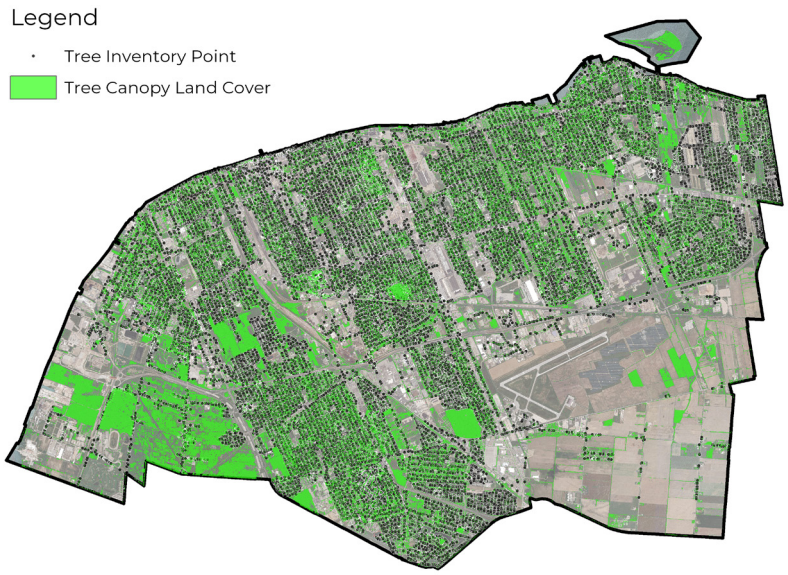


Figure 20. | Comparison of tree canopy cover identified in the UTC assessment with locations of inventoried street and park trees.

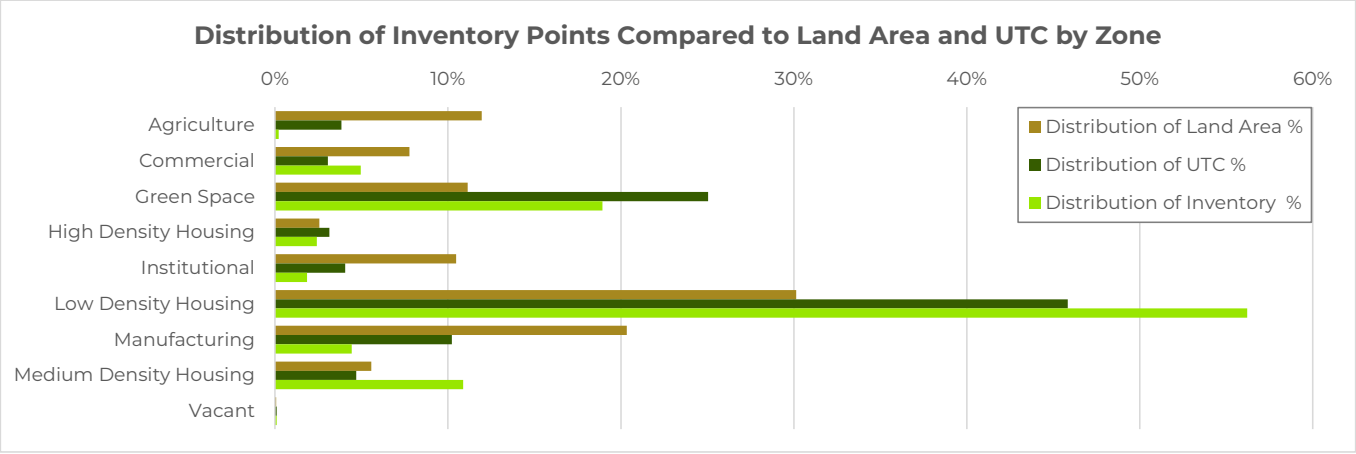


Figure 21. | Comparison of land area, canopied area, and inventoried trees within each zoning type.

RESULTS

A total of 86,635 trees were inventoried in Windsor's parks and rights-of-way. Data was collected on each tree's species, size, health, structure, risk rating, and other attributes of interest. A total of 162 unique species and 77 unique genera were identified. The most common species were the honeylocust, Norway maple, and silver maple, each comprising approximately 9-10% or 200 hectares or more of Windsor's total urban tree canopy. Species composition varied throughout zoning types. Low-density housing contained the greatest number of unique species (148) followed by green space (137) while the fewest were found in agriculture (39) and vacant land (24).

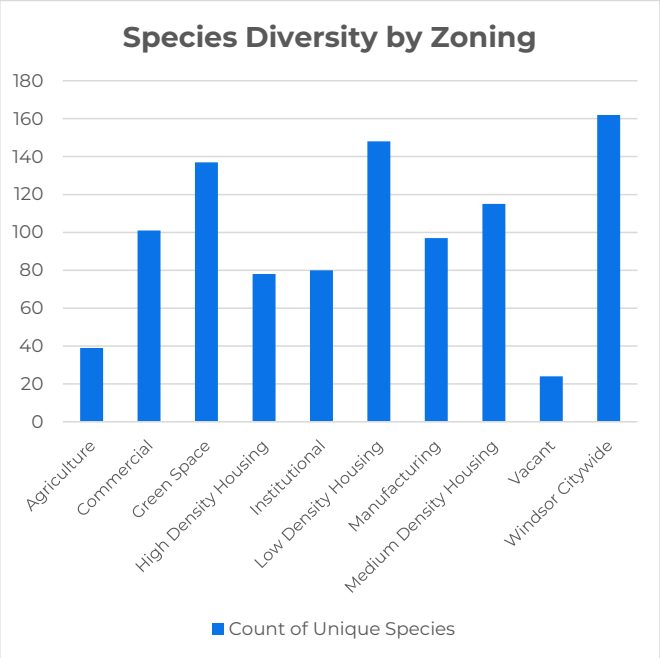


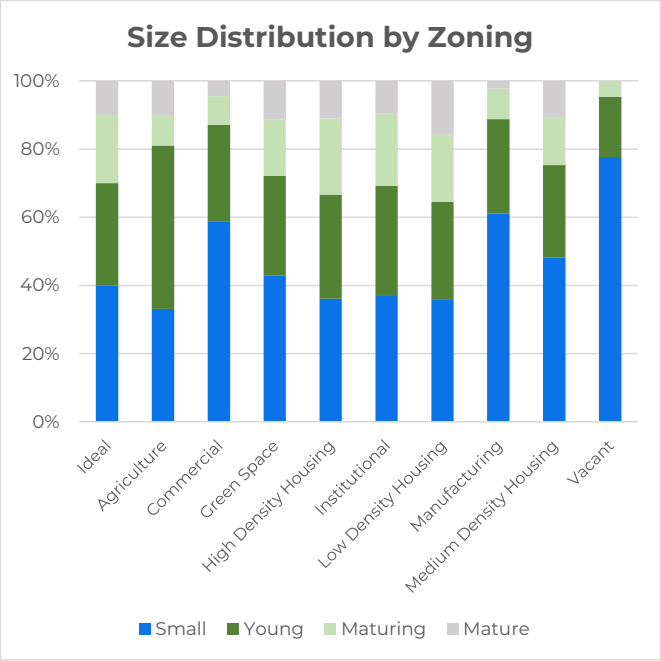
Figure 22. | Counts of species identified within zones.

In addition to the number of species, another measure of diversity is how much of the urban forest each species makes up. In some places, the top species were of concern due to its prevalence. The "10-20-30" rule proposed by Santamour and considered an industry standard for urban forest management states that in order to maintain a healthy species diversity when designing the urban forest, a community should plant no more than 10% of any one species, 20% of one genus, and 30% of one family. In particular, Windsor's institutional, commercial, and high-density housing zones contained 19%, 16%, and 13% honeylocust, respectively, while low- and medium-density housing each contained 12% Norway maples and vacant zones contained 15% littleleaf lindens, putting each of these areas at risk for catastrophic losses if a pest or disease affecting those species were to arrive.

Table 9. | Tree species diversity for the 10 most common species, as a percent of trees inventoried and in hectares and percent of UTC.

	Tree Inventory Data		Canopy Calculations	
Tree Species	**# of Trees**	**% of Inventory**	**UTC area (ha)**	**% of UTC**
Honeylocust	9,495	11%	223	10%
Norway Maple	9,017	10%	201	9%
Silver Maple	8,276	10%	199	9%
Littleleaf Linden	5,686	7%	127	6%
Bradford Pear	3,344	4%	77	4%
Lilac	3,214	4%	70	3%
Colorado Blue Spruce	2,989	3%	72	3%
Native Hackberry	2,983	3%	66	3%
Freeman Maple	2,474	3%	70	3%
Eastern White Cedar*	1,882	2%	44	2%
Top 10 Total	**49,360**	**57%**	**1,150**	**54%**
All Other species	**37,548**	**43%**	**982**	**46%**
Total	**86,908**	**100%**	**2,132**	**100%**

Table 1 on the left shows the species composition of Windsor's urban forest. First, the percentage of each tree species relative to the total inventory tree population was assessed by zoning type ("% of Inventory"). Next, this number was multiplied by the area of UTC identified within that zoning type, in hectares, to get an area of that species within that zone. Lastly, the UTC areas of that species were summed across all zoning types to get a total area of each species, and the percentage of that species relative to the City's total canopied area was calculated ("% of UTC"). For example, Norway Maples are the most common tree species in low-density housing areas, making up 12.35% of all trees inventoried there. Low-density housing areas contain a total of 977.26 hectares of urban tree canopy. Therefore, by multiplying 12.35% * 977.26 hectares, ~120 hectares of Norway maples are estimated to be found in low-density housing areas. Repeating this process for all zoning types and summing the results yielded ~201 total hectares of Norway maples in Windsor.



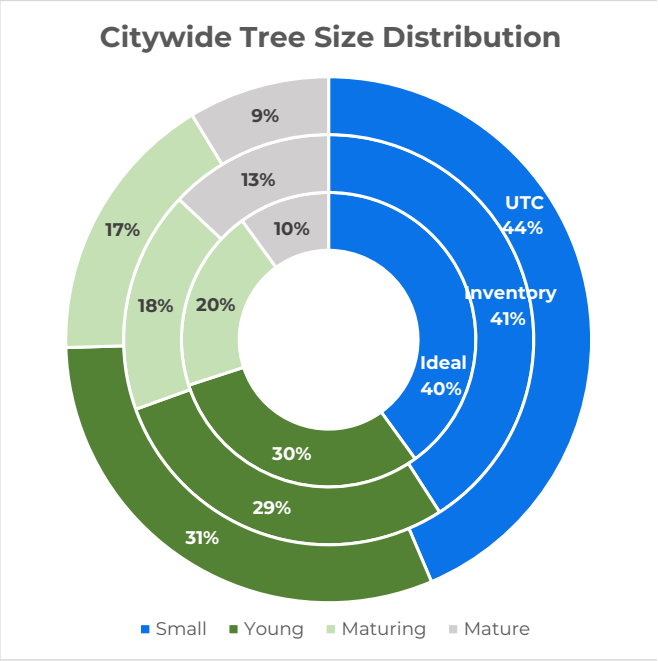


Figure 23. | Size distribution of inventoried trees by zoning class (left) and estimated for the total City area (right).

In terms of its size distribution, which is representative of the age structure of the urban forest, Windsor is fairly well aligned with recommended levels. McPherson's proposed "Ideal" distribution states that the greatest proportion of trees should always fall within the smallest size class so that there are enough new trees growing at any given time to replace large, mature trees that are lost to natural mortality, development, pests, disease, drought, etc. and prevent large losses in canopy from occurring. As the charts above illustrate, when the size structure of Windsor's inventoried areas by zoning types was extrapolated to the full City area, an estimated 44% of trees were in the Small size class (compared to the recommended level of 40%), 31% in the Young class (compared to 30%), 17% in the Maturing class (compared to 20%), and 9% in the Mature class (compared to 10%), indicating healthy proportions of trees of all size/ages.

The distribution of Windsor's trees by health, structure, and risk rating, each on scales of 1-4, were also assessed by zone and then estimated within the full City boundary. Results for tree health and risk of failure did not vary significantly from the inventory results when scaled to the full City area. However, when the trees' structural ratings were evaluated by zone and applied to the full City area, the trees appeared to be in better condition than they had initially appeared based on the inventory results alone, with a total of 20% shifting to a higher rating. This could imply that a disproportionate amount of the trees that were inventoried along public streets and in park areas were in poorer condition compared to the trees on private property, which could not be inventoried but were estimated based on known attributes for their zoning type. Trees on public property, particularly within the right-of-way, face unique threats that may lead to relatively poor health.. Overall, Windsor's urban forest is comprised of trees in good condition (79%) with good structure (58%) and a low risk of failure (96%).

Table 10. | Citywide health, structure, and risk ratings.

Health	Inventory %	UTC %
Good	79%	79%
Fair	19%	19%
Poor	1%	1%
Dead	1%	1%
Structure	**Inventory %**	**UTC %**
Good	39%	58%
Fair	57%	40%
Poor	2%	1%
Dead	2%	1%
Risk	**Inventory %**	**UTC %**
Extreme	0%	0%
High	0%	0%
Moderate	4%	5%
Low	96%	95%

CONCLUSIONS AND RECOMMENDATIONS

The City of Windsor has demonstrated that it values its natural resources and wishes to maintain a healthy and sustainable urban environment. This tree canopy assessment represents an important first step 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.

Target new tree plantings on city owned land within the right-of-way

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

To preserve, protect, and maintain Windsor's tree canopy, the City should have a tree canopy assessment performed on a regular interval of 5-7 years depending on presence of pests and diseases, storm events, and land development patterns. As the City changes, 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 Windsor with a wealth of environmental, social, and even economic benefits which relate back to greater community 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 expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Windsor's 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 and planting prioritization 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 canopy cover goals for the short- and long-term.

2. Use priority planting analysis to identify plantable ares within the right-of-way and other public lands

The City and its various stakeholders can utilize the results of the UTC, PPA, canopy change, and priority planting analyses to identify the best locations to focus future tree planting and canopy expansion efforts. Trees can play a large role in improving public health by improving air quality, reducing temperature, and making public spaces more inviting. The City should use the priority planting analysis to identify planting opportunities in areas with high concentrations of impervious surfaces, within the right-of-way, and on public lands throughout the City. Over 800 hectares of plantable space currently exist within the right-of-way. Trees planted along sidewalks and next to streets provide an abundance of benefits to the environment, residents, and visitors of Windsor.

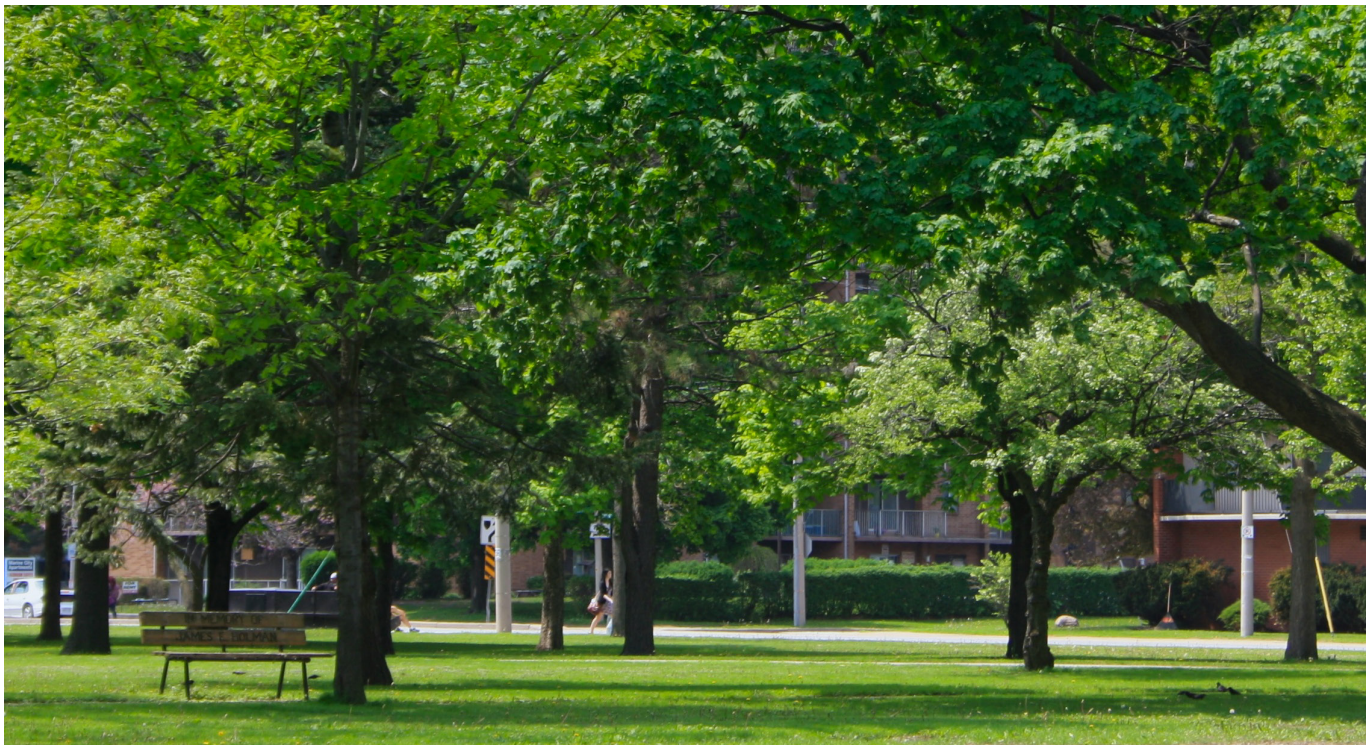
PLANTING 5,000 NEW TREES PER YEAR COULD INCREASE CANOPY IN WINDSOR BY 8% OVER 30 YEARS

3. Develop education and outreach programs towards private landowners

67% of all plantable space in Windsor was found on private property, and, more specifically, 38% is found in low density housing. The City should focus on community outreach and education programs to better inform citizens and private land holders of the environmental, social, and financial benefits trees provide and consider other strategies to help preserve and grow tree canopy. Tree giveaways, tree planting programs, and other incentives can be developed to further promote new tree plantings. In addition, the City should continue to conduct volunteer tree planting events to increase awareness and engagement levels in the community.

4. Focus new plantings in high priority areas

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, such as the map on page 21, show the areas of highest priority for all sustainability themes and land cover metrics. 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 air quality, urban heat, and human health. For example, the Industrial Park North and Industrial Park South wards have some of the lowest existing canopy percentages (7% and 3%, respectively) combined with some of the highest percentages of impervious area (50% and 57%), making them ideal targets to expand canopy. Focusing urban forest management resources on expanding and maintaining tree canopy in this area 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 the businesses that this highly urbanized region is home to, in order to promote new tree plantings and continued tree maintenance which will be particularly important for new trees trying to get established in an industrial environment.



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 2019. This accuracy assessment was completed using high resolution satellite imagery, with computer and manual verification. No field verification was completed.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS

1. Seven hundred and fifty (750) sample points, or approximately 5 points per square kilometer area in Windsor (147 sq. miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the Pleiades satellite image 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]

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 Windsor'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

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.

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 (131 + 258 + 264 + 67 + 10 = 730 / 750 = 97%), and the matrix can be used to calculate per class accuracy percentage's. For example, 141 points were manually identified in the reference map as Tree Canopy, and 131 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: (131/141 = .93), meaning that we can expect that ~93% of all 2019 tree canopy in the Windsor, ON study area was classified as Tree Canopy in the 2019 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, 131 classification pixels intersecting reference pixels were classified as Tree Canopy, but 3 pixels were identified as Vegetation in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (131/134 = 0.98), meaning that ~98% 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 Windsor in 2019. The largest sources of classification confusion exist between tree canopy and vegetation.

Table A1. | Error matrix for land cover classifications in Windsor, ON (2019).

Classification Data	Reference Data: Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	131	3	0	0	0	134
Vegetation	9	258	0	0	0	267
Impervious	1	6	264	1	0	272
Soil / Dry Veg.	0	0	0	67	0	67
Water	0	0	0	0	10	10
Total	141	267	264	68	10	750

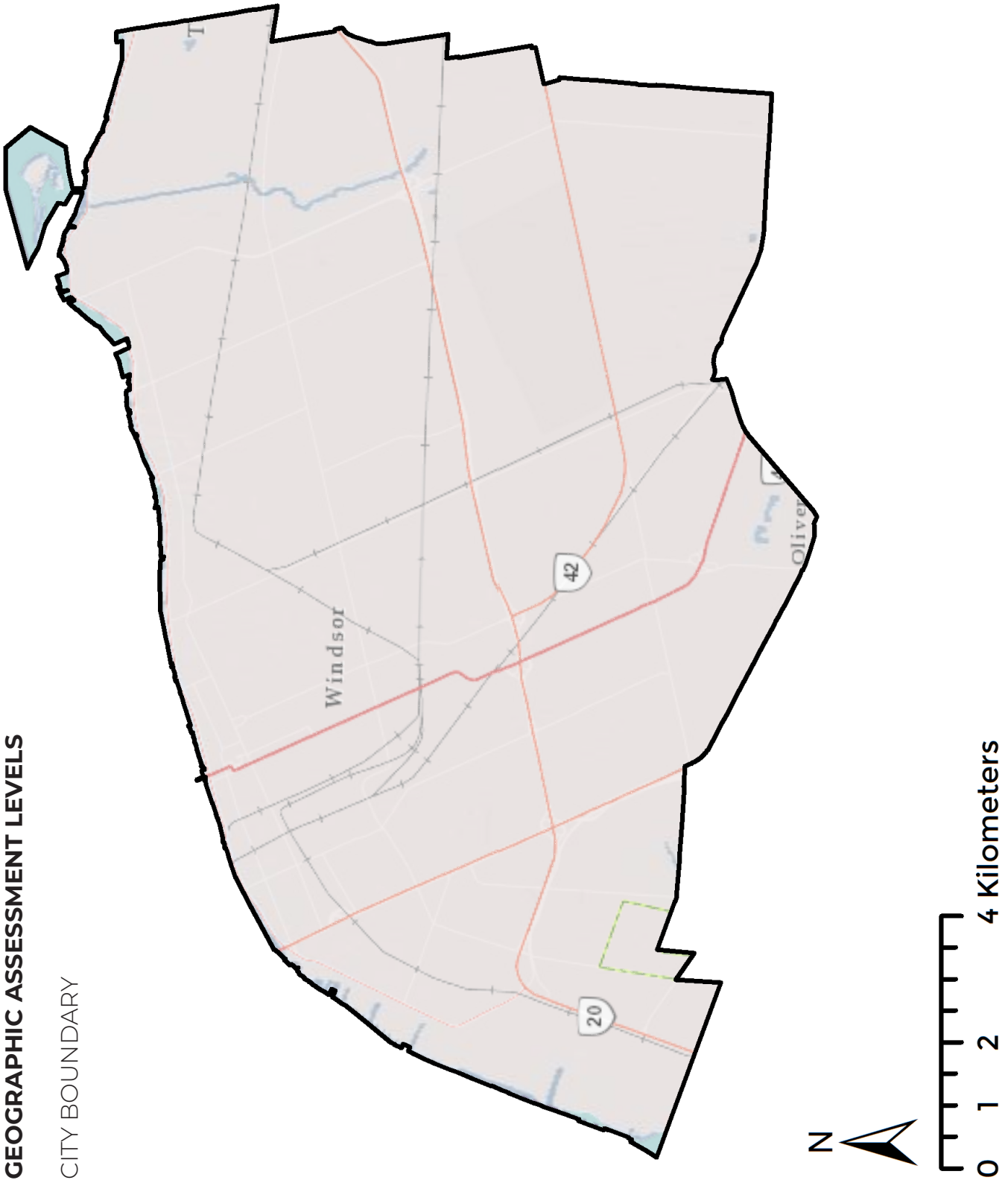
Overall Accuracy = 97%

Producer's Accuracy	
Tree Canopy	93%
Veg. / Open Space	97%
Impervious	100%
Bare Ground / Soil	99%
Water	100%

User's Accuracy	
Tree Canopy	98%
Veg. / Open Space	97%
Impervious	97%
Bare Ground / Soil	100%
Water	100%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Windsor'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 2019 data indicates that regardless of how and when it was achieved, Windsor's current tree canopy can be safely assumed to match the figures stated in this report (approximately 19%).


GEOGRAPHIC ASSESSMENT LEVELS
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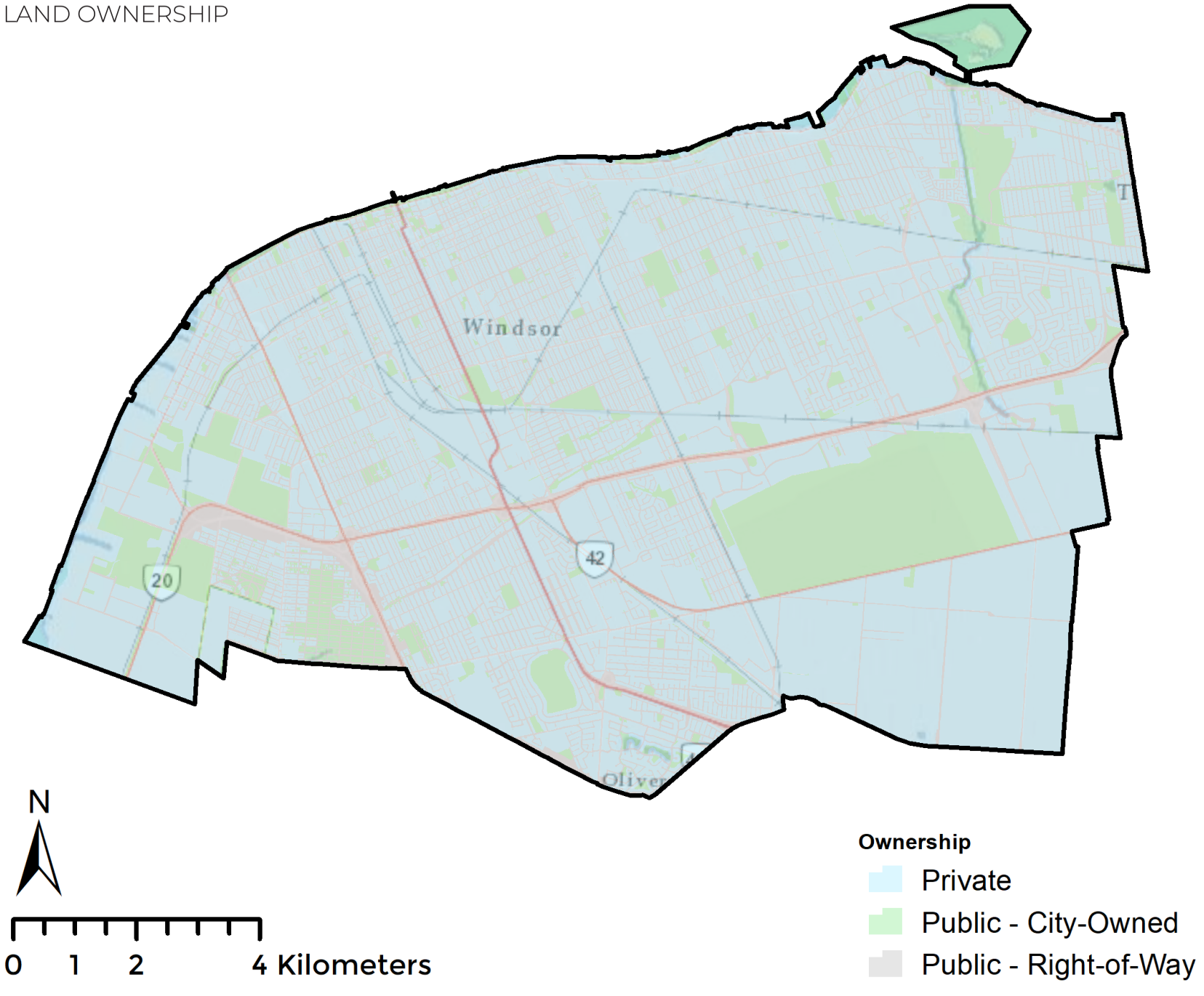
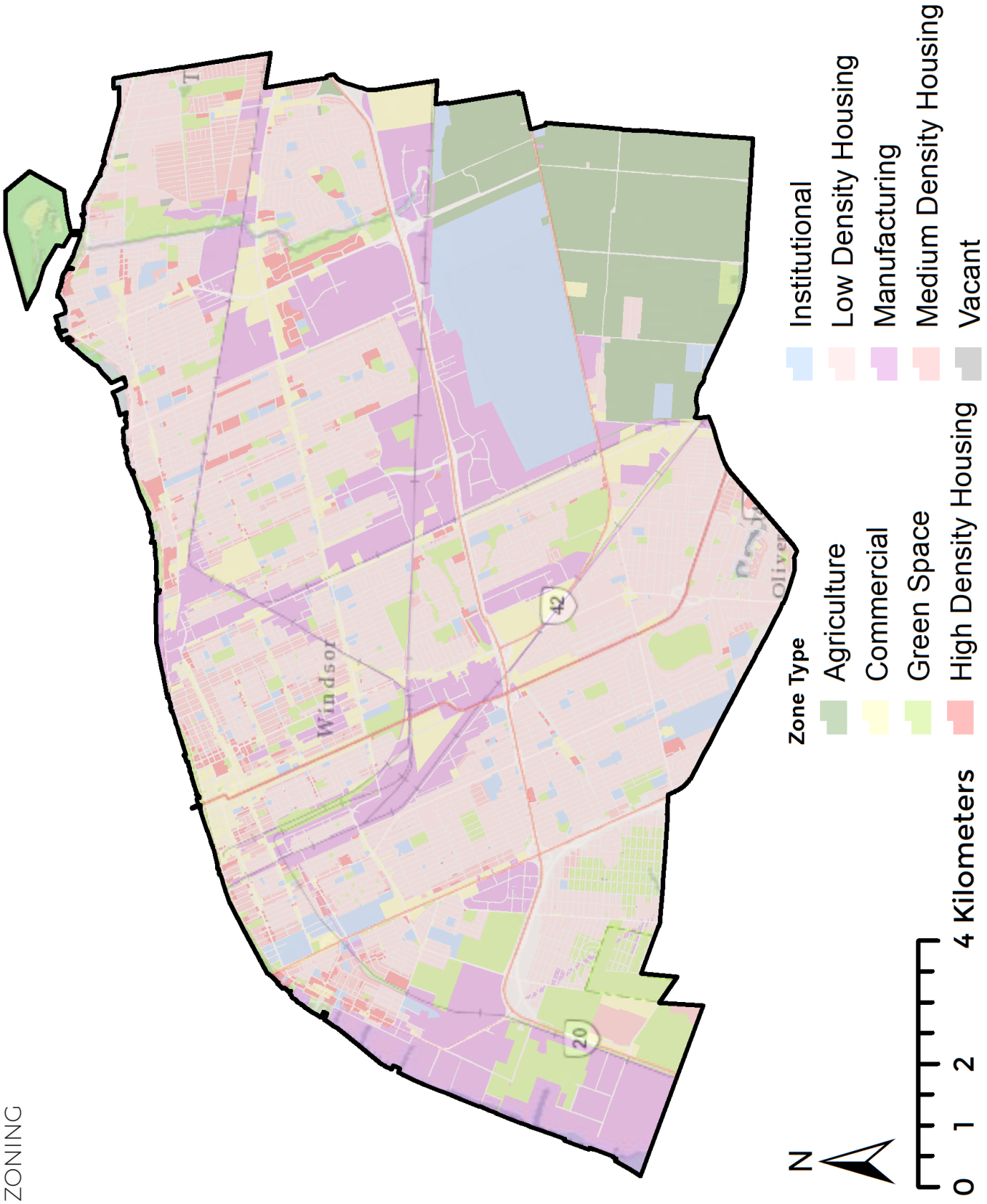
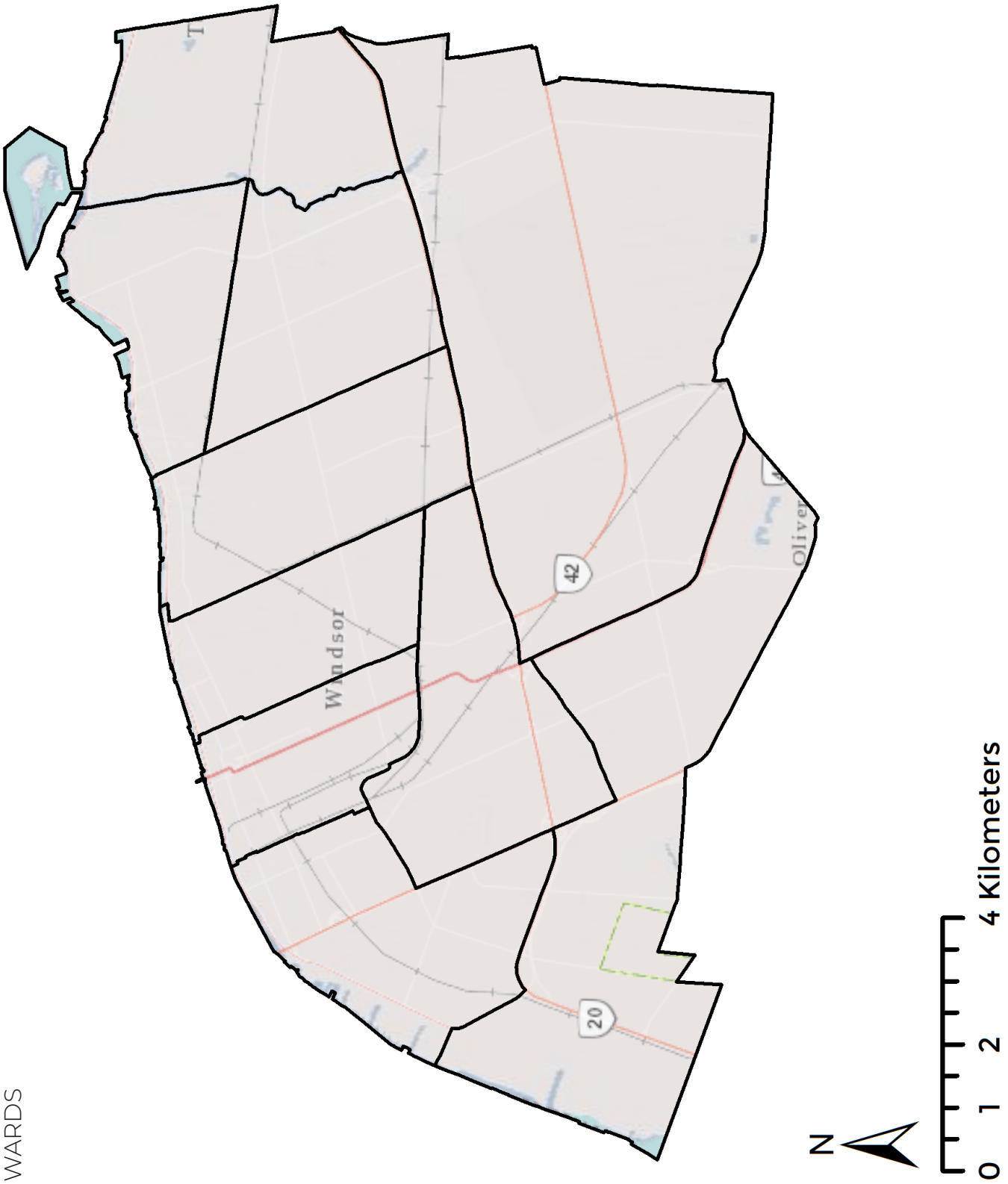
LAND OWNERSHIP



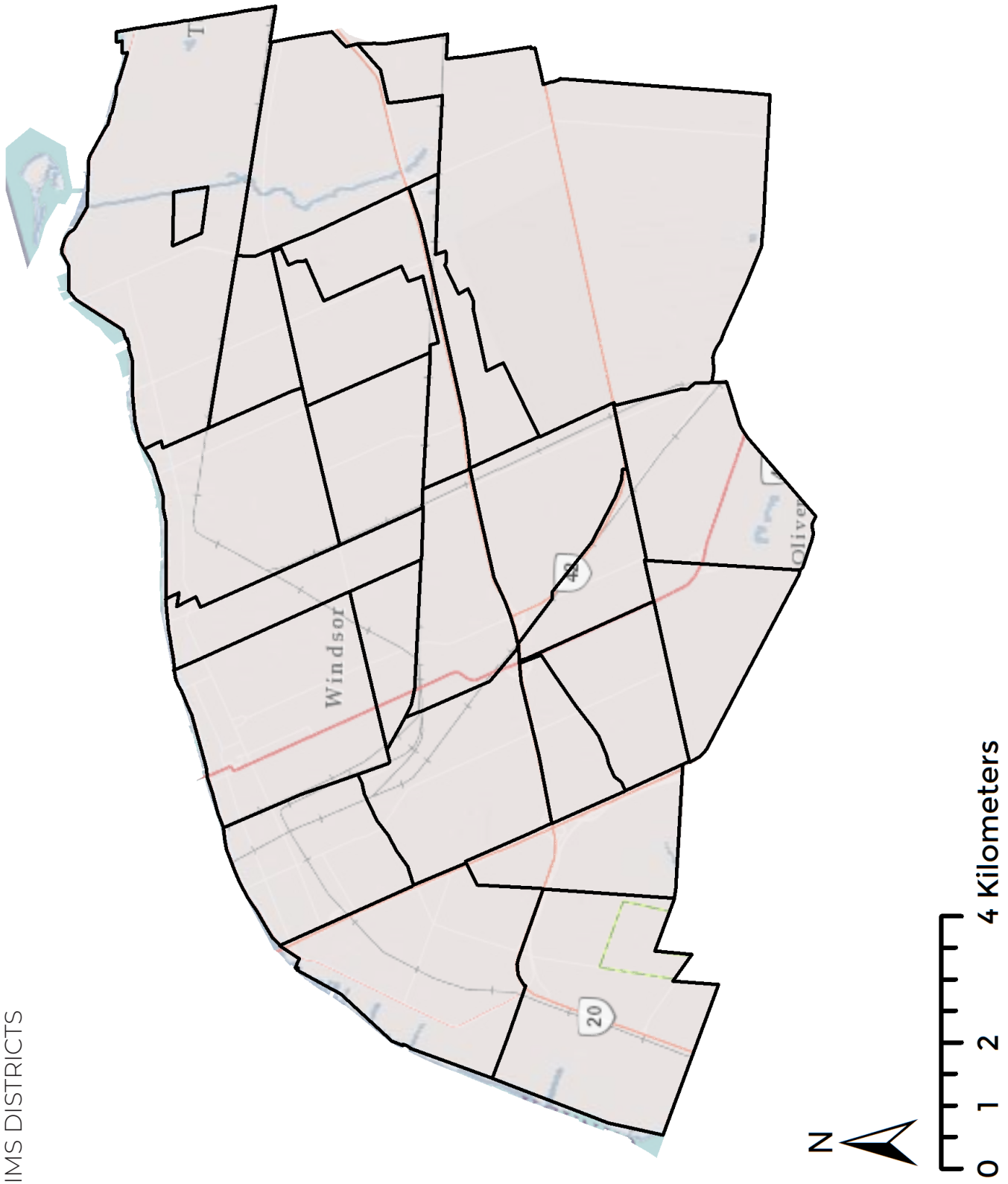
ZONING


Zone Type
Agriculture
Commercial
Green Space
High Density Housing
Institutional
Low Density Housing
Manufacturing
Medium Density Housing
Vacant
N
0
1
2
4 Kilometers
Windsor
42
20



WARDS

IMS DISTRICTS



PROJECT DATA

The following datasets and files were provided to the City of Windsor in a separate data delivery. The files provided include:

1. Imagery:

a. 50-centimeter resolution, 4-band multispectral Pleiades satellite imagery collected in July 2019, clipped to the city boundary.

b. 1-meter resolution Pleiades satellite imagery resampled for tree canopy assessment purposes.

c. Normalized digital surface model (nDSM) showing relative height above the ground surface. Created from the CanElevation 2017 Lake Erie LiDAR collection.

2. Land Cover Classification: Provided in raster and vector formats:

a. All-class land cover GIS raster layer including tree canopy, non-canopy vegetation, impervious surfaces, water, and bare soil/dry vegetation.

b. UTC class GIS raster layer including urban tree canopy, possible planting area vegetation, unsuitable vegetation, unsuitable impervious, unsuitable soil, and water.

c. Tree canopy GIS shapefile.

3. GIS Assessment Boundaries: UTC results provided in vector shapefile format with attribute fields (area/percent metrics) for each land cover class and UTC Type (UTC, PPA, Unsuitable UTC) for the following boundary layers (including metadata):

a. City Boundary (AOI)

b. Land Ownership

c. Zoning

d. Wards (with planting prioritization fields)

e. IMS Districts (with planting prioritization fields)

4. Project Maps:

a. Formatted MXD documents with stored relative paths linking to the assessment results in the 'UTC_Results' folder (Note: folder structure must be maintained to avoid breaking the data paths). Maps include land cover, UTC and PPA results by assessment boundaries, and planting prioritization categories.

b. Formatted project maps (exported from the MXDs provided) in PNG and PDF formats.

5. Reporting:

a. Final UTC Assessment Results spreadsheet including the area and percent of UTC/PPA for the assessment boundaries listed above, as well as UTC change.

b. Accuracy Assessment

c. Assessment report in PDF format (separate deliverable).

GLOSSARY/KEY TERMS

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

Natural Regeneration: The growth of trees by means of self-sown seeds. Natural regeneration occurs within and adjacent to existing trees and woodlands.

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 Hectares: Total area, in hectares, of the assessment boundary.

Unsuitable Impervious: Areas of impervious surfaces that are not suitable for tree planting. These include buildings, 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.

JANUARY | 2020

URBAN TREE CANOPY ASSESSMENT

WINDSOR, ONTARIO

THE CITY OF WINDSOR
ONTARIO, CANADA

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