



Tree Canopy Report: Kitchener, Ontario

Why is Tree Canopy Important?

Trees provide many benefits to communities, such as improving water quality, reducing stormwater runoff, lowering summer temperatures, reducing energy use in buildings, reducing air pollution, enhancing property values, improving human health, and providing wildlife habitat and aesthetic benefits¹. Many of the benefits that trees provide are correlated with the size and structure of the tree canopy (TC) which is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above. Therefore, understanding tree canopy is an important step in urban forest planning. A tree canopy assessment provides an estimate of the amount of tree canopy currently present as well as the amount of tree canopy that could theoretically be established. The tree canopy products can be used by a broad range of stakeholders to help communities plan a greener future.

¹National Research Council. *Urban Forestry: Toward an Ecosystem Services Research Agenda: A Workshop Summary*. Washington, DC: The National Academies Press, 2013.

How Much Tree Canopy Does Kitchener Have?

An analysis of the City of Kitchener based on land cover data (Figure 1) derived from high-resolution aerial imagery and LiDAR found that 3,474 hectares of the study area were covered by tree canopy (termed Existing TC). This represents 26% of all land in the study area (Figure 2). An additional 57% (7,767 hectare) of the city's land area could theoretically be modified to accommodate tree canopy (termed Possible TC). Within the Possible TC category, 40% (5,458 hectare) of total land area was classified as Vegetated Possible TC and another 17% as Impervious Possible TC (2,309 hectare). Establishing tree canopy on areas classified as Impervious Possible TC will have a greater impact on water quality and summer temperatures while Vegetated Possible TC, or grass/shrub, is more conducive to establishing new tree canopy where such lands are not agricultural, active parkland, meadow habitat, etc.



Figure 1: Study area and example of the land cover derived from high-resolution imagery for this project.

Project Partners

This project applied the USDA Forest Service's Tree Canopy Assessment protocols to the City of Kitchener. The analysis was conducted using imagery that was acquired in 2014 and LiDAR data that was acquired in 2014. The Spatial Analysis Laboratory (SAL) at the University of Vermont's Rubenstein School of the Environment and Natural Resources carried out the assessment in collaboration with the USDA Forest Service; the SAL has completed over 75 of these assessments in the US and Canada.

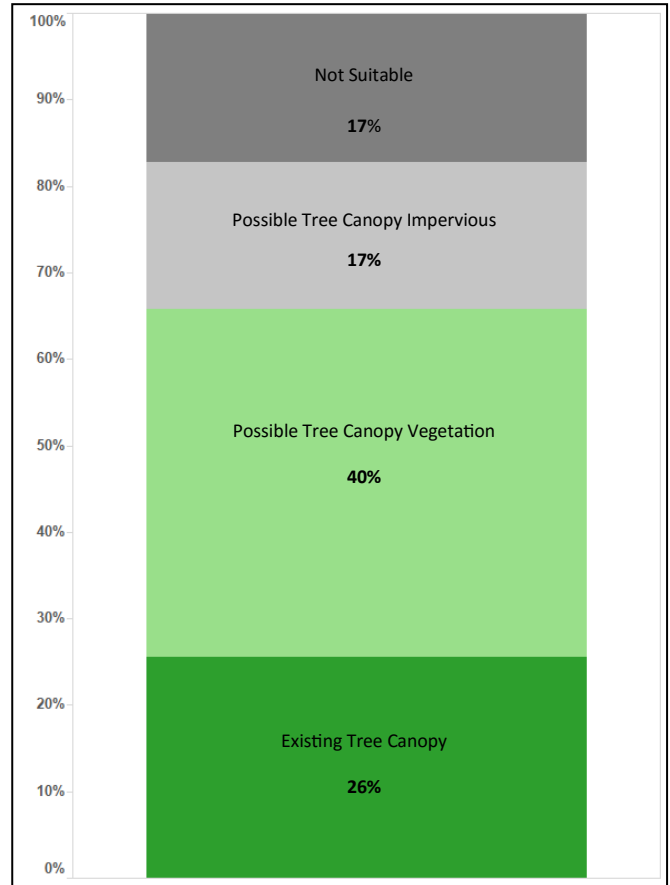


Figure 2: Tree Canopy metrics for Kitchener on percent of land area covered by each tree canopy type.

Key Terms

TC: Tree canopy (TC) is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above.

Land Cover: Physical features on the earth mapped from aerial or satellite imagery, such as trees, grass, water, and impervious surfaces.

Existing TC: The amount of urban tree canopy present when viewed from above using aerial or satellite imagery.

Impervious Possible TC: Asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy.

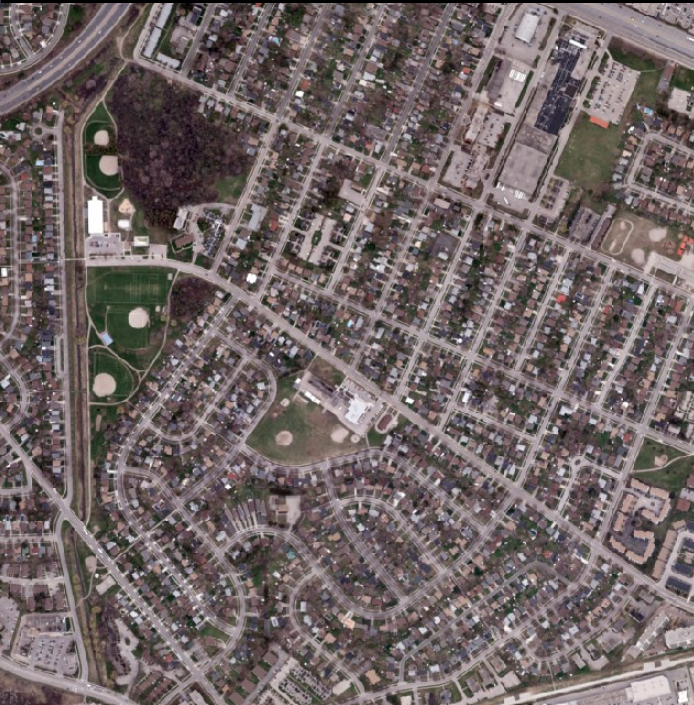
Vegetated Possible TC: Grass or shrub area that is theoretically available for the establishment of tree canopy.

Not Suitable: Areas where it is highly unlikely that new tree canopy could be established (primarily buildings and roads).

Mapping Kitchener's Trees

Using high-resolution imagery (Figure 3a) from 2014 and LiDAR acquired in 2014, land cover for the City of Kitchener was mapped with such detail that individual trees were detected (Figure 3c). This new tree canopy dataset represents the most accurate accounting of tree canopy ever done for Kitchener, with trees as small as 2 meters

a. 2014 Aerial Imagery



b. Tree Canopy from 2014 Imagery

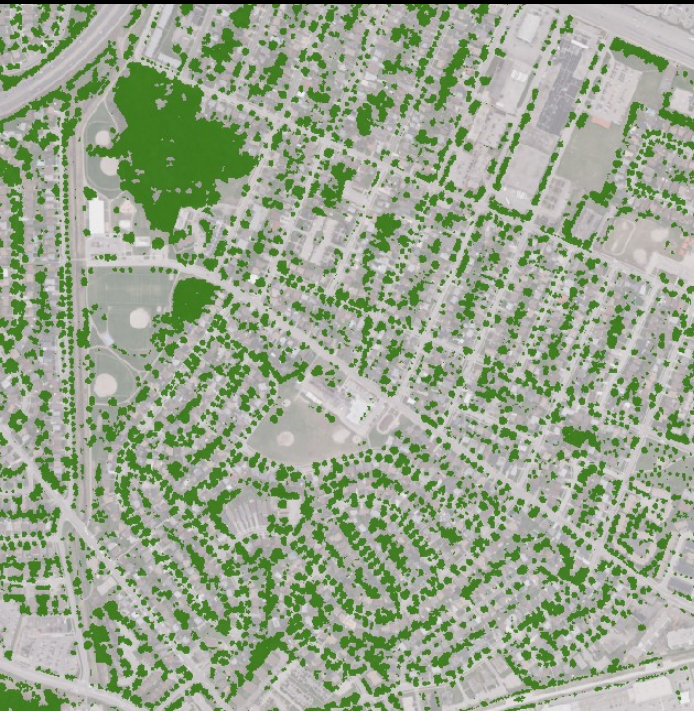
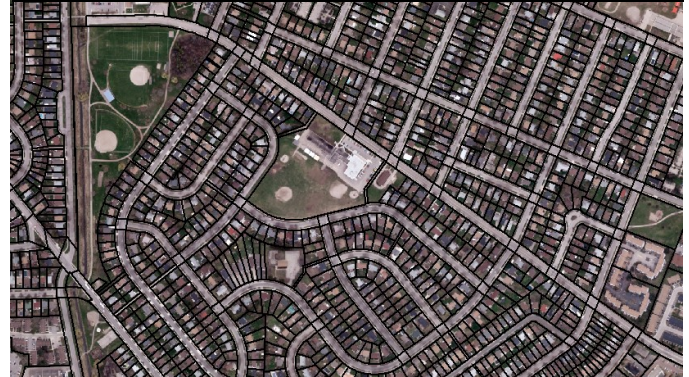


Figure 3: High-resolution imagery (a) and tree canopy (b) derived for this study (Ward 3, Wilson Park\Ave Area).

Parcel Summary

Tree Canopy (TC) metrics, produced from the land cover data, provide insight into the Existing and Possible tree canopy at the parcel level. Existing TC and Possible TC metrics were calculated for each parcel, both in terms of total area (square meters) and as a percentage of the land area within each parcel (Tree Canopy area divided by land area of the parcel) (Figure 4). This data can be used to understand the current tree canopy and tree planting opportunities for every property in Kitchener. For more explanation about Possible TC refer to the last bullet point (pg 10) in the conclusion section.

Parcels



Existing Tree Canopy



Possible Tree Canopy



Figure 4: Parcel-based tree canopy metrics. Tree canopy metrics are generated at the parcel level, allowing each property to be evaluated according to its Existing TC and Possible TC.

Land Use & Land Cover

To examine the relationship between land use¹ and land cover, the total area for each land use class was summarized and then the percent of vegetated cover (trees, grass, and shrubs) in each land use category was computed (Figure 5). The strategy for greening will likely differ by land use class. To better understand how to prioritize these efforts we examined the relationship between land use and vegetative cover. This analysis provides an understanding of how “green” each land use class is. The largest single land use category is Residential followed by Agriculture and, not surprisingly, Agriculture is the most green land use class, with 99% of its land area covered by vegetation. At the low end, 33% of the land in the commercial land use category is covered by vegetation.

¹The land use shown reflects the last known use existing on the property. The acknowledgement of this existing land use by the City does not in any way signify that the land use complies with the Ontario Planning Act or the City's official plan and zoning bylaws.

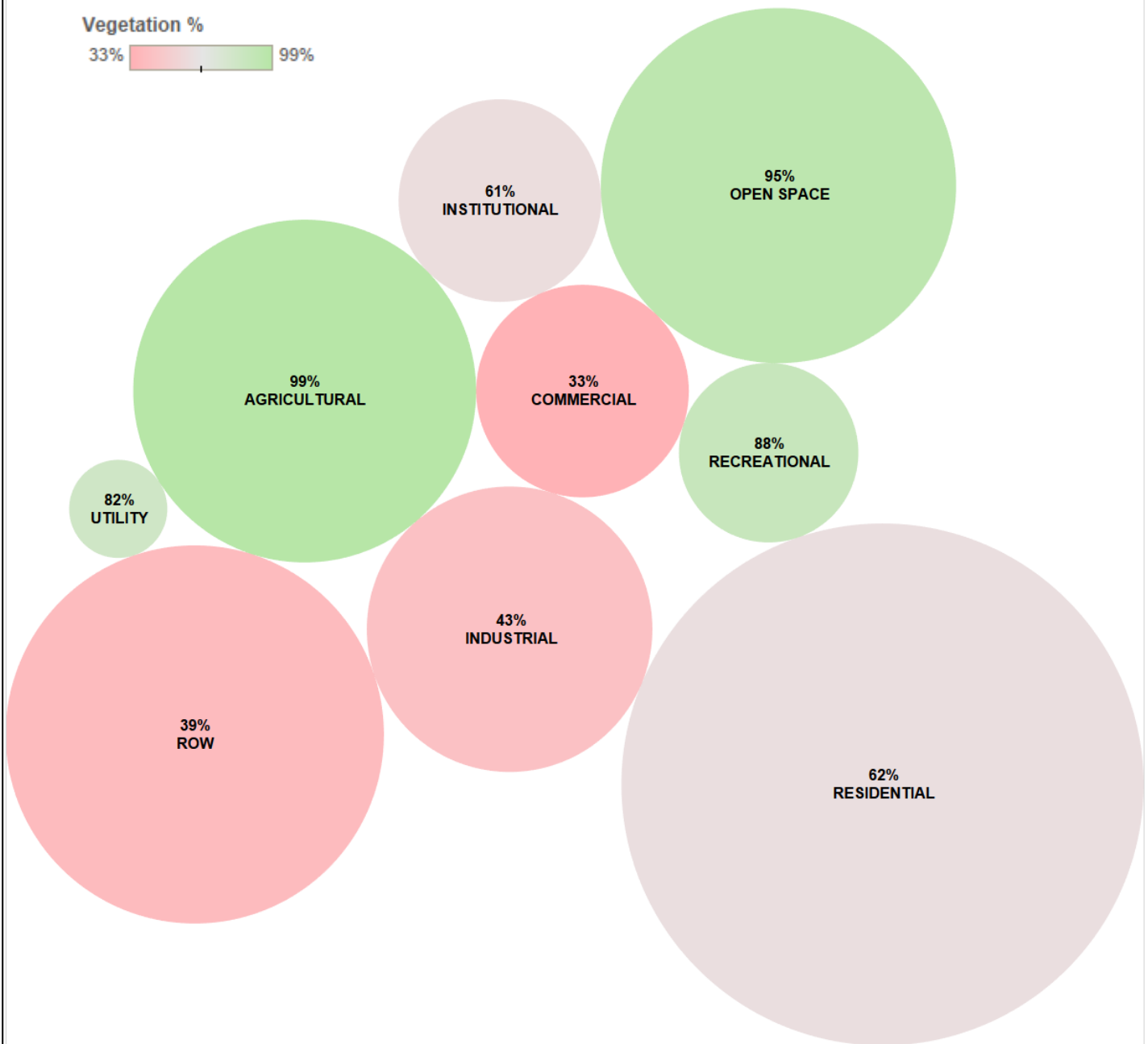


Figure 5: Percent of vegetated cover for each land use class in relation to total land area. The size of the circle represents the total land area, the color gradient represents the percentage of vegetation. Percentages are calculated based on the amount of vegetation relative to land area (i.e. water is excluded).

Land Use

Tree Canopy metrics at the property parcel were grouped according to land use. Residential is the dominant land use in Kitchener and thus, has the most Existing and Possible Tree Canopy by total area (Figure 6). On average, 56% of Open Space land is covered by tree canopy, which is the highest percentage out of the Land Use groups (Figure 6). Utility has the second highest percentage of tree canopy at 40%, and, not surprisingly, Agriculture has the greatest percentage of its land available for establishing new tree canopy with 79% Possible Tree Canopy. For all land uses there is an inverse relationship between Existing Tree Canopy and Possible Tree Canopy (Figure 7). This indicates that land uses with large amounts of tree canopy generally have less open space to plant new trees, but this relationship does not always hold true in more urbanized areas where select parcels with low Existing Tree Canopy also have low Possible Tree Canopy. An approach that considers all land use types is important to maintain and increase Kitchener's tree canopy, with governments, residents, non-profits, and the private sector all playing a role.

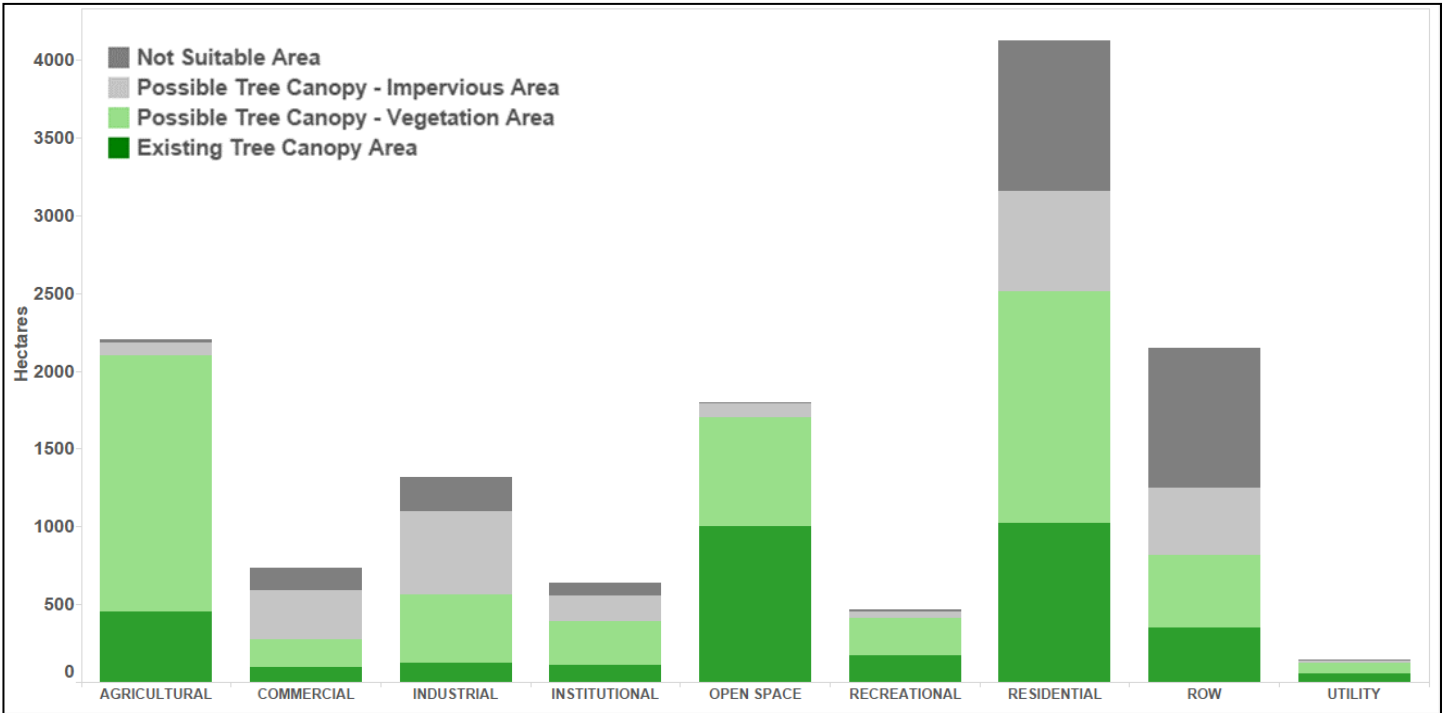


Figure 6: Tree canopy metrics derived from the parcel dataset summarized by land use.

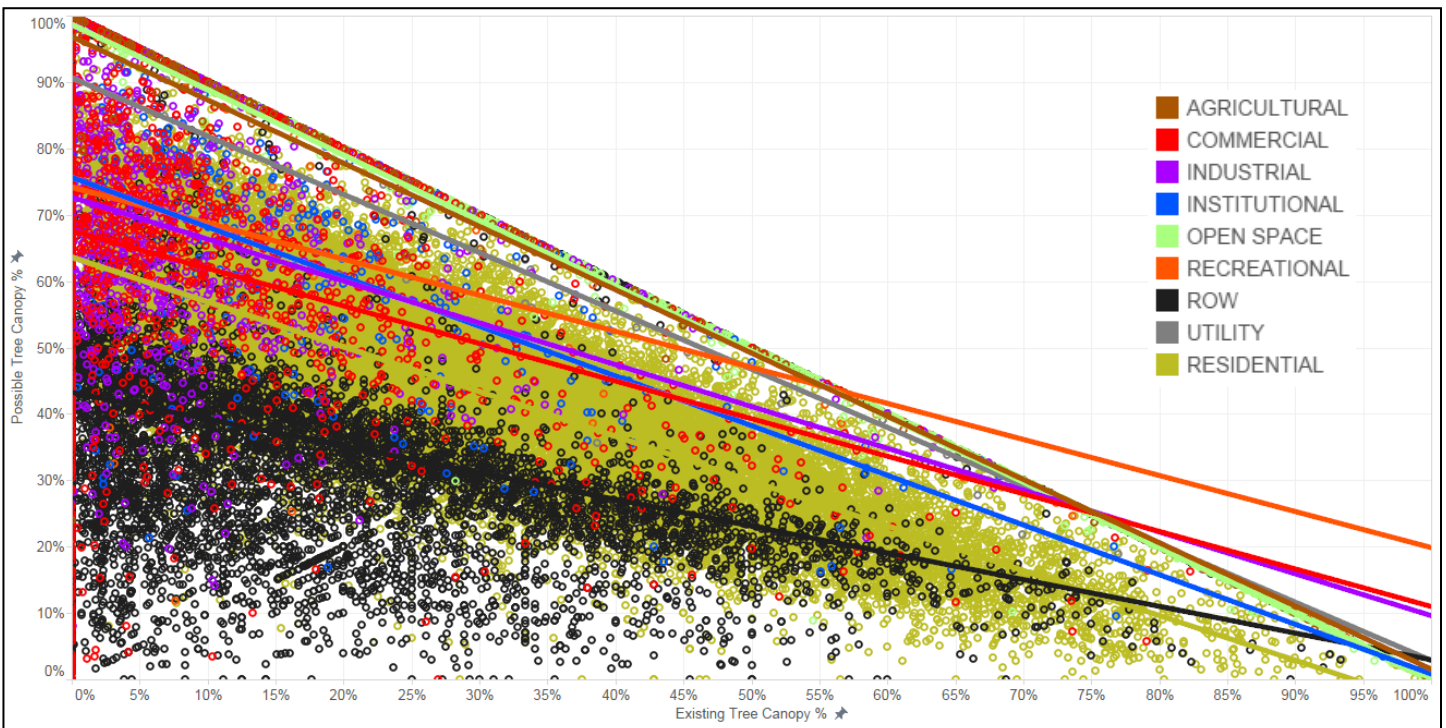


Figure 7: Relationship between Existing Tree Canopy and Possible Tree Canopy for each parcel in the Kitchener study area.

Urban Heat Island

Urbanized areas are typically substantially warmer than surrounding more rural locations. This effect, known as the urban heat island has multiple negative impacts such as increased energy expenditures and higher mortality in vulnerable populations. Trees reduce ground-surface temperatures, through shading and transpiration. Impervious surfaces further increase surface temperatures because they absorb and hold thermal radiation from the sun. Analysis of recent thermal data (Landsat, September 7th, 2015) illustrated this effect in Kitchener (Figure 8). The relationship was further confirmed by plotting surface temperature versus Existing Tree Canopy (Figure 9). The statistically significant inverse relationship between tree canopy and surface temperature provides clear evidence that trees help reduce the urban heat island effect.

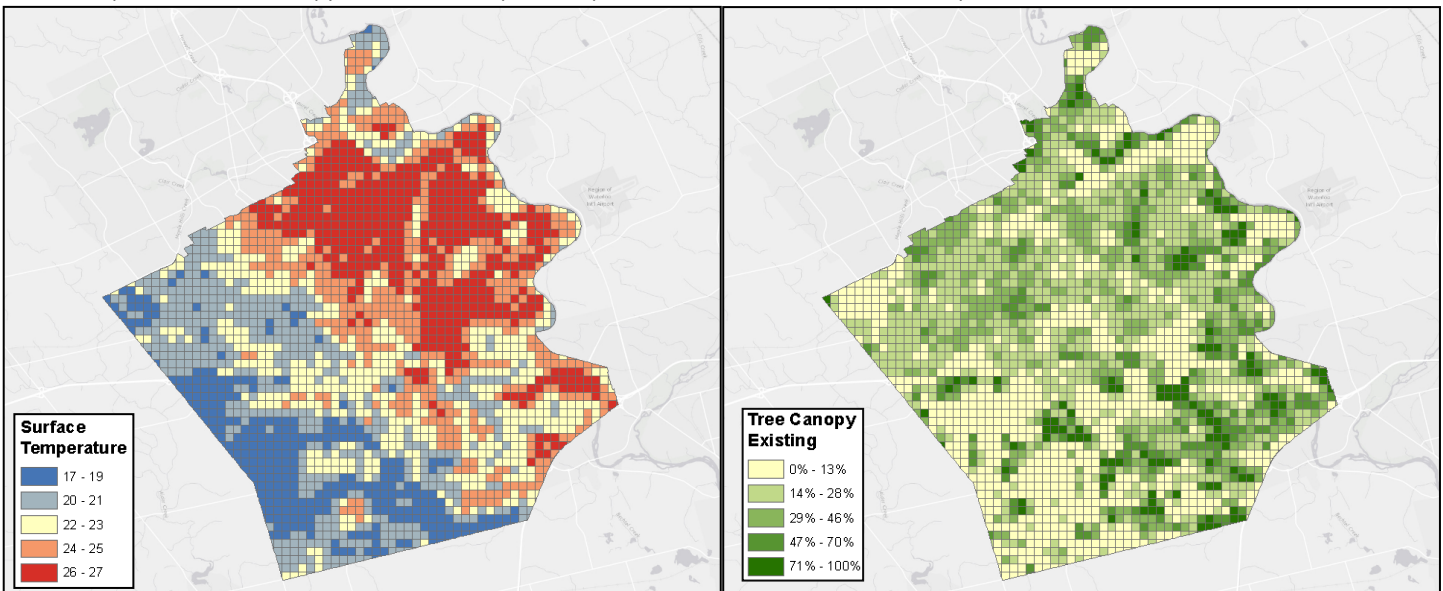


Figure 8: Surface temperature, degrees Fahrenheit on September 07, 2015 (left) in comparison with Existing Tree Canopy (right).

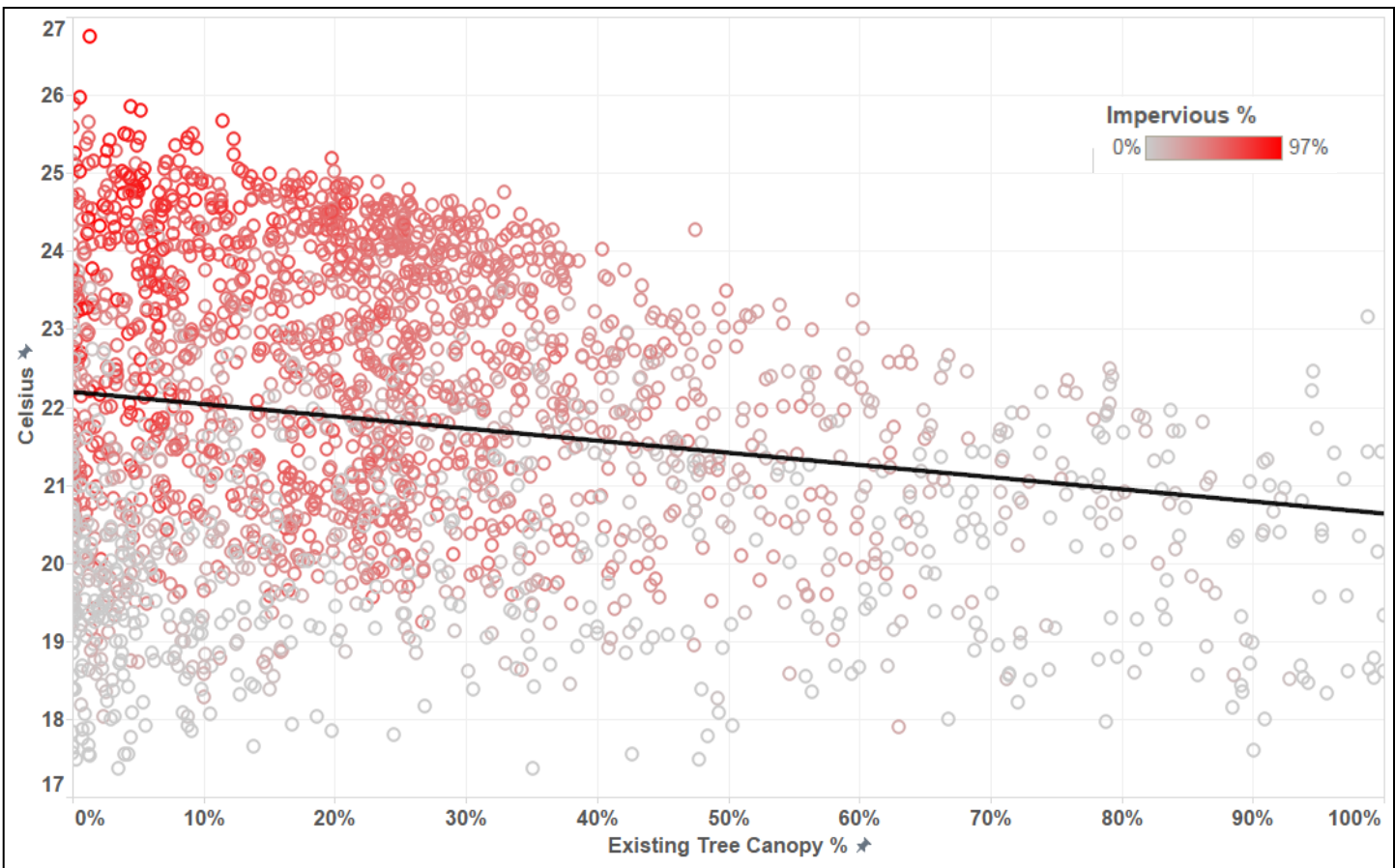


Figure 9: Surface temperature in relation to percent tree canopy. A 250m x 250m grid was overlaid on the region and for each grid cell the percent tree canopy, percent impervious, and average surface temperature were summarized. Surface temperature was derived from Landsat satellite imagery acquired on September 07, 2015.

Wards

Wards covering Kitchener were used for summarizing Existing and Possible TC by percent category (Figure 12). Based on the percent category Ward 4 had the most Existing TC (35%) with 578 ha which includes many of Kitchener's largest natural areas while Ward 5 had the most Possible TC (75%) with 2,227 ha which also includes the City's designated agricultural lands.

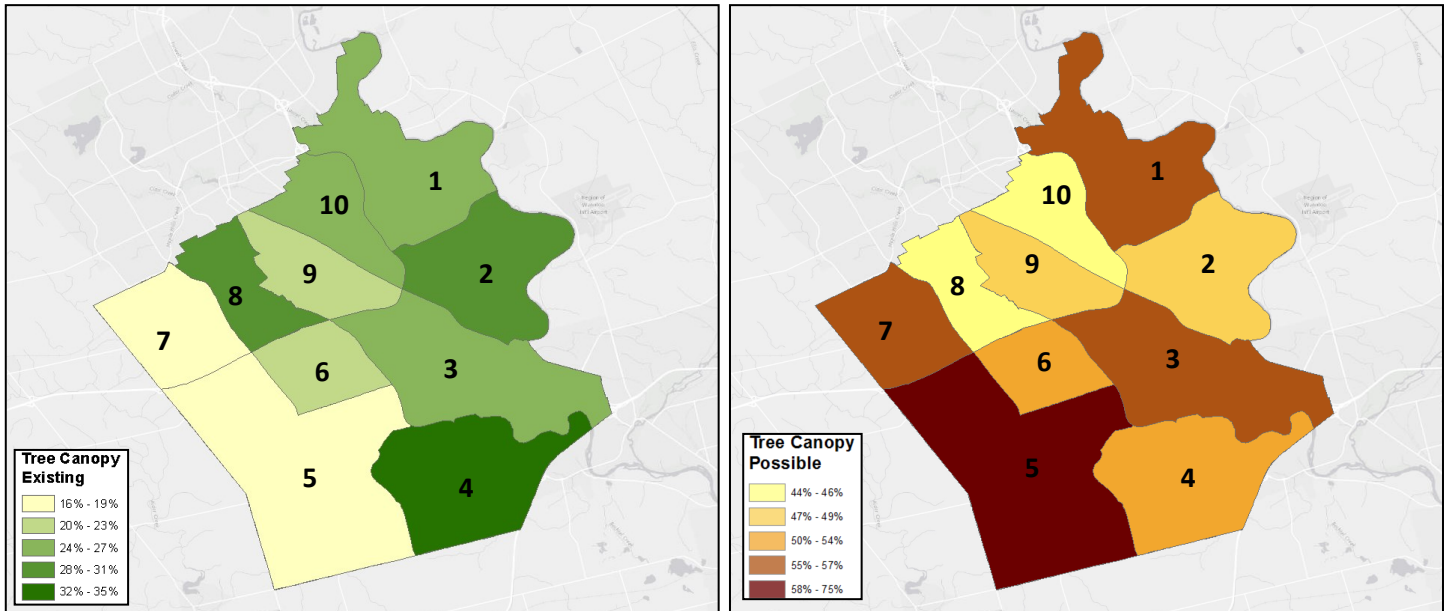


Figure 10: Tree canopy metrics by ward. Tree canopy metrics are generated for each ward, allowing each ward to be evaluated according to its Existing TC and Possible TC and compared with other wards.

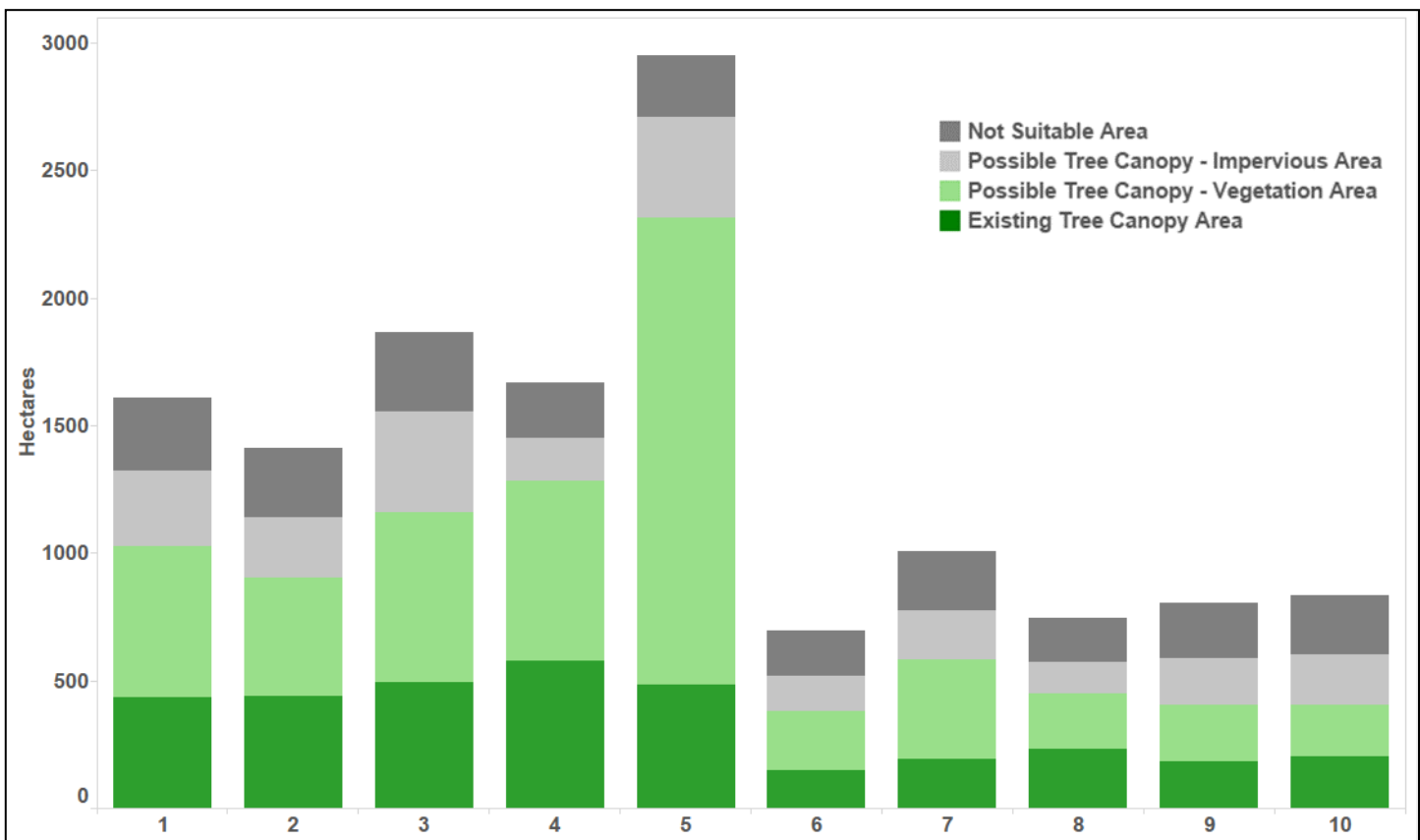


Figure 11: Tree canopy metrics summarized by ward.

Tree Patch Analysis

Not all tree canopy provides the same ecosystem services. Forest patches that are larger in size with less edge are associated with improved wildlife habitat and watershed health, among others. Identifying such patches involves more than simply looking at the size of connected portions of the tree canopy, as morphological factors, such as the edge to perimeter ratio, must be considered. The tree patch analysis partitions the tree canopy into three classes based on size and morphology: 1) small (~0.009 ha) 2) medium, (~0.24 ha) and 3) large (~5 ha) (Figure 12). In general, small patches represent individual trees or small rows of connected canopy, medium patches represent larger clumps of trees with high amounts of edge, often in suburban or agricultural settings, and large forest patches consist of forested stands with higher amounts of core forested area. Kitchener's tree canopy is nearly evenly distributed across the three patch classes (Figure 13).



Figure 12: Tree patch classes, in which the tree canopy is subdivided into one of three categories (Ward 2 – Idlewood Park \ River Road Area).

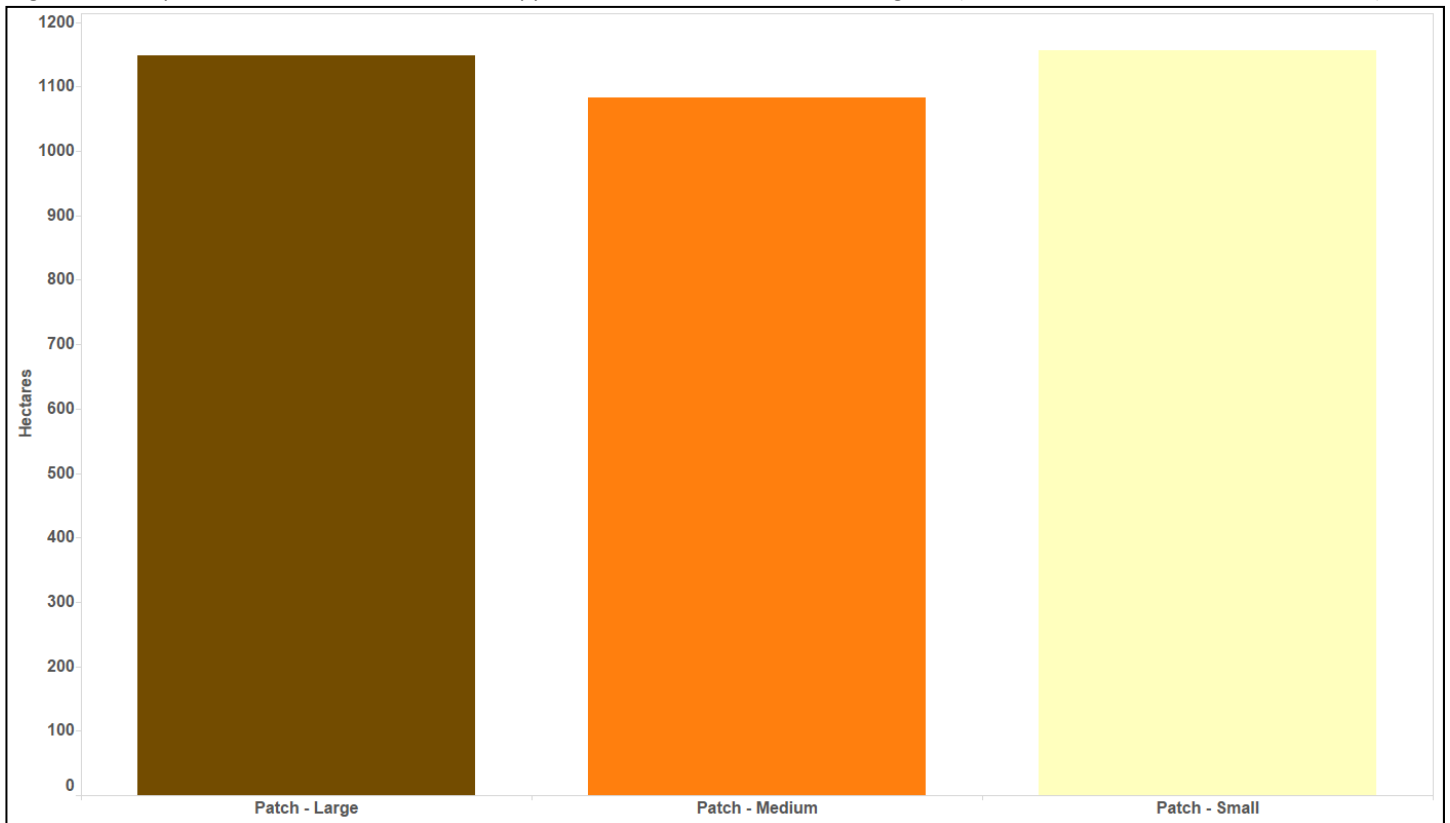


Figure 13: Number of hectares each tree patch size contains.

Tree Canopy Height

Knowing the height of the tree canopy can be of value for a variety of uses, ranging from locating large trees for preservation to estimating the age of a forest stand. The tree canopy dataset was divided into polygons that approximate individual trees using a combination of high-resolution imagery and LiDAR. Each one of these polygons was then attributed with average and maximum height information from the LiDAR data that were collected in 2014 (Figure 15). The resulting tree polygon database can be used to visualize the tree canopy in three dimensions or carry out other analyses, such as estimating biomass, finding the tallest trees, or computing the number of trees over a certain height. The most commonly occurring height class in Kitchener is the 6 to 12 meters class (Figure 16).

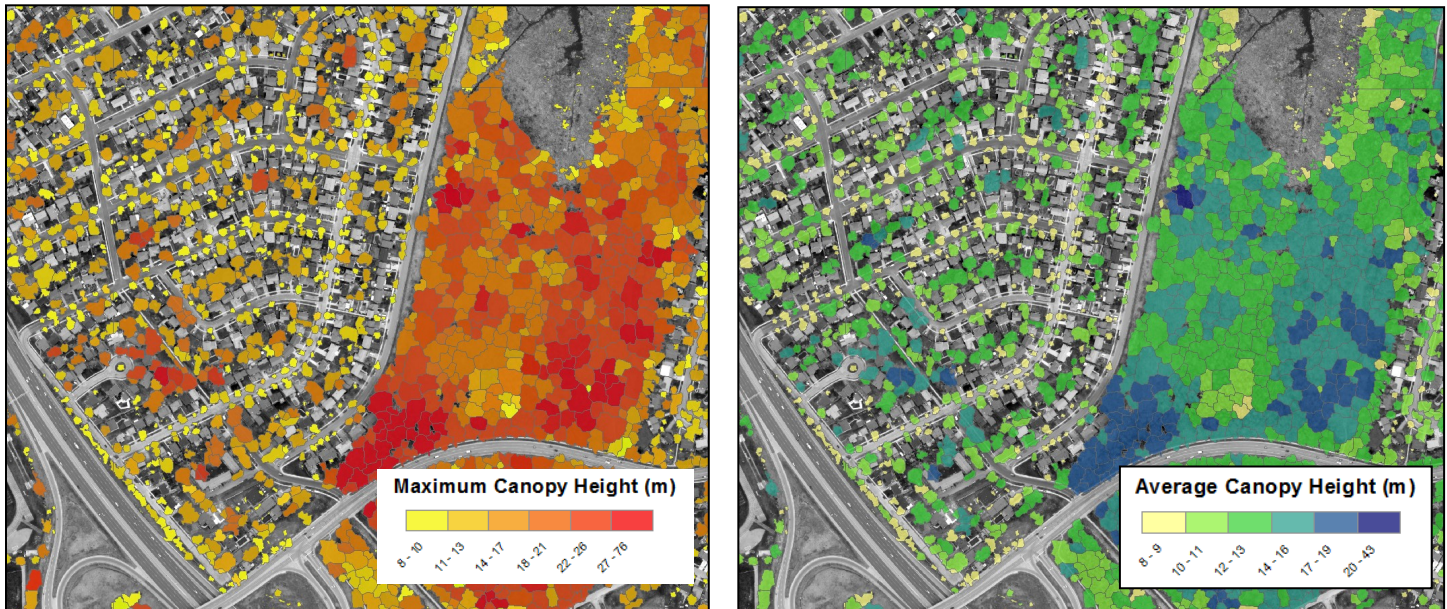


Figure 15: Maximum canopy height (left) and average canopy height (right) for Kitchener (Ward 2/Stanley Park Conservation Area/Ottawa Road) .

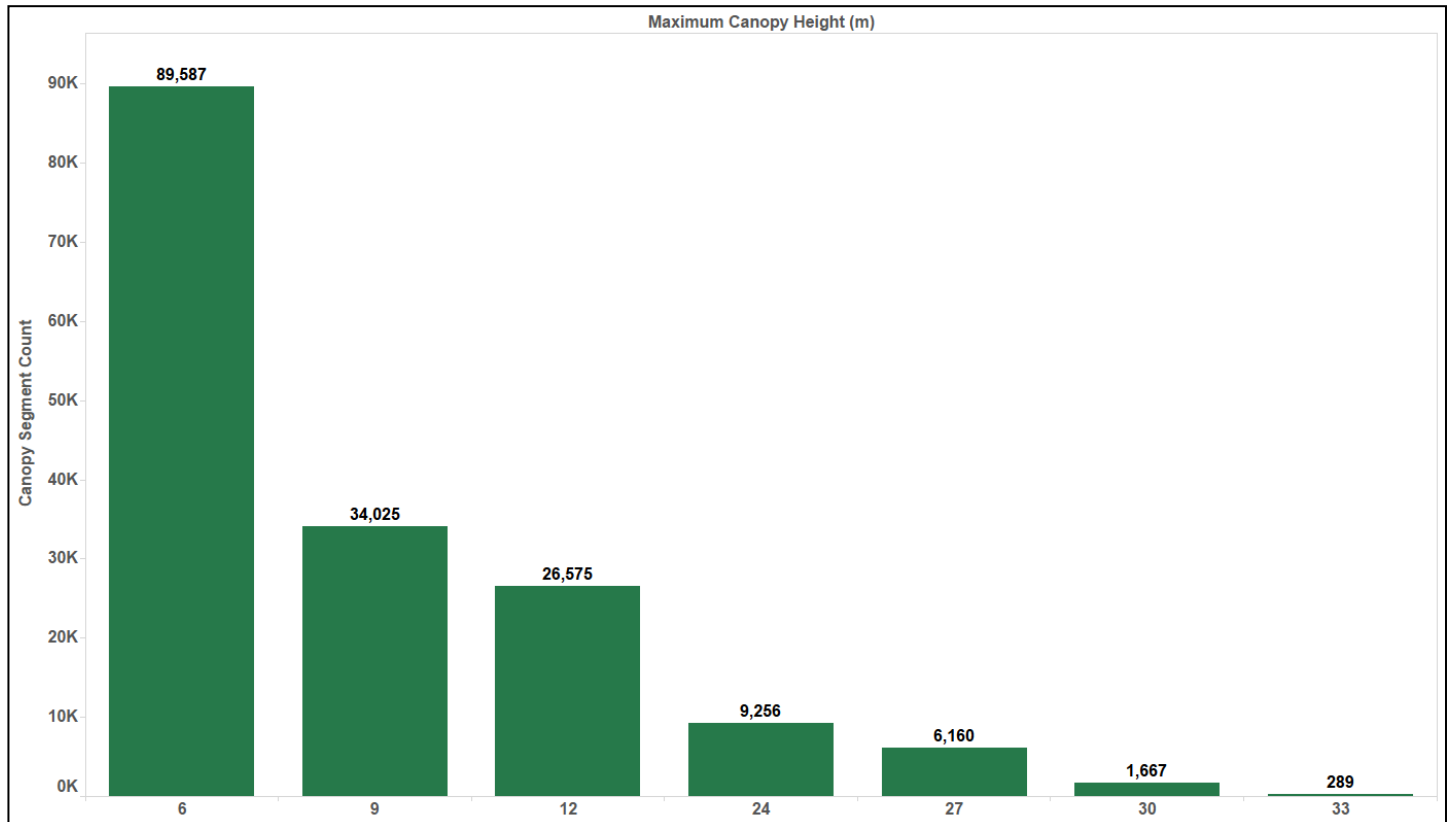


Figure 16: Count of tree canopy segments by max height class. The height of the bar reflects the number of tree canopy segments in each one of the 3m height classes.

Tree Canopy Change 2007-2014

Understanding tree canopy change is important for tracking the long-term health of a community's green infrastructure, in addition to understanding the drivers of such changes. Mapping tree canopy change is challenging due to the inherent differences in the source datasets used to map tree canopy. This often makes comparing two independent tree canopy assessments invalid. This study generated a detailed tree canopy change dataset that provides an in-depth and accurate accounting of Kitchener's tree canopy change over the period of 2007-2014.

The first assessment of Kitchener's tree canopy was done in 2007 using only imagery (Figure 17), while the 2014 assessment made use of LiDAR and imagery (Figure 18). The combination of LiDAR and imagery greatly reduces the confusion between tree canopy and shrubs, which have a similar texture in imagery but are readily differentiated in three dimensions. In addition, LiDAR can penetrate shadows, improving the ability to detect trees in urbanized areas and does not have tree lean, a common source of error in canopy estimates from imagery.

The 2007 and 2014 individual assessments were not directly comparable due to the issues mentioned above and because of poor alignment between the imagery and LiDAR. To resolve this issue, a new tree canopy change detection layer was generated (Figure 19). The purpose of the tree canopy change detection layer was to map change at the individual canopy level, thereby bringing the two assessments into alignment. The LiDAR used for the 2014 assessment enabled a more accurate, detailed accounting of the tree canopy than the original 2007 tree canopy estimates. Therefore, the resultant change detection layer had slightly different results for 2007 when compared to the original 2007 assessment.

In the tree canopy change detection layer, canopy 'gain' represents an area where tree canopy has increased from 2007 to 2014 while loss represents a decrease in tree canopy from 2007 to 2014. No change represents areas where tree canopy existed in both the 2007 and 2014 datasets (Figure 19). In 2007, it was determined from available aerial imagery that Kitchener had 26% (3,526 ha) of tree canopy. In 2014 using high-resolution imagery and LiDAR-derived surface models it was determined that Kitchener had 26% (3,474ha) tree canopy. Over the seven year interval, Kitchener's tree canopy decreased by 52 hectares.

Despite little overall change, there were areas where loss was evident from tree removal or disturbance, and areas where gain occurred from new plantings or natural growth (Figure 20). With Kitchener's tree canopy cover now quantified, this baseline data will be very useful for long-term monitoring changes to the existing tree canopy (e.g. loss of trees due to Emerald ash borer). The change layer provides greater accuracy for canopy changes by type and location and for tracking increases in the city's tree canopy should such goals be established.



Figure 17: 2007 color-infrared aerial imagery.



Figure 18: 2014 natural color aerial imagery.

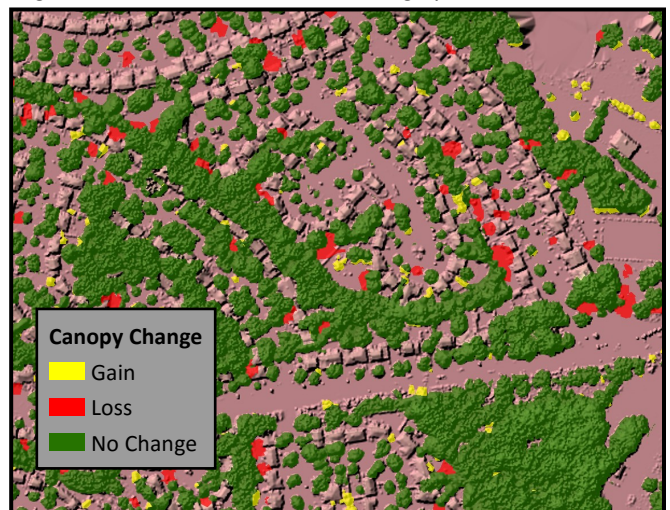


Figure 19: Lidar-derived surface model and tree canopy change layer (Ward 8 – Lakeside Park \ Greenbrook Dr area).

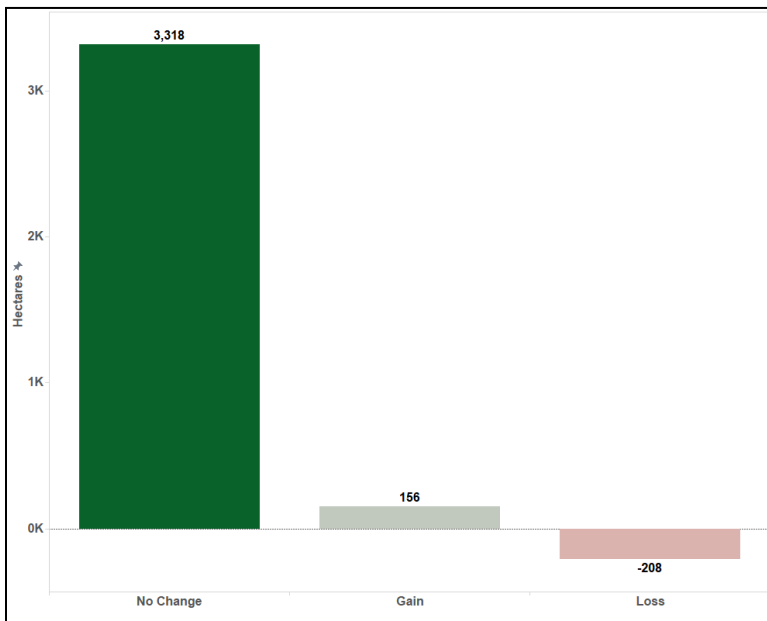


Figure 20: Comparison of 2007 tree canopy and 2014 assessment of canopy gain and loss.

Conclusions

- Tree canopy in Kitchener is a vital asset that reduces stormwater runoff, improves air quality, reduces the city's carbon footprint, enhances quality of life, contributes to savings on energy bills, and serves as a habitat for wildlife. These benefits are known as ecosystem services and have been well documented in the scientific literature. At this time Kitchener has not quantified the ecosystem services its urban forest.
- Targeted increases in tree canopy would enhance the ecosystem services that trees provide and setting tree canopy goals would help the City of Kitchener maximize the benefits of trees. Canopy goals can be better implemented and more effective when they are targeted towards specific audiences (e.g. residents) or goals like reducing stormwater runoff.
- A key tactic to increase tree canopy is the protection, stewardship and maintenance of the existing trees.
- Tree canopy is correlated with lower surface temperatures. Increasing canopy cover in Kitchener will help reduce summer temperatures, thereby reducing energy use, improving health, and saving businesses and homeowners money by lowering energy bills. Targeting tree planting in sites with high surface temperatures would maximize these benefits.
- Kitchener's residents are paramount to preserving existing tree canopy and increasing canopy cover in the future, as residential land is the single largest land use type. While there is currently more tree canopy on residential land than any other land use type, there is also more room to plant trees on residential property than on any other land use type.
- Despite the dominance of residential land use within the study area, all land use types have vegetated or impervious surfaces that could host additional tree canopy. With Existing TC and Possible TC identified at the parcel level and integrated with the city's GIS database the City can carry out further analysis at the ward, planning unit, storm water, social/economic and neighbourhood level to identify possible targets and priorities to maintain and or increase tree canopy cover.
- Wards 5 and 7 have the lowest existing tree canopy cover (16-20%). These low values are due to the fact that both areas were recently developed, and that prior to development the agricultural lands had very few natural areas, when compared to areas such as Ward 4. These two Wards along with Wards 1 and 3 have the greatest opportunities to increase tree canopy. While changes in construction practices over time and a focus on intensifying development further compound the challenges to increase tree canopy in recently developed areas ongoing advances in arboricultural research and the establishment of best practices provide the best opportunity to increase tree canopy in these areas.
- The current analysis of Possible TC includes recreation fields, residential lawns, non-transportation paved surfaces, agricultural lands, etc. further analysis and community discussion will be required to determine where it is: 1) cost effective to plant trees and 2) socially desirable.

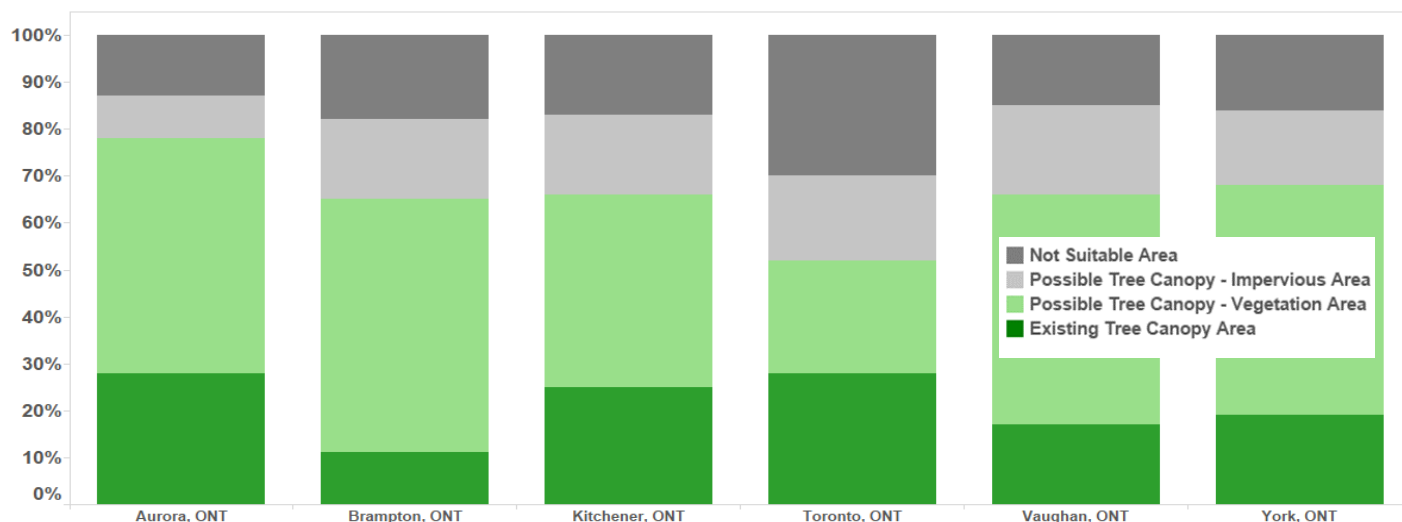


Figure 21: Comparison of Existing and Possible Tree Canopy with other communities in Ontario that have completed Tree Canopy Assessments conducted by the University of Vermont, Spatial Analysis Lab (SAL). The City of Cambridge, ONT completed a UTC assessment in 2013 and it was found that 27% of the land was Tree Canopy. It should be noted that the Cambridge, ONT assessment was not conducted by the SAL and used different standards.

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Additional Information

For more info on the Urban Tree Canopy Assessment please visit <http://nrs.fs.fed.us/urban/UTC/>



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