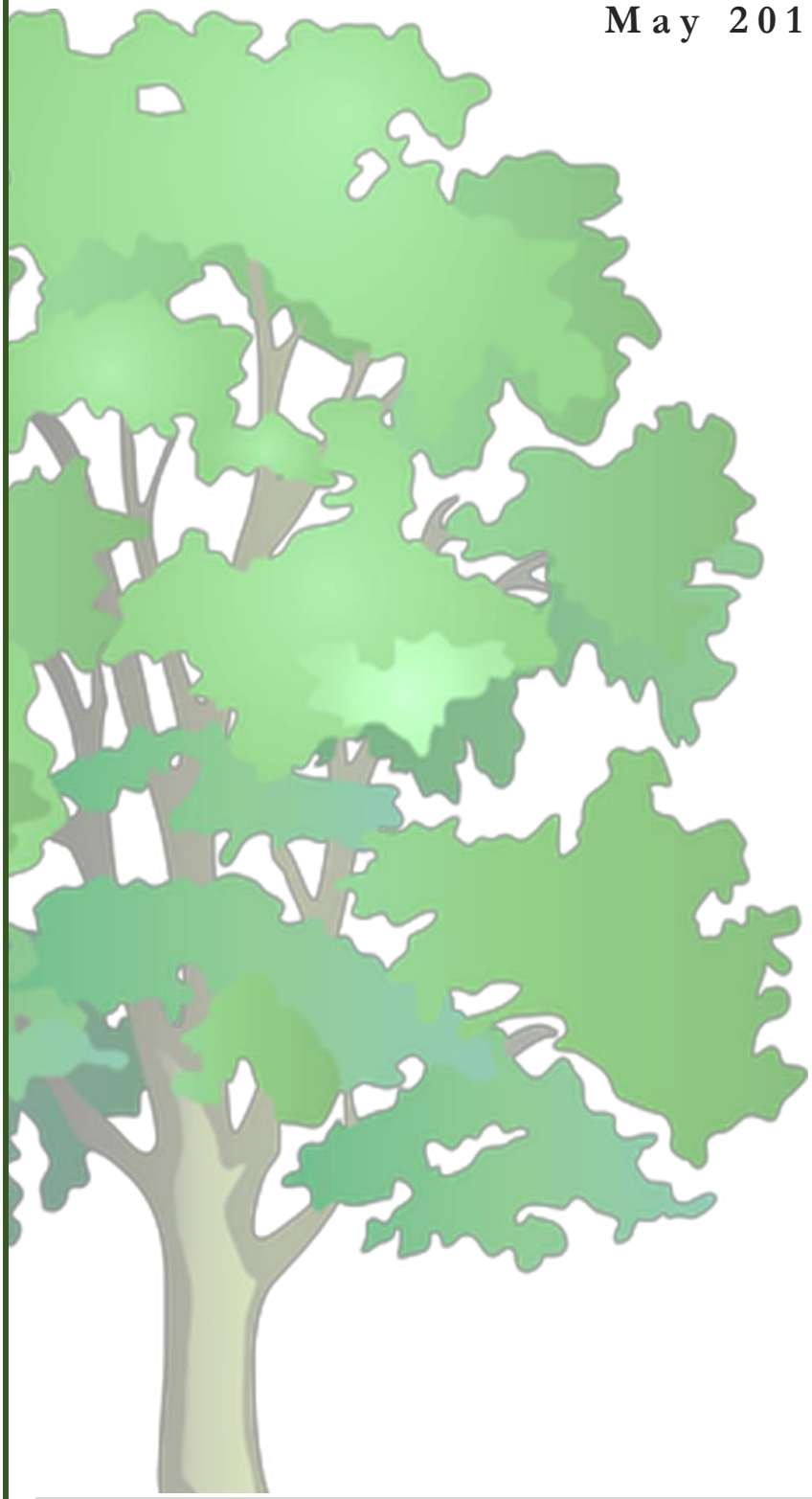
An Assessment of Urban Tree Canopy in Grand Rapids, Michigan

May 2015



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CITY OF GRAND RAPIDS

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“Someone is sitting
in the shade today
because someone
planted a tree a
long time ago”

-Warren Buffet

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May 2015

Prepared By

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Acknowledgements

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Prepared For

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EXECUTIVE SUMMARY

In the City of Grand Rapids, trees along streets, in parks, cemeteries, yards, and natural areas constitute a valuable urban forest. This resource is a critical element of green infrastructure, contributing to environmental quality, public health, water quality, property values, and aesthetics. Urban forests provide *triple bottom line benefits* – social, economic, and environmental. Periodic assessments of Urban Tree Canopy (UTC) viewed from above provide a benchmark for managing and protecting this resource across public and private property.

Existing Tree Canopy

This study found that urban tree canopy (UTC) covers **34%** (9,775 acres) of the City of Grand Rapids. The trees that make up this urban forest provide a multitude of economic, environmental, and social benefits, conservatively valued at approximately **$2.64 million** annually based on carbon sequestration, air pollutant removal, and stormwater mitigation/treatment.

Trends in Tree Canopy

Despite efforts to expand UTC in Grand Rapids, impacts from the Emerald Ash Borer (EAB), new development, and other factors have resulted in a net loss of 203 acres in tree canopy since a 2008 study based on 2005 aerial imagery. This is equivalent to losing **17 football fields per year** over the nine year span.

Canopy Goals and Available Planting Space

To increase UTC in Grand Rapids, existing trees must be protected and additional trees be planted to retain and expand the benefits of the urban forest. Current canopy is 6% below the City's goal of 40% average tree canopy cover set in 2011. With **7,032 acres** of Possible Planting Area (PPA) from lawns and open space vegetation, there is ample room to reach and sustain the City's 40% UTC goal. Specific results on available planting space include:

*This is a conservative valuation and does not include numerous other urban forest benefits such as impact on property values and energy savings.

34%

Average (UTC) in Grand Rapids

$2.64 million*

Annual Ecosystem Services

-0.7%

Percentage Point UTC Change from 2005-2014

7,032

Acres Possible Planting Area

1,640

Acres Increase Needed to Meet 40% UTC Goal

- To reach the City's urban canopy goal, 1,640 acres are needed to be planted, or 23% of all available space.
- Of the 37 neighborhoods within the city, 19 of these neighborhoods are below the citywide average of 34% UTC.

Tree Canopy by Zoning Classes

Results for Zoning Class quantify and illustrate both the progress and challenges within public sectors (i.e. Open Space) and private property (i.e. Low Density Residential Zoning). The highest percentage of UTC within an individual Zoning Class was in the Open Space Zoning Class at **42% UTC**. The Low-Density Residential Zoning Class, due largely to its relatively expansive land area, contributes **74%** of the city's total UTC. The City Center Zoning Class was most sparsely canopied, with only a **4% average UTC**.

Tree Canopy and Socio-Demographics

A comparison of tree canopy and census data shows that in Grand Rapids, as in many U.S. cities, residents of many lower-income neighborhoods (i.e., neighborhoods with lower educational attainment, lower median incomes, lower median home values, and lower rates of owner occupancy) have less access to the benefits that trees provide than residents of higher-income neighborhoods. This data can inform prioritization of tree planting efforts to address equity issues. Results include:

- As the percentage of UTC increases, median income also increases.
- As the percentage of UTC increases, median home value also increases.
- The rate of owner occupancy is greater in areas with a higher percentage of UTC.

Tree Canopy Distribution Across Other Geographic Scales

In addition to Zoning Classes and Neighborhoods, existing tree canopy metrics, impervious surface area, and available planting space were also analyzed for Commission Wards, City Maintenance Districts, Parks, Census Block Groups, Street Rights-of-Way, HUC-12 Watersheds, and individual property parcels. Maps, tables and figures are provided in the Key Findings and Appendix. The acronym HUC-12 refers to the hydrologic unit coding system used by the United States Geological Survey (USGS). *

With land cover information across these geopolitical, planning, and management scales, different audiences can take action to protect and grow the City's urban tree canopy.

Recommendations and Strategies

This report presents a variety of UTC improvement scenarios, broad recommendations, and a few specific strategies to assist in implementation of UTC goals using the GIS data, tools, and findings. Additionally, the UTC assessment data are available in an online interactive map for planning and prioritizing tree planting and maintenance.

***For more information on the hydrologic units systems, visit http://water.usgs.gov/GIS/huc.html.**

PROJECT BACKGROUND

The Grand Rapids Urban Forest Plan, developed in 2009, includes a 40% canopy goal for the city, based in part on a 2008 canopy study using 2005 aerial imagery. This goal has been adopted by the Grand Rapids City Commission as part of Green Grand Rapids, an amendment to the City's master plan.

The Urban Forest Plan also calls for stronger data to support effective decision-making. To this end, the City completed a sample street tree inventory in 2010 and will have a new, complete street tree inventory in 2016. In addition an urban forest ecosystem analysis was completed in 2011. In 2011, The Grand Rapids Urban Forest Project, an initiative of Friends of Grand Rapids Parks in partnership with the City of Grand Rapids and funding partner, the Grand Rapids Community Foundation was started to get more of our community active in protecting and growing our urban forest. The City, the Grand Rapids Urban Forestry Committee, and Friends of Grand Rapids Parks all recognize the importance of periodically monitoring the community's progress toward its 40% canopy goal. To this end, in 2014 Dyer-Ives Foundation awarded Friends of Grand Rapids Parks a grant to commission this study. FGRP subsequently contracted with Plan-It Geo to conduct the assessment.

This tree canopy study, based on 2014 imagery, provides a wealth of data that can be used to measure progress toward the canopy goal. The study quantifies the net outcome of canopy-impacting factors such as storms, pests (e.g., the emerald ash borer), natural tree growth and mortality, development, infrastructure projects, and tree planting initiatives. The study also enables the community to better understand and address variations in canopy and in tree planting potential among neighborhoods and land use categories. The study data can provide the foundation for developing canopy targets and priorities for various assessment boundaries throughout the city. Enhancing Grand Rapids' tree canopy is important for achieving goals outlined in the City's master plan as well as in its Sustainability, Climate Resiliency, Stormwater and Vital Streets plans. This urban tree canopy study will be an important tool to support ongoing community conversations and frame future strategies to protect, enhance and expand tree canopy throughout Grand Rapids.

Figure 1: Photo credit: Friends of Grand Rapids Parks

METHODOLOGY

This section outlines the methods and terminology used to assess land cover, UTC (Urban Tree Canopy), and available planting space in Grand Rapids. Included are brief methodology overviews of: Mapping Land Cover Types, Visualizing Urban Tree Canopy Percentages, Possible Planting Area, Canopy Change, Assessment Levels, and Ecosystem Services.

Mapping Land Cover Types

This study utilized a top-down (aerial imagery-based) method to break land cover types in Grand Rapids into five classes:

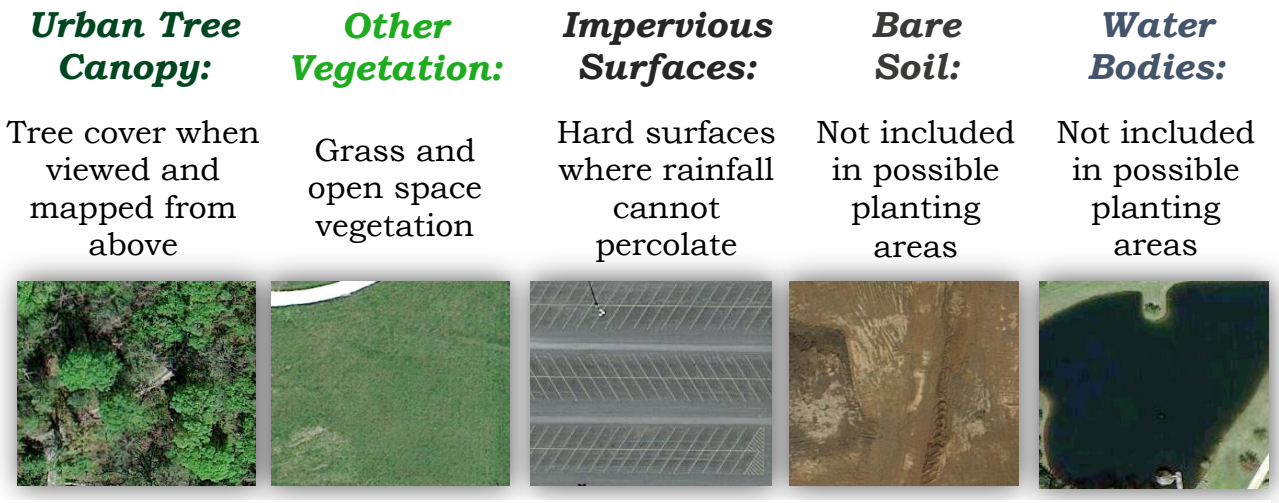


Figure 2: Aerial views corresponding to the land cover types mapped in this study.

The process began with the acquisition of high-resolution (1-meter) 2014 aerial imagery from the USDA's National Agricultural Imagery Program (NAIP). Then, an object-based image analysis (OBIA) software program called Feature Analyst (ArcGIS Desktop) was used to classify features through an iterative approach. The spectral signatures of pixels across four bands (blue, green, red, and near-infrared), textures, and pattern relationships were taken into account. Data layers from the City were also utilized after being manually improved to capture finer feature detail. Note building footprints were not available in all areas of the City.

Figure 3: Zoomed in example of the final GIS-based land cover classification data provided through this study.

Visualizing UTC Levels/Percentages

Urban tree canopy (UTC) maps in this report express relative UTC levels in each land area as a percentage of total land area (not including water). These UTC levels are broken up into four classes: less than 20% UTC, 21-30% UTC, 31-40% UTC, and over 40% UTC for meaningful representation of UTC levels on each map. See the map below for visual examples of what the various UTC levels as symbolized by the four classes look like on the imagery. This figure is intended as a demonstration. For detailed results at this level, see Socio-Demographic Assessment Level, starting on page 19.

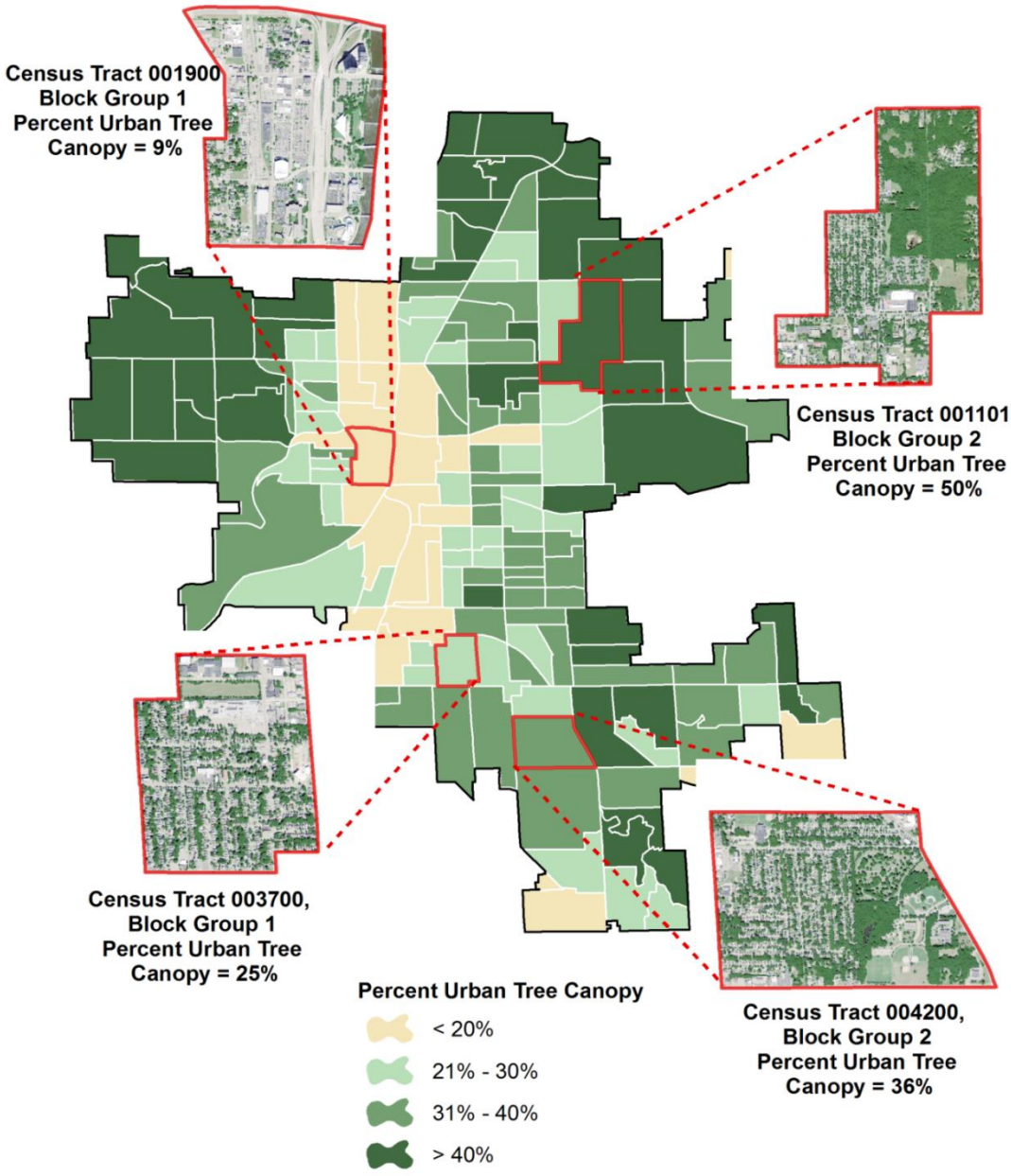


Figure 4: Examples of varying levels of urban tree canopy. (Delineated by census tract).

Finding Possible Planting Areas (PPA)

The delineation of possible planting areas (PPA) began with the other vegetation land cover class. PPA was then augmented by manually mapping and excluding sports fields, agriculture, and other areas unsuitable for trees. Planting areas of higher priority were then mapped by finding areas with both high PPA and low UTC.

Despite the stormwater and urban heat island benefits of converting impervious area (e.g. parking lot area) into planting space, PPA in this report does not include areas within the impervious area (IA) class due to incomplete building footprint data. This footprint data was used when delineating IA, but using it to identify Impervious PPA would have placed PPA on buildings. PPA results in this report are within vegetated (pervious) areas only.

Objective	GIS Action	Example
Plant in grassy or other open space areas	Used "other vegetation" land cover class as initial input	
Avoid unsuitable areas	Removed areas like airports, golf courses, baseball fields, etc.	
Prioritize	Queried data to find areas with low UTC and high PPA	

Detecting and Analyzing Urban Tree Canopy Change

Urban tree canopy (UTC) change analysis quantifies canopy loss due to natural events (i.e. disease) and anthropomorphic influences (i.e. development) and gains due to canopy growth and new plantings. To detect UTC change in Grand Rapids, Plan-It Geo used the results of a 2008 UTC study conducted by the Annis Water Resources Institute at Grand Valley State University that was based on 2005 imagery. During the analysis of the existing data one key difference was determined: the 2008 study included water area in the UTC percent value, while this study did not. The result of this discrepancy can be seen in slightly varying total acreage values for Grand Rapids (a difference of 23 acres).

Defining Assessment Levels

Citywide land cover results were then used as an input data layer for analysis at finer assessment levels. The area and percent of each land cover class was calculated for three commission wards, twelve city zoning classes, forty one city maintenance districts, and seventy six parks, making it a useful planning tool for city foresters and maintenance crews. Although, some of Grand Rapids' parks do extended beyond city boundaries; this study only analyzes the areas within Grand Rapids city proper.

To provide actionable information to frame public outreach efforts, the data was also processed at the level of thirty seven neighborhoods and one hundred and seventy one census block groups. The census block group-level analysis takes into account socio-demographic factors including income, home value, educational attainment, ethnicity, race, and tenure.*

OF AREAS

3 ... *COMMISSION WARDS*

12 ... *ZONING CLASSES*

41 ... *MAINTENANCE DISTRICTS*

76 ... *PARKS*

37 ... *NEIGHBORHOODS*

6 ... *WATERSHEDS*

171 ... *CENSUS BLOCK GROUPS*

An analysis at the level of watersheds was also conducted; six watersheds overlap with City of Grand Rapids boundaries. This analysis level yields results with implications for a variety of groups vested in Grand Rapids UTC. Infrastructure developers, land conservancy groups, and environmental groups may find it especially useful.

Quantifying Ecosystem Services

Urban forests provide many valuable direct and indirect "ecosystem services," i.e., benefits that people obtain from urban forest ecosystems. These benefits—particularly those such as aesthetic and recreational enrichment—are difficult to quantify. However, in recent years tools have been developed to measure some of these benefits, such as carbon storage, carbon sequestration, air quality improvement, energy savings, stormwater interception, and increased property values. Quantifying these benefits helps to demonstrate the value of urban forests and the return on investment in maintaining and enhancing urban forests. For example, some studies indicate that planting a tree can yield a return on investment of nearly 200% (McPherson, et al., 1997).

Plan-It Geo used i-Tree Canopy, a software tool developed by the USDA Forest Service, to estimate the value of three ecosystem services—carbon storage, annual carbon sequestration, and annual air pollution removal—provided by Grand Rapids' urban forest. Additionally, stormwater benefits were estimated using i-Tree Eco's annual avoided runoff estimations.

* **Source: U.S. Census. American Community Survey data by Block Group, 5-year estimates 2009-2013.**

KEY FINDINGS

Land Cover in Grand Rapids, MI

This section provides resulting tables and maps from the urban tree assessment based on data derived from land cover mapping. The detailed land cover dataset below was derived using object based image analysis on multispectral aerial imagery, texture analysis, and pattern recognition. Aerial imagery is available through the US Department of Agriculture's National Agriculture Imagery Program (NAIP). In this representation, land cover has been broken up into seven different classes: tree canopy, grass/open space, buildings, roads, other impervious, water, and bare soil/dry vegetation.

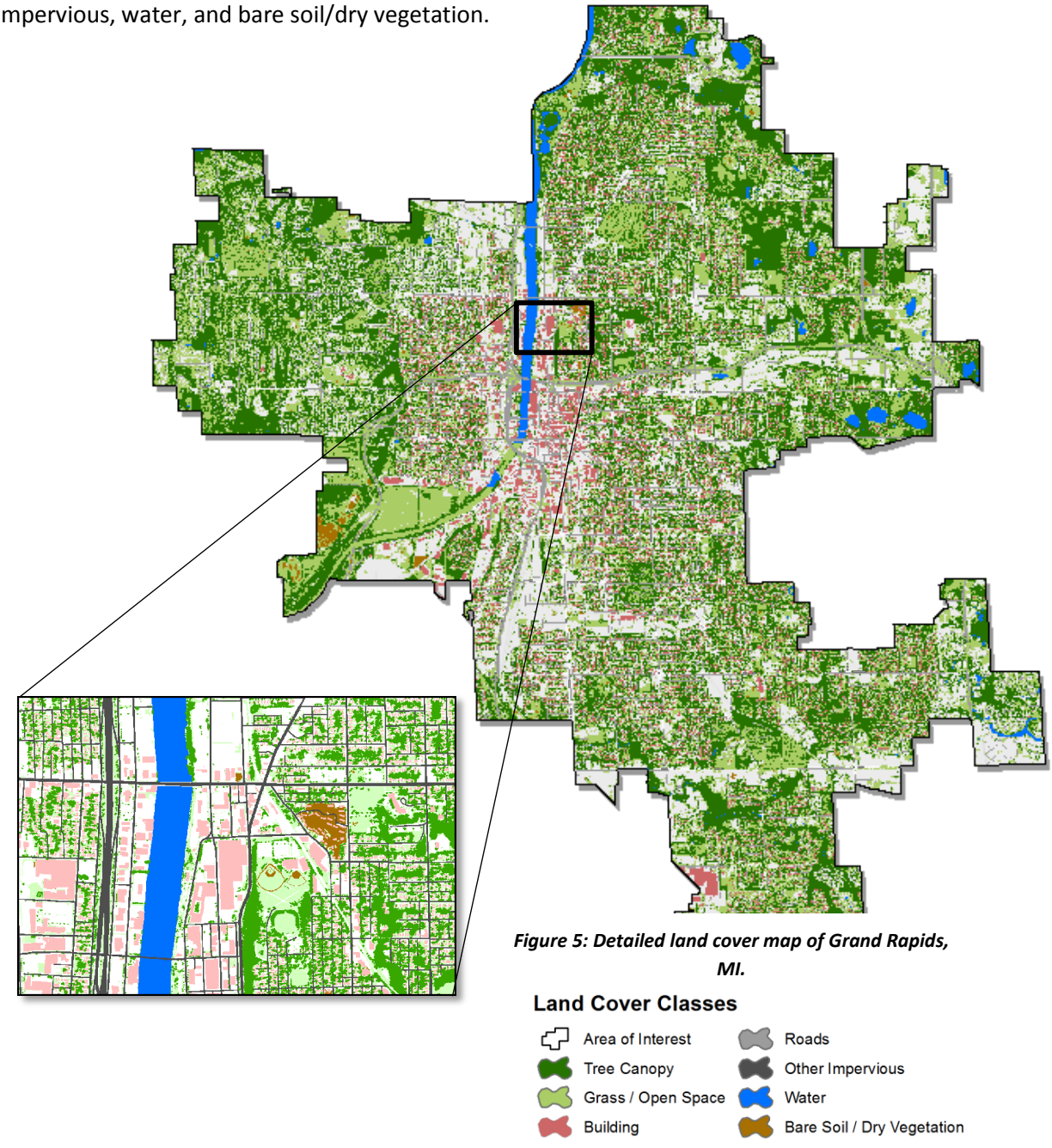


Figure 5: Detailed land cover map of Grand Rapids, MI.

City Assessment Level

According to the data derived from the Urban Tree Canopy Assessment and land cover analysis, the amount of tree canopy in Grand Rapids is 34%. Below is a representation of Percent Urban Tree Canopy by city parcel. Generally speaking, most tree canopy will be located in residential areas and less will be found in industrial/densely populated urban areas. When compared to the zoning map on the following page, there is a notable correlation between low UTC values and proximity to urban/industrial areas (particularly along the Grand River corridor).

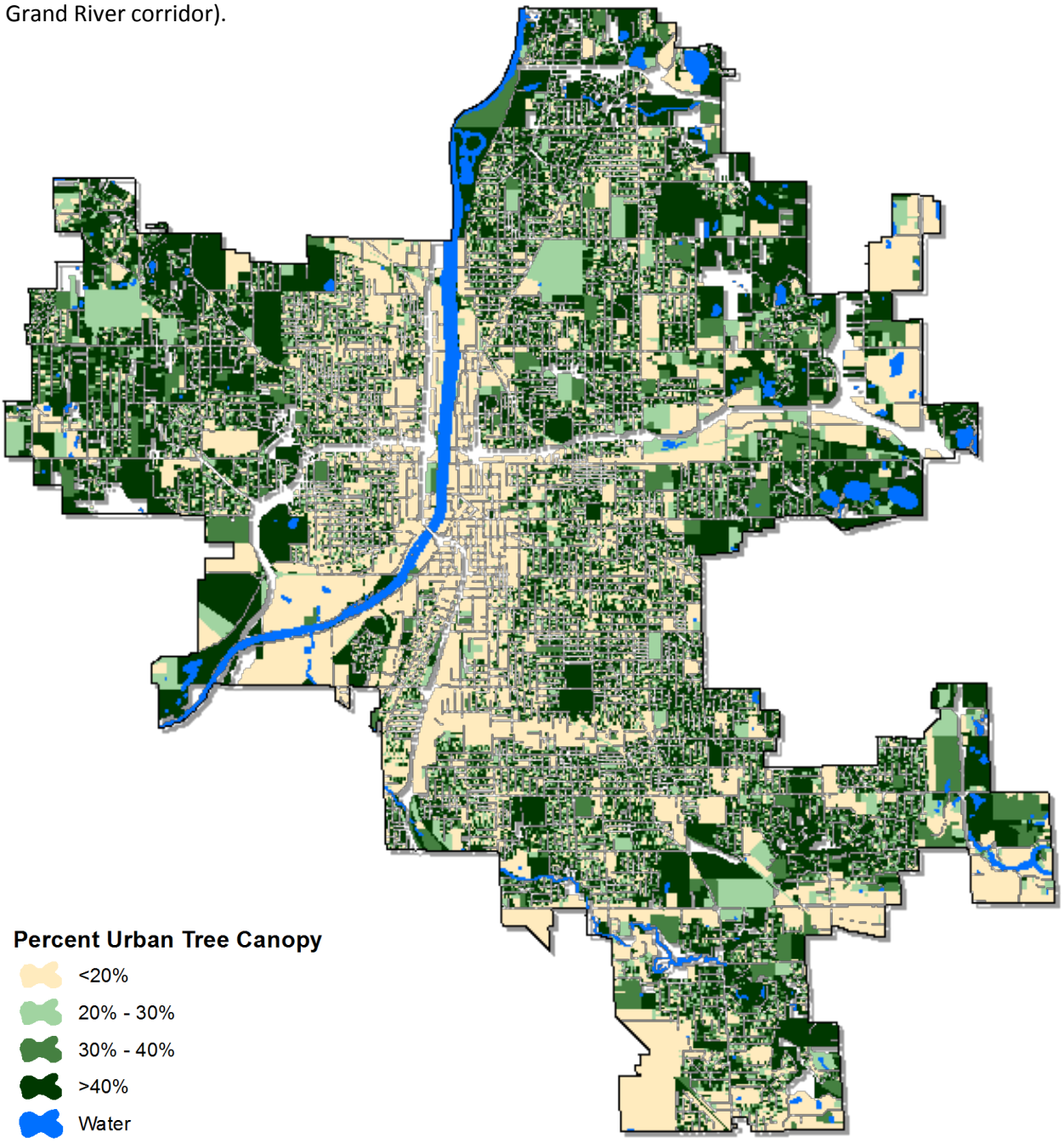


Figure 6: Urban Tree Canopy (%) by parcel in Grand Rapids, MI.

Zoning Class Assessment Level

This study processed urban tree canopy (UTC) levels and possible planting area (PPA) data at the level of twelve city zoning classes. The locations and citywide distribution make-up of zoning classes across Grand Rapids is shown in the map below. The majority of Grand Rapids is made up of low density residential, with a concentration of industrial transportation and city center along the Grand River corridor.

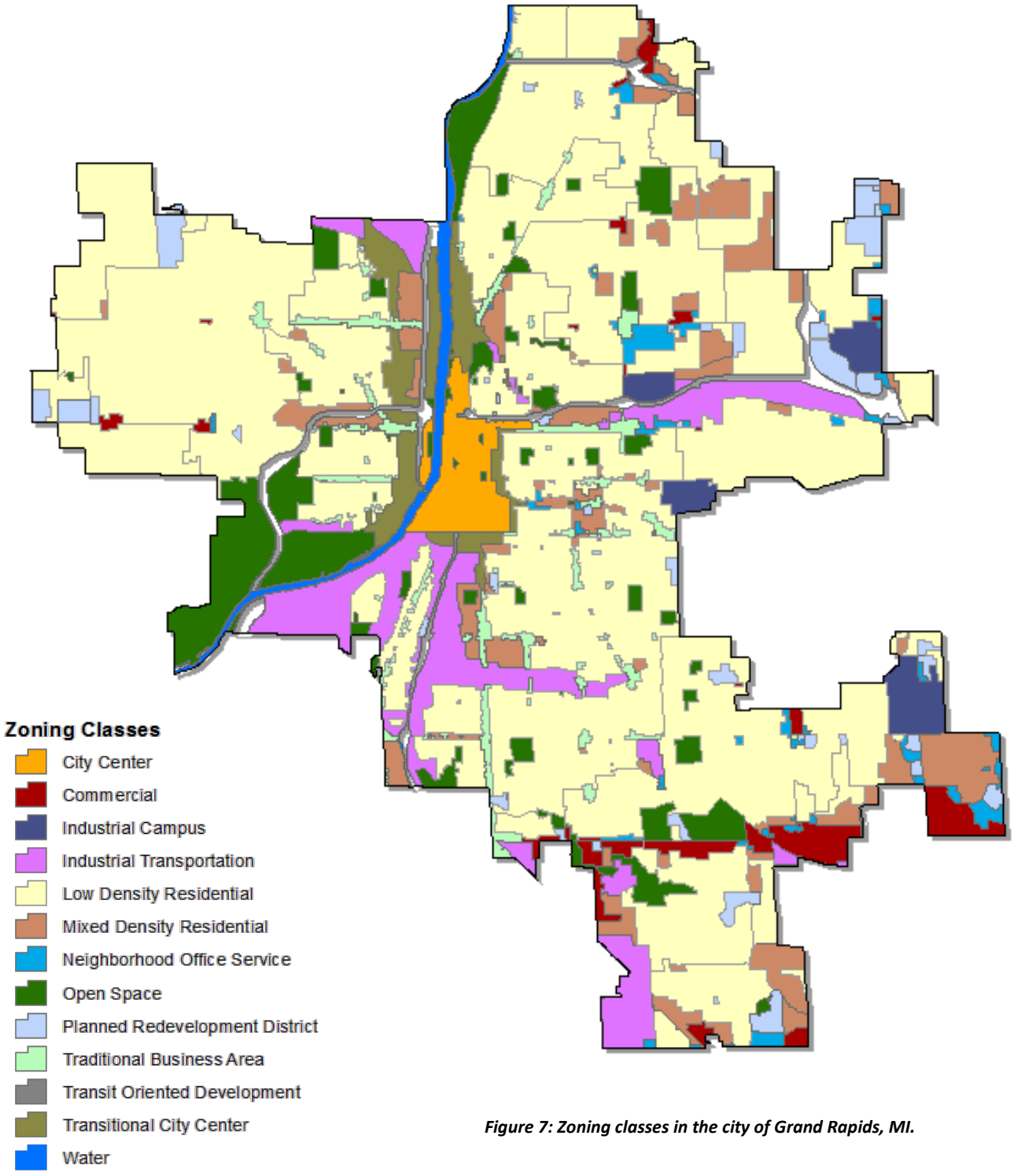


Figure 7: Zoning classes in the city of Grand Rapids, MI.

Many of the policies and regulations influencing tree canopy in Grand Rapids are dependent on zoning class. To provide data that advances urban forest policy and management, 12 zoning classes were assessed for tree canopy and potential planting area (PPA) within zoning classes, UTC ranged widely from 4-42%. Potential Planting Area (PPA) was as low as 0.1 acres in the transit oriented development class or as high as 4,330 acres in the low density residential class. See the chart below for more details.

Table 1: Urban Tree Canopy and Possible Planting Area metrics by zoning class*

Zoning Code	Zoning Class	% Urban Tree Canopy within Zoning Class	% Possible Planting Area in Zoning Class	Acres Possible Planting Area in Zoning Class
CC	City Center	4%	6%	33
C and C-A	Commercial	10%	13%	92
SD-IC	Industrial Campus	30%	28%	141
SD-IT	Industrial transportation	11%	16%	329
LDR	Low Density Residential	42%	26%	4,330
MDR	Mixed Density Residential	36%	25%	544
SD-NOS	Neighborhood Office Service	21%	25%	107
SD-OS	Open Space	42%	36%	722
SD-PRD	Planned Redevelopment District	30%	29%	226
TBA and TBA-A	Traditional Business Area	9%	9%	61
TOD	Transit Oriented Development	8%	6%	0.1
TCC	Transitional City Center	8%	11%	89

***See page 41 in the Appendix for more information.**

Commission Ward Assessment Level

City commission wards had relatively equal levels of UTC, with only a five percentage point difference from the lowest to the highest ward. Because of its higher UTC level and larger size, Ward 1 contributes the most (39%) to citywide UTC; Ward 3 contributes the least (27%).

Ward 2 was covered by the lowest level of UTC (32%); this ward also had the highest percentage of Possible Planting Area (PPA). Ward 2 then could be considered to have the greatest opportunity for UTC growth.

Table 2: Urban Tree Canopy and Possible Planting Area metrics by Ward in Grand Rapids, MI.

Ward	Urban Tree Canopy % within Ward	Urban Tree Canopy Distribution within Grand Rapids	% Possible Planting Area within ward	Acres Possible Planting Area
1	37%	39%	25%	2,521
2	32%	34%	25%	2,619
3	34%	27%	24%	1,866

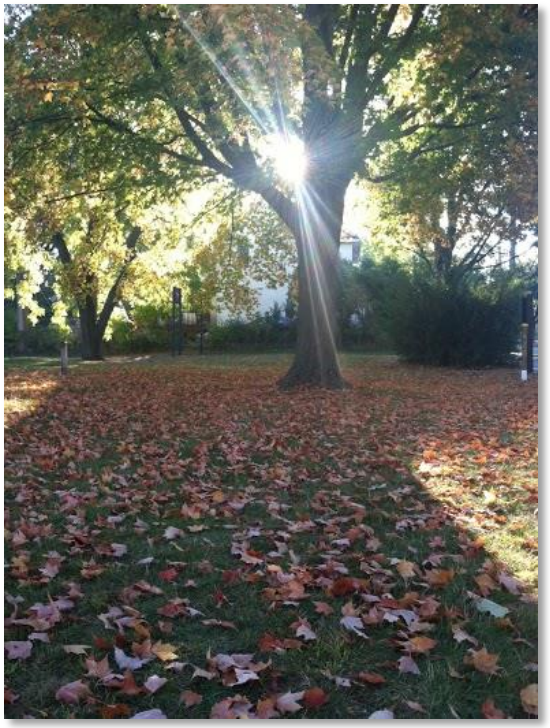


Figure 8: Photo credit: Friends of Grand Rapids Parks.

ROW within Maintenance District Assessment Level

Urban Tree Canopy (UTC) within public Right of Way (ROW) comprises an important component of Grand Rapids' urban canopy. To better maintain current UTC and highlight priority areas for new planting within the Right of Way, UTC has been split up by each maintenance district within Grand Rapids.

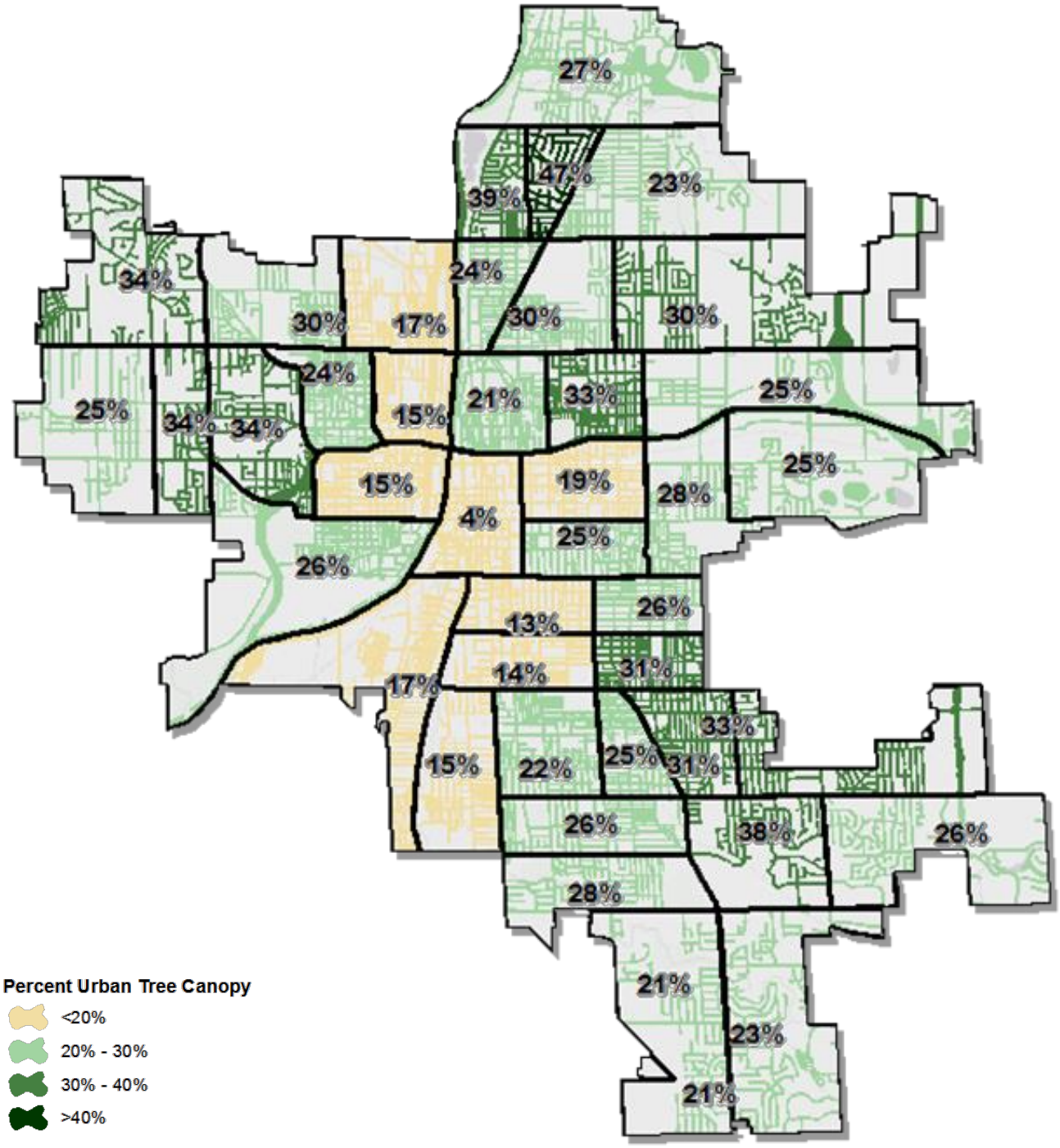


Figure 9: Urban tree canopy within the right of way, delineated by maintenance district.

Highest UTC in ROW by Maintenance District

The three districts with the highest UTC in the Right of Way are districts 27, 26, and 37. Note that the percentages are relative based on the total area of that particular maintenance district. Thus, the highest % of UTC within the ROW may not correspond to the highest acreage of existing UTC.

Table 3: Highest Urban Tree Canopy in ROW by maintenance district.

Maint. District	% Urban Tree Canopy Within ROW	Acres Urban Tree Canopy	Total Acres Possible Planting Area
27	47%	34	11
26	39%	28	11
37	38%	38	17

Lowest UTC in ROW by Maintenance District

The three districts with the lowest UTC in the Right of Way are districts 16, 14, 0. These districts would benefit the most from using the current PPA acreage for new street trees and ensuring maintenance for the trees that are already in place.

Table 4: Lowest Urban Tree Canopy in ROW by maintenance district.

Maint. District	% Urban Tree Canopy Within ROW	Acres Urban Tree Canopy	Total Acres Possible Planting Area
16	13%	14	13
14	13%	14	11
0	4%	7	18

Neighborhood Assessment Level

This study processed urban tree canopy (UTC) totals, UTC change, and possible planting area (PPA) data at the level of thirty seven neighborhoods. UTC percentage within each neighborhood is shown below, with higher-percentage neighborhoods appearing darker green and lower-percentage neighborhoods appearing in lighter green.

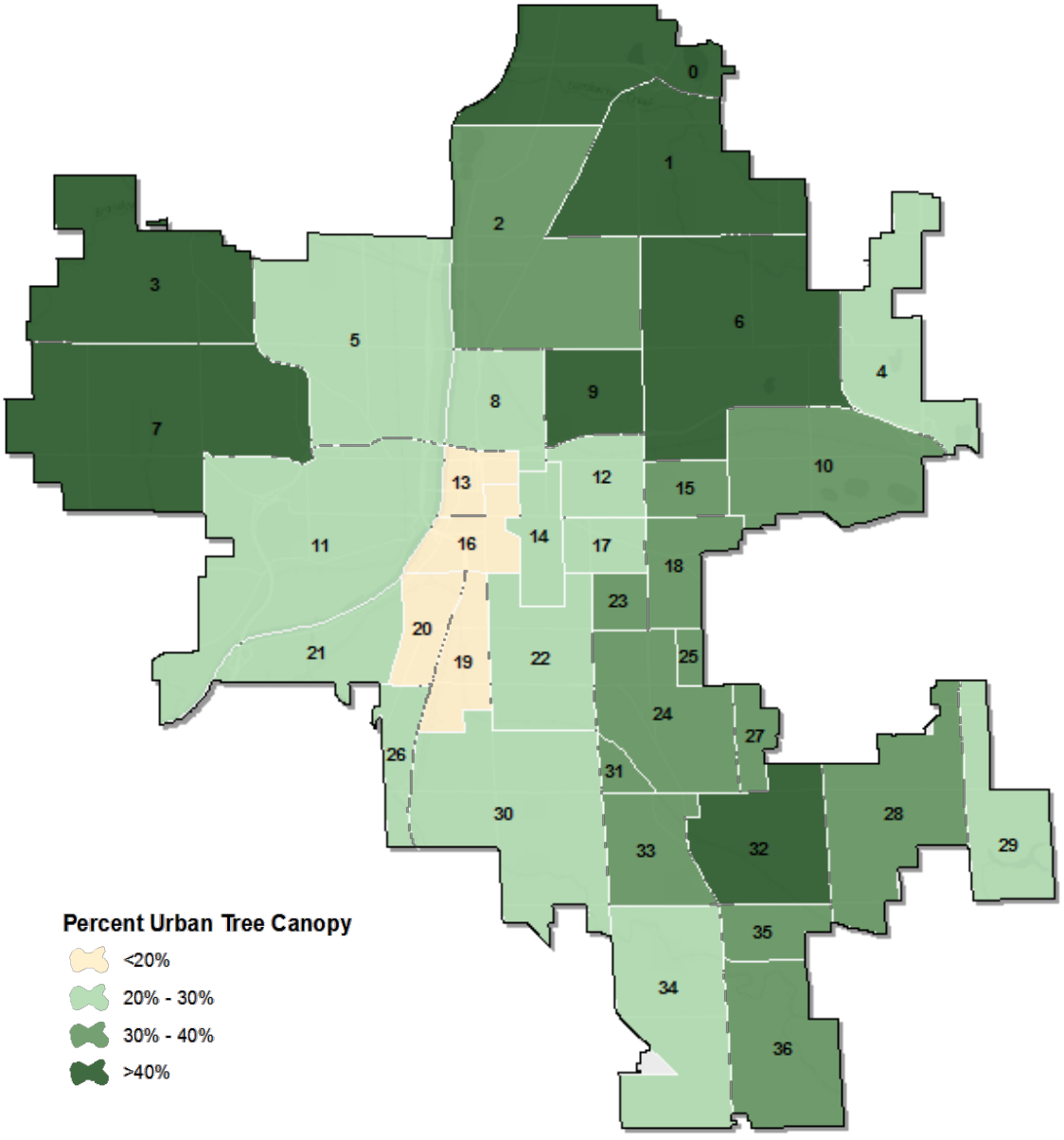


Figure 10: Percent UTC by neighborhood in Grand Rapids, MI.

Table 5: List of neighborhood names and Urban Tree Canopy percentages with their corresponding SP_ID number. For greater detail, see appendix.

Neighborhood	SP_ID*	Urban Tree Canopy (%)
Alger Heights	33	34%
Baxter	23	33%
Belknap Lookout	8	26%
Black Hills	21	22%
Creston	2	37%
Downtown	13	4%
East Hills	17	30%
Eastern-Burton	31	35%
Eastgate	27	37%
Eastown	18	34%
Fulton Heights	15	35%
Garfield Park	30	30%
Grandville	20	18%
Heritage Hill	14	30%
Highland Park	9	41%
John Ball Park	11	30%
Ken-O-Sha Park	34	29%
Lake Eastbrook	29	30%
Leffingwell-Twin Lakes	4	30%
Michigan Oaks	10	40%
Midtown	12	26%
Millbank	36	38%
North End	1	44%
North Park	0	48%
Northeast	6	40%
Oldtown-Heartside	16	6%
Ottawa Hills	25	36%
Richmond-Oakleigh	3	46%
Ridgemoor Park	28	32%
Roosevelt Park	26	24%
Shangrai-La	35	37%
Shawmut Hills	7	47%
Shawnee Park	32	42%
Southeast Community	22	26%
Southeast End	24	36%
Southwest	19	10%
West Grand	5	25%

*SP_ID is a unique identification number assigned by Plan-It Geo's scripting procedures.

Highest UTC Neighborhoods

North Park, Shawmut Hills, and Richmond-Oakleigh were the neighborhoods that had the highest percentage UTC in 2014, with the highest at 48% (North Park). In this neighborhood, canopy has increased by 2.4% (23 acres) since 2005.

Table 6: Three neighborhoods with the highest Urban Tree Canopy percentage.

Neighborhood	% Urban Tree Canopy Within Neighborhood	Urban Tree Canopy Change from 2005 (%)	Total Acres Possible Planting Area
North Park	48%	+2.4%	394
Shawmut Hills	47%	-4.4%	946
Richmond-Oakleigh	46%	-4.8%	629

Lowest UTC Neighborhoods

Southwest, Oldtown-Heartside and Downtown were the neighborhoods that had the lowest percentage of tree canopy, with the lowest being 4% (Downtown). In this neighborhood, canopy has decreased by 0.9% (2 acres).

Table 7: Three neighborhoods with the lowest Urban Tree Canopy percentage.

Neighborhood	% Urban Tree Canopy Within Neighborhood	Urban Tree Canopy Change from 2005 (%)	Total Acres Possible Planting Area
Southwest	10%	-1.9%	251
Oldtown-Heartside	6%	0.6%	172
Downtown	4%	-0.9%	80

Watershed Assessment Level

This study processed urban tree canopy (UTC) totals, UTC change, and possible planting area (PPA) data at the level of seven watersheds. UTC percentage within each watershed is shown below, with higher-percentage watersheds appearing darker green and lower-percentage watersheds appearing lighter. Findings at a watershed level can be used for any number of different studies/projects, including hydrologic modeling tools, water resource management plans, forest management plans, water quality studies, and more. Note that because the assessment levels were clipped to the boundary of Grand Rapids, partial watersheds are included at this level.

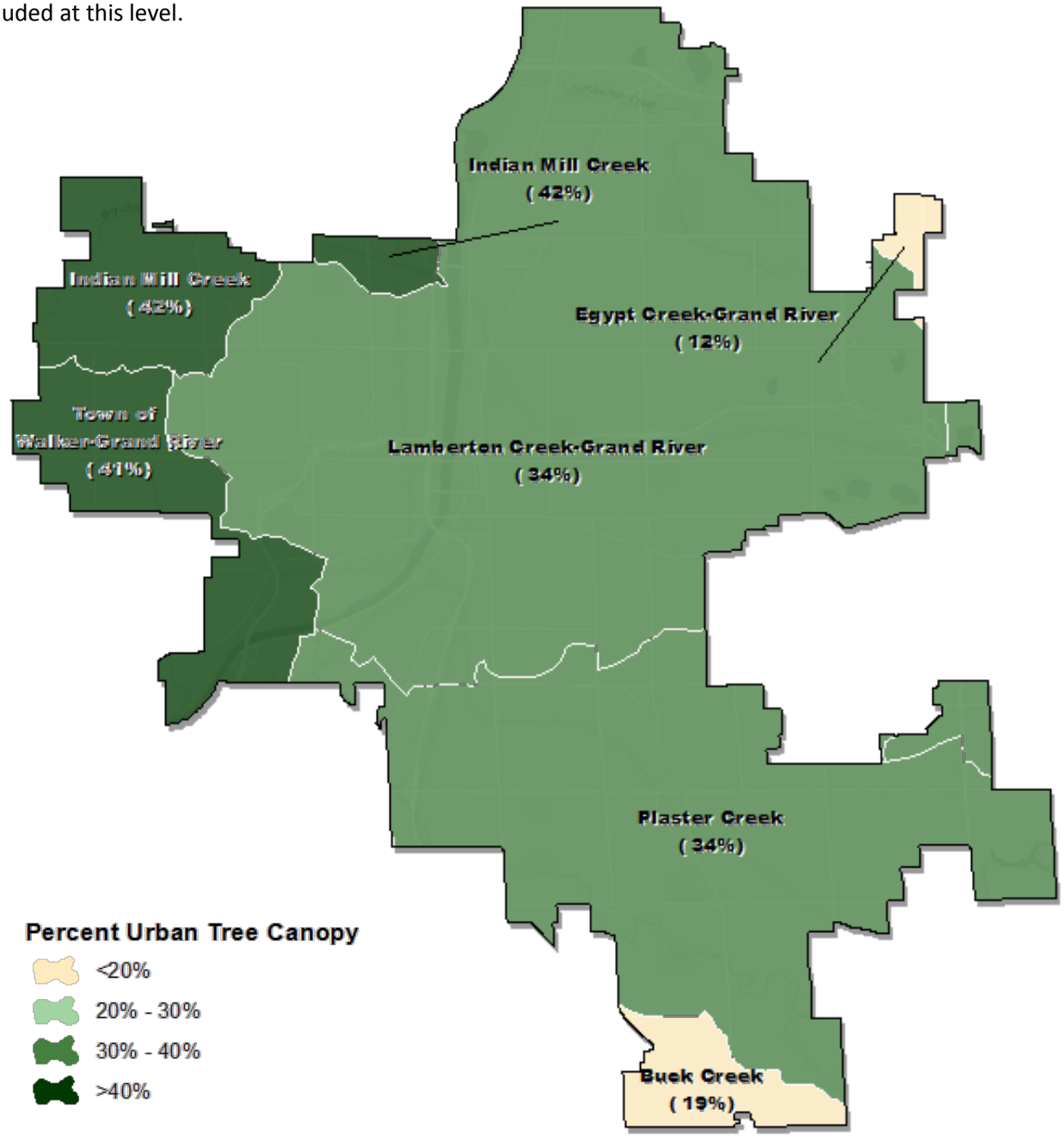


Figure 11: Percent UTC by Watershed (USGS HUC-12).

Socio-Demographic Assessment Level

Plan-It Geo's comprehensive canopy analysis includes an exploration of the relationship between tree canopy cover and social-demographic and economic data from the U.S. Census American Community Survey. Analysis of Urban Tree Canopy distribution by census block groups (shown in the figure below) against detailed census data reveals a clear relationship between tree canopy and economic vitality of households, as seen in income levels, home values, educational attainment, and rates of owner occupancy. In addition, areas with the highest levels of tree canopy also tend to have smaller minority populations. Data from this UTC study is also being shared with Grand Valley State University's Community Research Institute for further analysis.

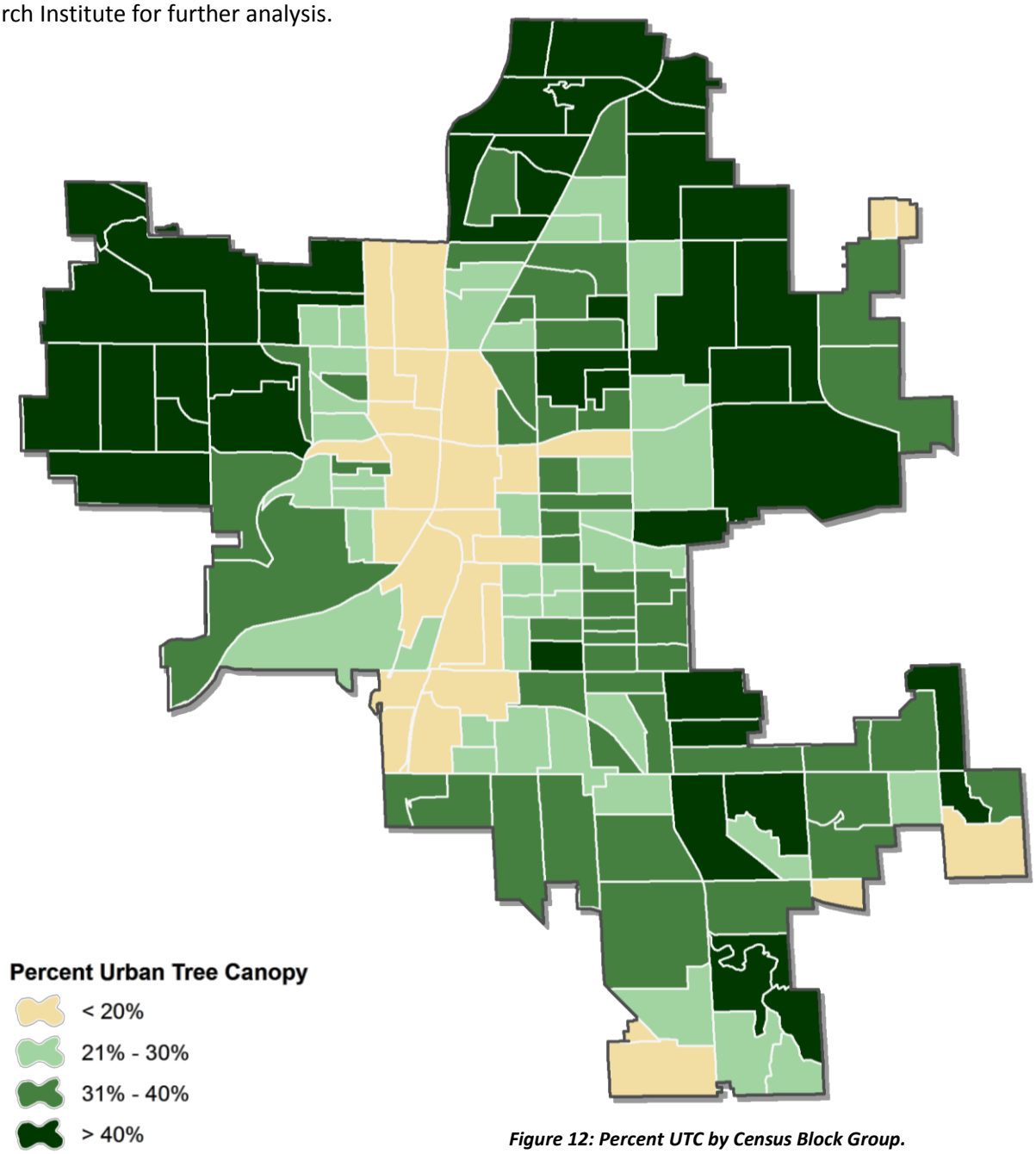
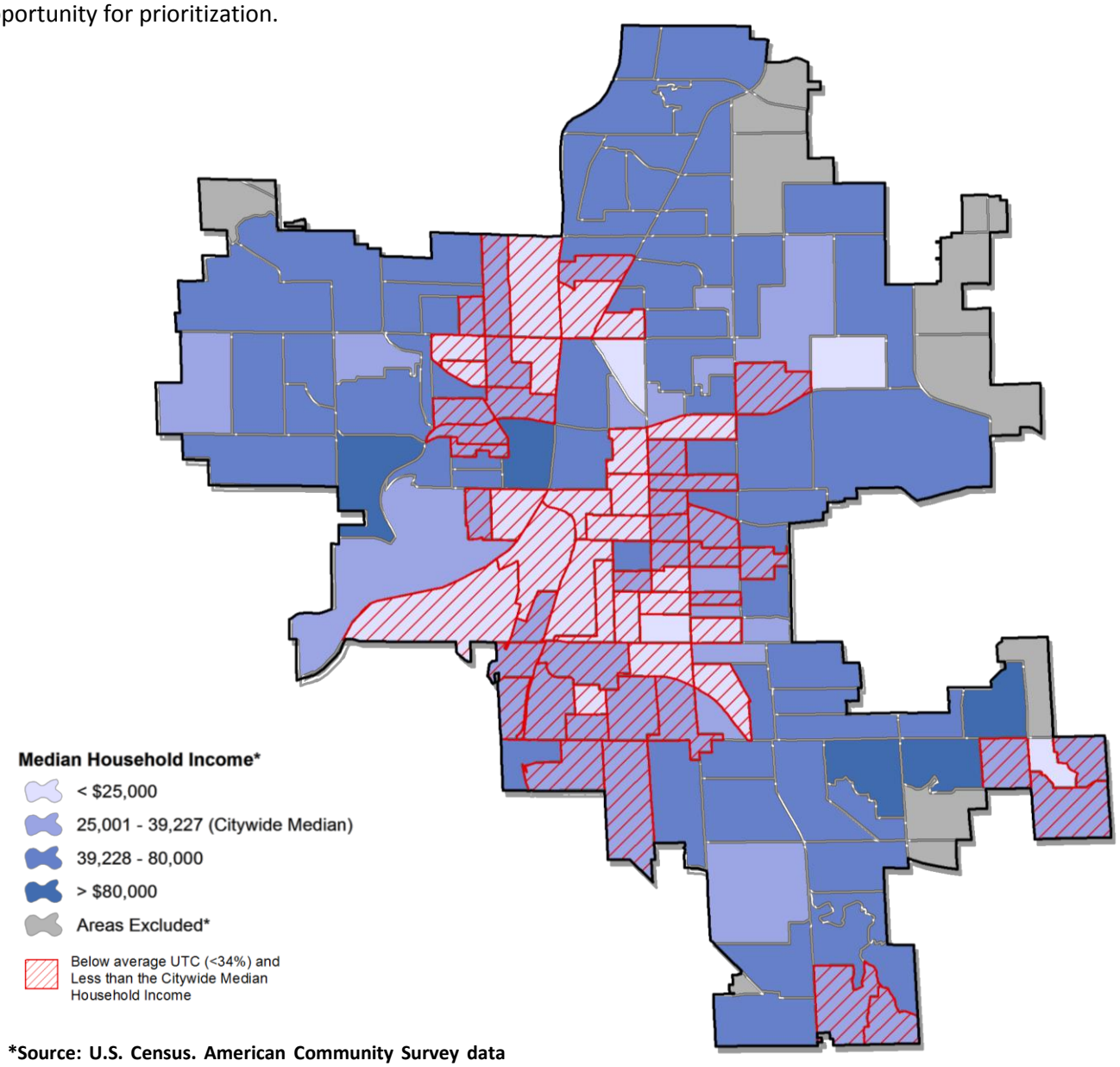


Figure 12: Percent UTC by Census Block Group.

Median Household Income in the Past 12 Months (Inflation Adjusted)

As the percentage of urban tree canopy increases in census block groups, median income also increases. The hatched areas in the map on the right show those block groups that fall below the City's median household income level of $39,227, and contain less than the average amount of UTC of 34%. These areas might have greater tree planting potential and opportunity for prioritization.

% Urban Tree Canopy	Average Median Income
41-100%	$49,285
21-40%	$39,001
0-20%	$30,597



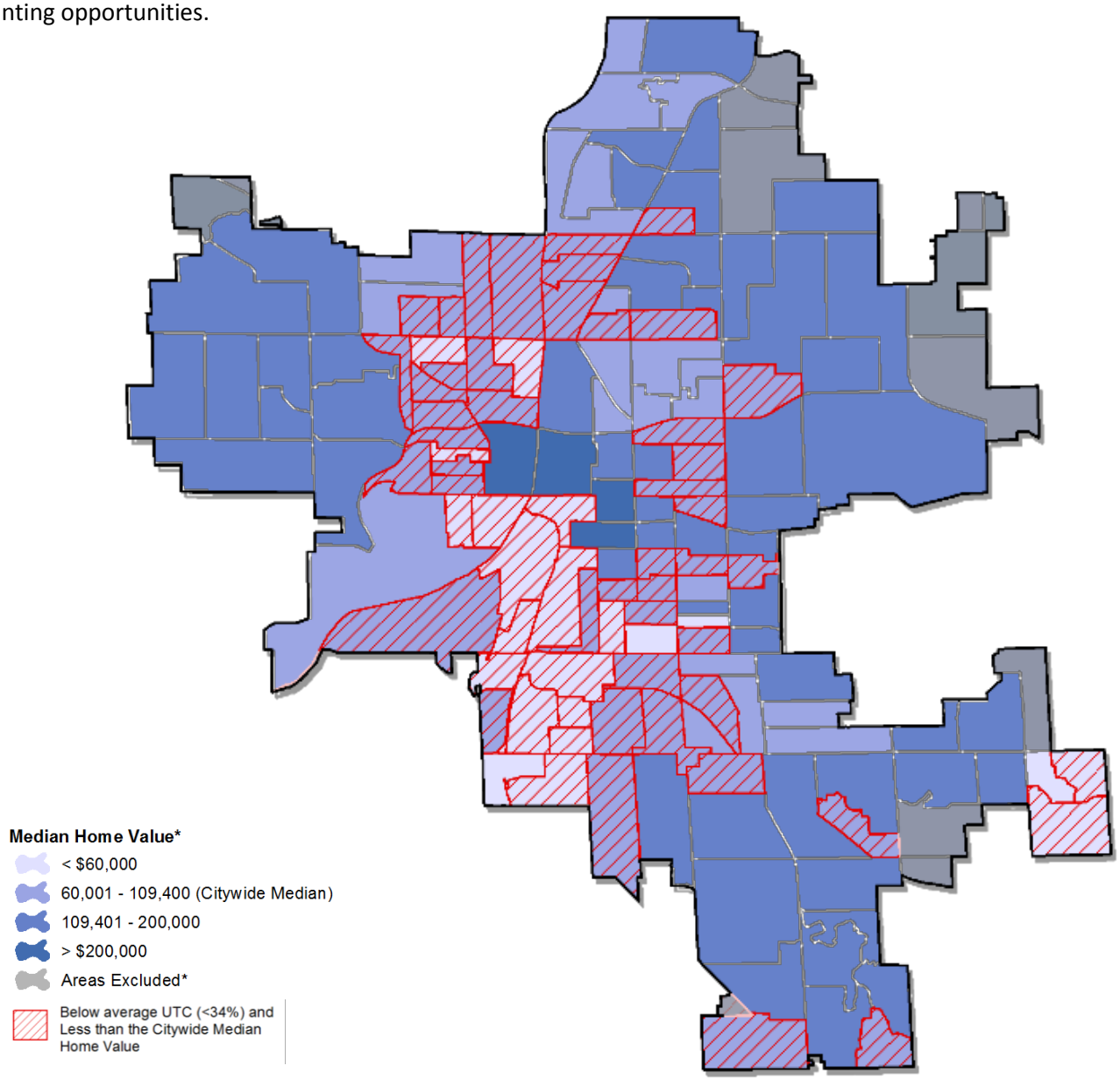
***Source: U.S. Census. American Community Survey data by Block Group, 5-year estimates 2009-2013. Areas excluded due to partial census block groups.**

Figure 13: Median household income by census block group.

Median Value for Owner-Occupied Housing Units

As the percentage of urban tree canopy increases in census block groups, median home value also increases. The hatched areas in the map on the right show those block groups with median home values that fall below the City's median home value of $109,400, and contain less than the average amount of UTC of 34%. These areas might be considered for tree planting opportunities.

% Urban Tree Canopy	Average Median Home Value
41-100%	$118,964
21-40%	$95,142
0-20%	$90,383



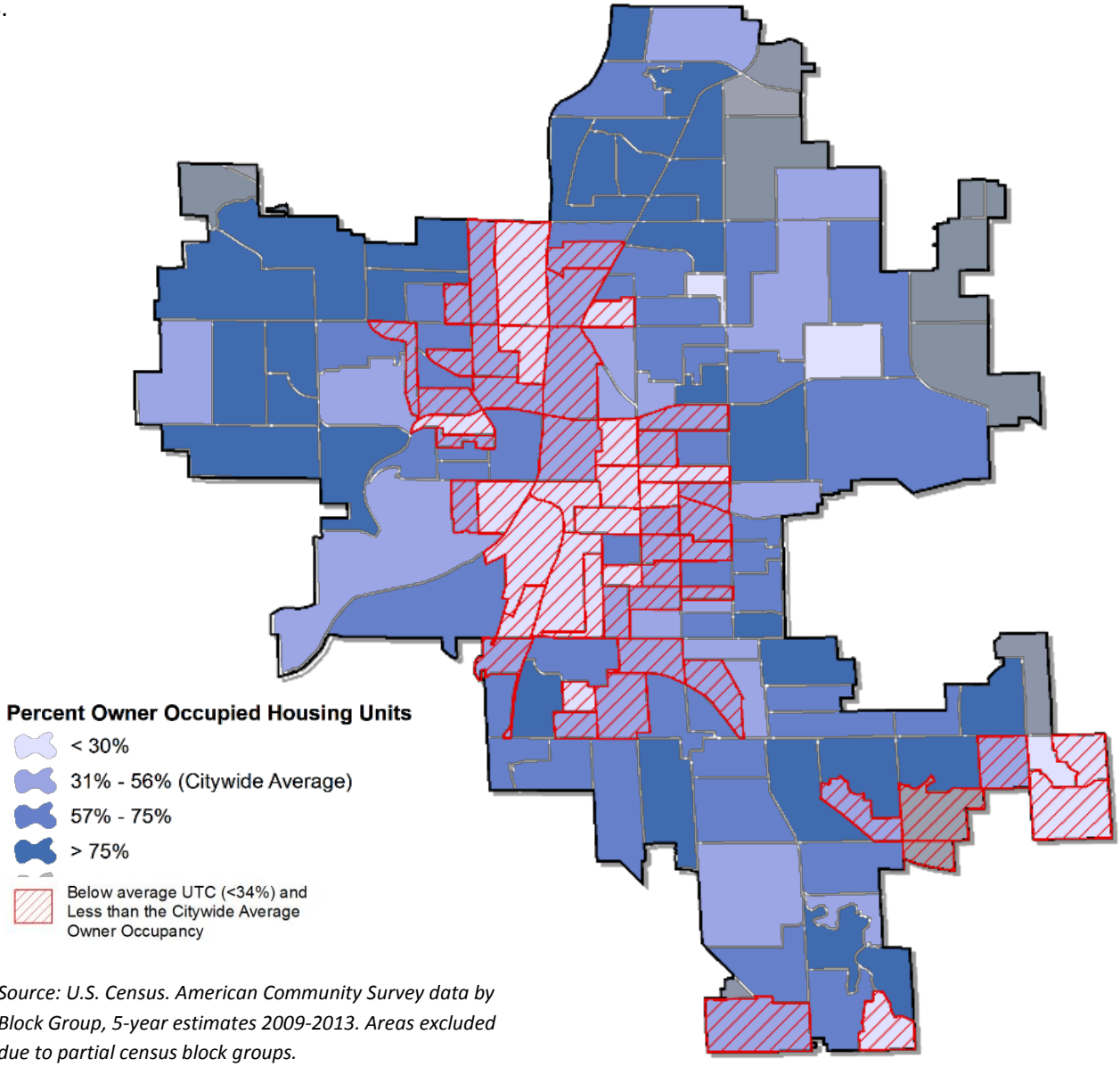
Source: U.S. Census. American Community Survey data by Block Group, 5-year estimates 2009-2013. Areas excluded due to partial census block groups.

Figure 14: Median home value by census block group.

Tenure for Occupied Housing Units

The rate of owner occupancy is greater in areas with a higher percentage of UTC. This indicator generally reflects the stability of a given area or neighborhood, as it is believed that there is more of a vested interest in personal property. For Grand Rapids, the homeownership rate is 56%. The hatched areas in the map on the right show those census block groups with less than average owner occupancy and less than the average UTC of 34%.

% Urban Tree Canopy	Percent Ownership
41-100%	67%
21-40%	56%
0-20%	31%



Source: U.S. Census. American Community Survey data by Block Group, 5-year estimates 2009-2013. Areas excluded due to partial census block groups.

Figure 15: Percent owner occupied housing units by census block group.

Priority Planting Areas

The results of this analysis show a clear relationship between tree canopy cover and social-demographic and economic conditions in the City of Grand Rapids. This information can help inform prioritization of tree planting and preservation efforts to address equity issues. The following map highlights those census block groups that contain all of the following conditions: below average UTC (< 34%), less than the citywide median income (< $39,227), less than the citywide median home value (< $109,400), and less than the citywide owner occupancy rate (< 56%). These areas should be considered as high priority planting areas.

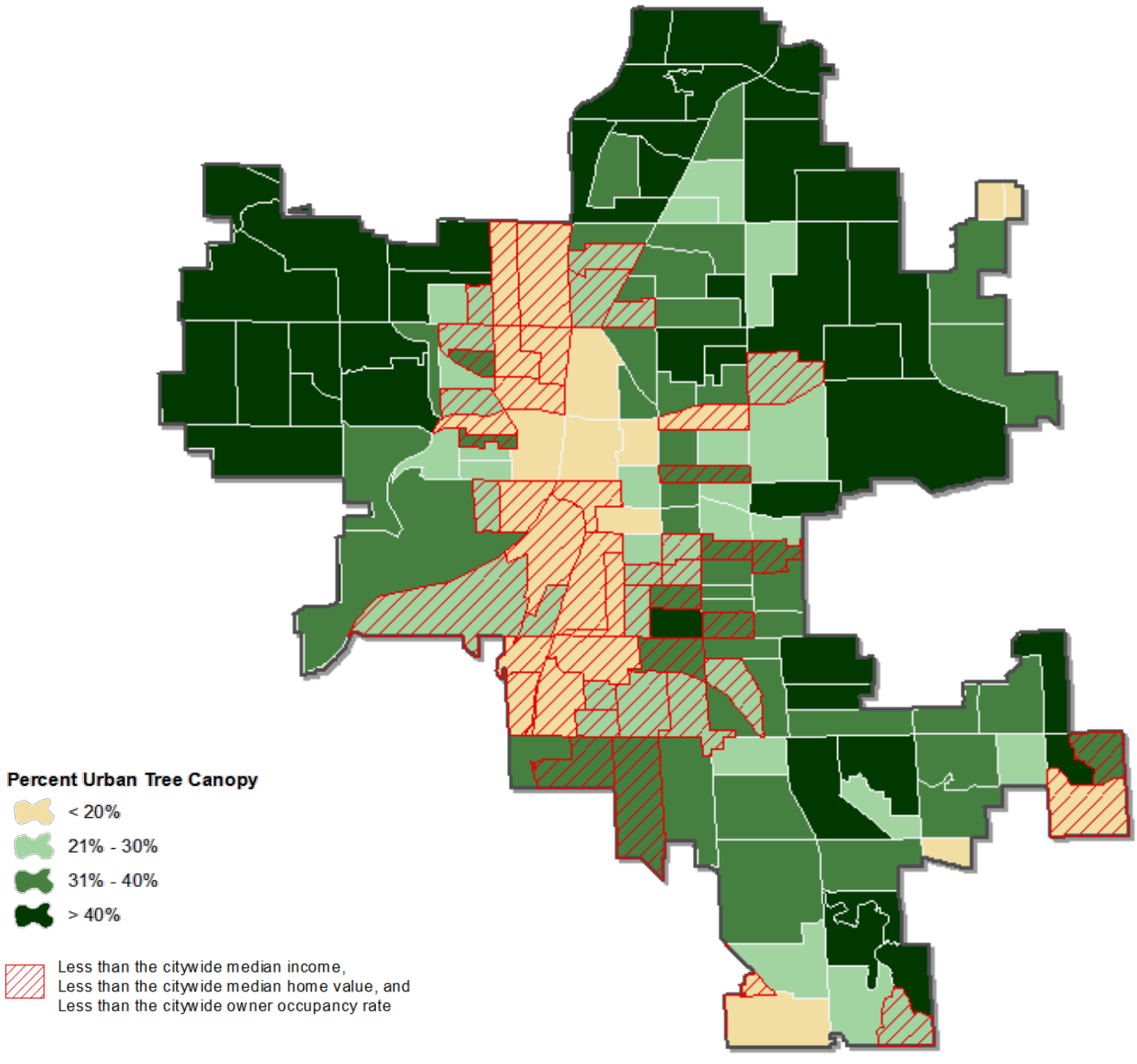


Figure 16: Percent urban tree canopy and priority planting areas by census block group.

Drivers of Canopy Change

Major drivers of canopy change in Grand Rapids in recent years include the emerald ash borer, development, and infrastructure projects.

Emerald Ash Borer (EAB)

The emerald ash borer (EAB), an Asian tree pest that arrived in Michigan in 2002 (Miller, 2015), first killed millions of ash trees in southeast Michigan before spreading to West Michigan. An ecosystem analysis conducted in 2011 identified ash trees as one of Grand Rapids' four most important tree species, comprising more than 7 percent of the city's trees.

Undoubtedly, the city's ash population is decreasing significantly as a result of EAB. The impact of EAB on the private land component of Grand Rapids' urban forest is unknown—but may be significant in view of the fact that more than 95% of the city's urban forest is on private land. Among public street trees alone, the City has removed more than 3,000 ash trees that succumbed to EAB, with additional removals numbering in the thousands anticipated—a loss of the majority of the 7,000+ street ash trees identified in a 2007 inventory. To mitigate canopy loss from EAB, the City is treating 1,400 high-value public ash trees to prevent EAB infestation, as well as prioritizing increased street tree planting.

The canopy impact of EAB is evident in the figure below (left two photographs), showing a stark contrast on Shawnee Drive SE (between N. Shiawassee and Tekonsha) before and after removal of ash trees, which comprised nearly the entire right-of-way canopy on this block. The two photographs on the right show Annchester Drive SE, where treatment of the EAB pest was successful and almost the entire canopy remains.

Ash Removal
2005-2014

Ash Treatment/Preservation
2005-2014

Figure 17: Before and after aerial photography of emerald ash borer infestation treatments.

Development

Over the past ten years Grand Rapids has completed millions of dollars worth of street reconstruction projects, including many aimed at addressing combined sewer overflow issues. These projects, as well as sidewalk repairs, often necessitate removal of trees, resulting in canopy loss for decades until the newly-planted replacement trees provide significant canopy.

Development of the city has been another major driver of urban tree canopy change in recent years. Forested lots are often cleared prior to the construction of residential and commercial structures, resulting in net UTC loss even when some new trees are planted around developments. Due to ever-increasing population, the need for newly developed areas will only increase in the future. The figure below shows tree clearing for a development on Summit Ridge Drive NE in northeastern Grand Rapids.

Figure 18: Before and after aerial photography of residential development in Grand Rapids, MI.

Ecosystem Services

Analysis of annual air pollution removal, stormwater mitigation, and carbon sequestration—just three of the many ecosystem services urban trees provide—show that Grand Rapids' urban forest provides at least **$2.64 million** in annual benefits. The illustration below demonstrates how the monetary value of these services provided by the city's tree canopy would increase or decrease based on different canopy change scenarios.

In addition the value of carbon storage of the urban forest cumulatively (all the carbon currently stored in the city's urban forest) is **$24.8 million**.

Table 8: Urban Tree Canopy (UTC) percentage change scenarios and the projected benefit values ($).

+7 Percentage Points	$ 3,178,700
+6 Percentage Points	$ 3,102,289
+5 Percentage Points	$ 3,025,877
+4 Percentage Points	$ 2,949,466
+3 Percentage Points	$ 2,873,055
+2 Percentage Points	$ 2,796,644
+1 Percentage Point	$ 2,720,233
Current UTC	**$ 2,643,822**
-1 Percentage Point	$ 2,567,411
-2 Percentage Points	$ 2,491,000
-3 Percentage Points	$ 2,414,589
-4 Percentage Points	$ 2,338,178
-5 Percentage Points	$ 2,261,767
-6 Percentage Points	$ 2,185,356
-7 Percentage Points	$ 2,108,945

i-Tree Canopy and its associated tools take into account many different variables when estimating monetary benefits. Larger, more well-documented benefits such as pollution mitigation are taken into account, as well as other benefits that are initially not as apparent (i.e. factoring in health and medical costs to the population for things like upper respiratory symptoms as a result of increased pollution). In the case of this model, several things are not taken into account that would increase the overall value of the present tree canopy, including:

- Social parameters that are difficult to assign a dollar value to, i.e. research that points towards a link between urban canopy and a decrease in crime rate, noise pollution
- Environmental parameters including valuations of animal habitats, erosion control, etc.

RECOMMENDATIONS

Utilizing UTC Assessment Results

The goal of this UTC Assessment is to provide both qualitative and quantitative data and information for enhancing, maintaining, and protecting tree canopy. This section provides insight into how to utilize the results of this study to ensure that Grand Rapids has a healthy and flourishing tree canopy for generations to come. In the following pages are general recommendations for data use as well as four tailored strategies to aid in planning and projections.

Planning & Community Development

- ✓ Current urban forestry planning for Grand Rapids can be updated with current UTC data.
    - Use the information to establish tree planting and canopy cover goals.
    - Evaluate staff or budget for maintenance, inspection, improvements, and enforcement.
- ✓ Enhance tree-related policies and ordinances to achieve management planning objectives/canopy goals.
- ✓ Continue tree planting events targeting areas with low UTC and high potential planting area by working with neighborhood associations and local residents/businesses. Use the data and tools from this project such as Plan-It Geo's web mapping applications.
- ✓ Foster partnerships with campuses, community groups, businesses, and job creation programs.
- ✓ Continue and expand the Urban Forest Project's Citizen Forester Program.

Figure 19: Photo credit: Friends of Grand Rapids Parks.

Land Cover Analysis

- ✓ Disseminate the land cover data to diverse partners for urban forestry and other applications while the data is current and most useful for decision-making and implementation planning.
- ✓ Re-assess canopy cover in no less than 10-year intervals, and use LiDAR data if available, aiming for 95% minimum overall accuracy.

Tree Canopy Overall

- ✓ Grand Rapids' urban forest green infrastructure is providing benefits that can be quantified. Use these results to encourage investment in forest monitoring, maintenance, and management.
- ✓ Develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues.

Tree Canopy for Air Quality

- ✓ This study identified 447 acres of PPA within street rights-of-way corridors where concentrations of particulate matter may be highest. Officials should partner to target canopy increases in street ROW as an air pollution mitigation strategy while increasing walkability, retail, and biking.
- ✓ Prioritize tree planting in areas with high impervious surface cover to mitigate the urban heat island effect by reducing ambient air temperatures and the formation of ozone and improving air quality.

Tree Canopy for Energy Conservation

- ✓ Develop strategies to plant trees for energy efficiency. Use i-Tree Design (http://www.itreetools.org/design.php) for site-specific benefit analysis and consider the Arbor Day Foundation's "Energy Saving Trees" program.
- ✓ Many new residential developments throughout Grand Rapids have newly planted trees. If properly cared for, these trees will contribute greatly to the urban forest.

Tree Canopy and Water Resources

- ✓ Tree canopy in urban areas helps to mitigate flooding and stormwater issues. The increased amounts of impervious areas due to parking lots, roads, sidewalks, and more lead to less rainwater infiltrating into the soil profile. Urban canopy helps to intercept some of the rainfall, mitigate flooding, regulate water quality, and influence the timing of peak runoff values (Dunne & Leopold, 1978).
- ✓ Using i-Tree Hydro or other hydrologic modeling tools, streamflow, runoff, and pollution loads can be estimated. Using land cover data from this study, these kinds of models can be run to show different scenarios of land cover change and their costs (both economically and environmentally) to the City of Grand Rapids.
- ✓ Present the findings of these studies to city planners, engineering firms, resource managers, and the public to further underline the importance of Grand Rapids' urban tree canopy.

Strategy 1: Focus on most accessible Low-UTC areas

An initial planting focus on areas with very low UTC may result in the greatest returns. A good example of this can be seen in the hydrograph response of areas with very low UTC percentages. Less tree cover means that less rainfall will be captured during a storm event, producing more runoff. This can put more pressure on existing stormwater management (or necessitate the construction of new facilities) and create the potential for more flooding. Below is an example of how parcels in Grand Rapids can be prioritized for future planting. In this case, areas with low UTC and high PPA were given priority as the "low-hanging fruit" of potential planting sites. Additional prioritization could be done with respect to proximity to riparian areas (buffer the river corridor to increase water quality and mitigate bank erosion) and proximity to hardscapes (planting near parking lots and roads to reduce impervious areas and the urban heat island effect).

Develop strategies in maintenance districts that address low UTC for the neighborhoods within the maintenance district's boundary. Prioritize low UTC within public ROW's and use the 2015 street tree inventory to predict and address future canopy loss. Develop strategies for low UTC on private land specific to the corresponding zoning type.

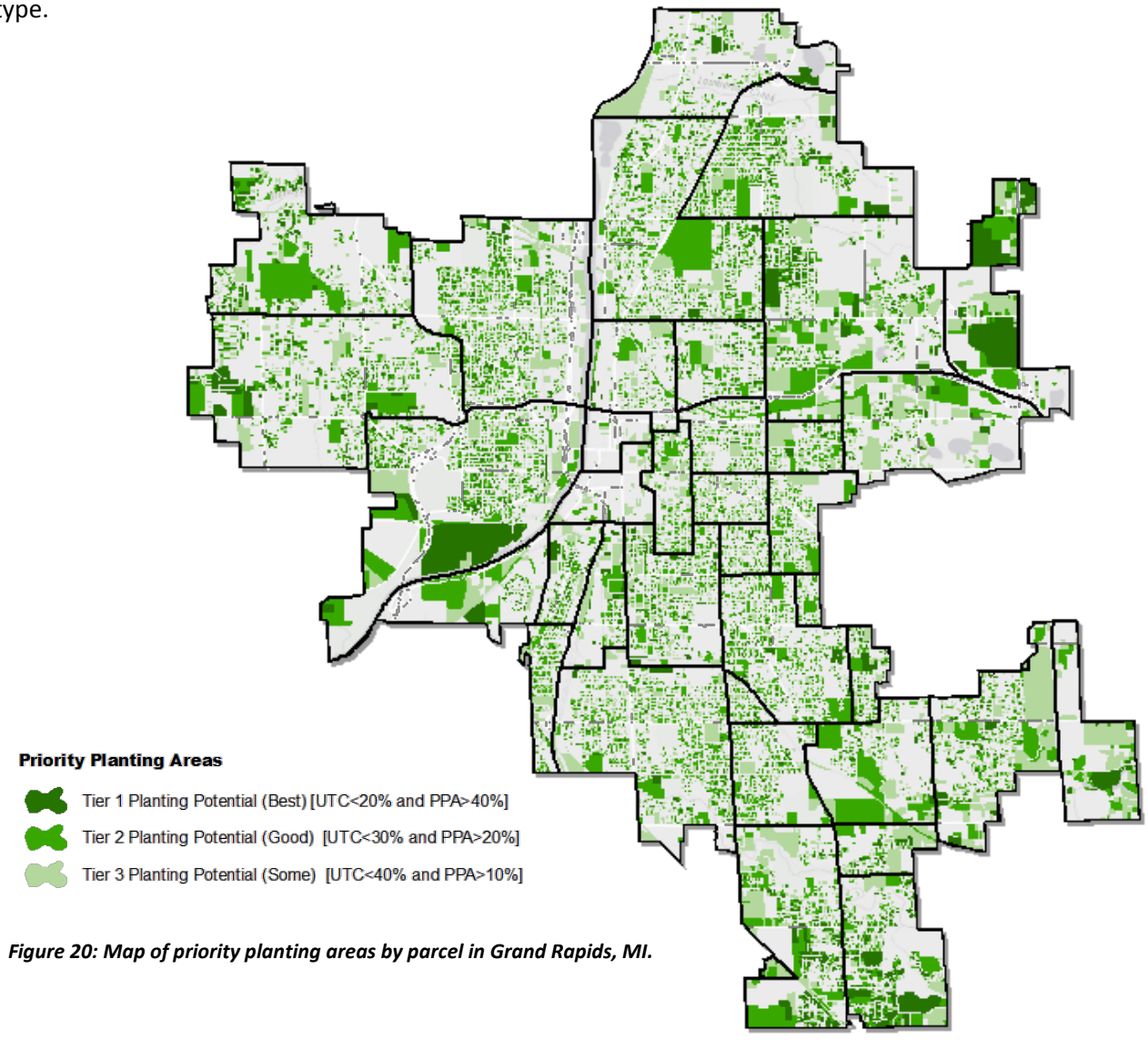


Figure 20: Map of priority planting areas by parcel in Grand Rapids, MI.

Strategy 2: Goal Setting Based on Tree Size

Larger stature trees that have been maintained over the years will help to reach the overall goal of 40% UTC faster than planting many small ones that are not well maintained. In other words, planting trees with the potential to grow to larger diameters (where possible) will yield a larger canopy growth than simply planting as many trees as possible. See below for a comparison between large and small trees. Analysis is based on the use of Plan-It Geo's Canopy Calculator. The Canopy Calculator is a tool built in Microsoft Excel that takes a number of different variables into account to estimate the acreage and number of trees required to reach specified goals.

Table 9: Example using the Canopy Calculator to illustrate the difference that tree size and mortality rates can make on the number of required tree plantings.

Tree Size	Number of Years	Average Crown Radius (ft)	Annual Mortality Rate (%)	Canopy Lost to Development (ac)	Trees required to meet goal of 40% Urban Tree Canopy*
Small	30	10	10%	10	266,232
Medium	30	15	10%	10	118,325
Large	30	20	10%	10	66,558

* This is a simplified scenario. Plan-It Geo's Canopy Calculator can be used to simulate any number of different scenarios based on more parameters than that are listed above. This case is intended to show the difference in size of trees can make on the number of trees required.

Figure 21: New to old neighborhood developments as an illustration of how canopy will mature over time.

Strategy 3: Tree Planting Goals by Neighborhood

Table 10 below is an example of how the information from Plan-It Geo's Canopy Calculator and UTC spreadsheet could be used to estimate the number of trees that is reasonable to plant in "focus neighborhoods" to reach the citywide UTC goal of 40%. For this example, "focus neighborhoods" were chosen by identifying those that are below the citywide average existing UTC of 34%. This resulted in the selection of 19 of the 37 total neighborhoods.

For the city to reach a canopy goal of 40%, an estimated 1,640 acres of new canopy is needed. The sum of the available planting space for each of the "focus neighborhoods" is approximately 3,047 acres; almost double the amount of acres needed to obtain the citywide canopy goal. Therefore, implementation was focused at 50% stocking of plantable space for each "focus neighborhood" and a canopy goal was established. For example, Garfield Park has 295 acres of plantable space with 30% existing canopy. If 50% (147 acres) of the plantable space was planted, an estimated new canopy of 39% could be reached.

This demonstration offers one strategy to approach the citywide canopy goal. To refine these goals, plantable spaces should be field-checked to determine optimal locations for planting trees. Also, several assumptions were made within the Canopy Calculator including; planting only occurs in these "focus neighborhoods", uniform tree size, mortality rate, crown radius, estimated canopy loss due to development, and natural regeneration estimates, which can all be configured in the tool.

Table 10: Example strategy for goal setting using Plan-It Geo's Canopy Calculator.

"Focus Neighborhood"	Existing Urban Tree Canopy (%)	Possible Planting Area Vegetation (acres)	Planting Implementation Target - 50% of PPA Vegetation (ac)	Canopy Goal %
Baxter	33%	27	14	42%
Ridgemoor Park	32%	277	139	45%
Garfield Park	30%	295	147	39%
Lake Eastbrook	30%	136	68	41%
Leffingwell-Twin Lakes	30%	273	136	46%
East Hills	30%	34	17	37%
Heritage Hill	30%	50	25	38%
John Ball Park	30%	685	342	46%
Ken-O-Sha Park	29%	286	143	41%
Southeast Community	26%	154	77	36%
Midtown	26%	66	33	35%
Belknap Lookout	26%	85	42	34%
West Grand	25%	341	171	35%
Roosevelt Park	24%	58	29	35%
Black Hills	22%	138	69	34%
Grandville	18%	49	24	26%
Southwest	10%	56	28	18%
Oldtown-Heartside	6%	27	14	10%
Downtown	4%	10	5	7%
Totals	N/A	3,047	1,523	N/A

Strategy 4: Create Canopy Goals for Zoning Classes

To best improve the city of Grand Rapids, positive growth in UTC across all zones is required. Each zoning class will come with its challenges and roadblocks, including funding sources, outreach, and projected time tables/schedules. Below is a table showing each zoning class and generalized recommendations for tree planting and planning in each. Use of the Canopy Calculator will help to determine acres and number of trees required.

Table 11: Recommendations for Urban Tree Canopy growth by zoning class.

Zoning Class	Recommendations
City Center	Integrate green infrastructure in retrofits. While planting space may be limited, preserve existing canopy and strive for a no net loss approach and plant at empty tree wells in the ROWs. Target Goal: **5-10%**
Commercial	Build partnerships for increasing canopy on the low UTC and high PPA parcels. Target Goal: **10-25%**
Industrial Campus	This zoning type includes innovative building designs, enhanced landscapes, large open spaces, and substantial pedestrian amenities. Use these criteria to enhance tree canopy with nontraditional partners. **Target Goal: 35-40%**
Industrial transportation	Plant trees along transportation corridor within public ROWs. **Target Goal: 15%**
Low Density Residential	Since the majority of existing tree canopy and possible planting area resides in residential zoned partials, focus community outreach to homeowners/homeowner's associations showing the benefits of increased tree canopy. **Target Goal: 45-50%**
Mixed Density Residential	Community outreach to homeowners/homeowner's associations showing the benefits of increased tree canopy. **Target Goal: 40%**
Neighborhood Office Service	Offer incentives for business owners to plant trees. Promote the benefits of trees to consumerism and wellbeing. **Target Goal: 25%.**
Open Space	Preserve and enhance canopy by planting in PPA areas to increase contiguous canopy (connect large patches of canopy). **Target Goal: 60%+**
Planned Redevelopment District	Strengthen ordinances to ensure canopy is preserved and/or enhanced during redevelopment. **Target Goal 35-40%.**
Traditional Business Area	Offer incentives for business owners to plant trees and encourage plantings by promoting the benefits they can have (to consumerism, wellbeing). **Target Goal: 10-15%**
Transit Oriented Development	Improving on the Complete Streets Program, enhance canopy within the ROWs for a more walkable community to those using city transit. **Target Goal: 10%**
Transitional City Center	Maintain existing canopy using the no net loss strategy and enhance by planting in open tree wells within the ROWs. **Target Goal: 10-15%**

APPENDIX

Accuracy Assessment

The main purpose of the classification accuracy assessment is to measure how well the land cover classification estimates 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 internal accuracy assessment was completed in five steps:

Five hundred sample points were randomly distributed across the study area and assigned a random numeric value.

Sorting from lowest random value to highest (to ensure sequential randomized locations of reference), each sample point was referenced using the NAIP imagery and assigned one of the five land cover classes ("Ref_ID"). In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis (no points were dropped for this assessment).

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 (for example, "The classification is currently underestimating forest" would instruct the quality control technician to focus on adding more tree canopy to the current classification across the entire study area.

Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved. Statistical relationships between the reference pixels (representing the true conditions on the ground; "Reference Data") and the intersecting classified pixels ("Classification Data") are used to understand how closely the entire classified map represents the Grand Rapids landscape. The sample error matrix represents the intersection of reference pixels manually identified by a human observer (columns) and classification category of pixels in the classified image (rows). The white boxes along the diagonals of the matrix represent agreement between the two pixel maps. Off-diagonal values represent the number 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 (129+227+116+6+1 = 479 / 500 = 96%), and the matrix can be used to calculate per-class accuracy percent.

For example, 173 points were manually identified in the reference map as Tree Canopy, and 186 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: (173/186 = 0.93), meaning that we can expect that ~93% of all tree canopy in the Grand Rapids study area is covered by the "Tree Canopy" classification map.

Conversely, the "user's accuracy" is calculated by dividing the number agreement pixel total by the total number of classified pixels in the row category. For example, 173 classification pixels intersecting reference pixels were

classified as Tree Canopy, but ten pixels were identified as vegetation and three as impervious in the reference map. Therefore, the user's accuracy for Tree Canopy is calculated as: (173/185 = 0.94) meaning that 94% of pixels classified as Tree Canopy in the classification were actual tree canopy in Grand Rapids. It is important to recognize that 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 (it is cost-prohibitive to sample every pixel, so we use randomly selected points).

Results

Interpretation of the sample error matrix results indicate this land cover does a very good job of mapping land cover accurately in the City of Grand Rapids. The largest source of classification confusion exists between impervious surfaces, vegetation, and soil / dry vegetation. This confusion is largely the result of human interpretation in that the interpreter must determine when a gravel parking lot should be considered pervious or impervious, or whether existing vegetation is living (green) or dry (brown).

Table 12: Error matrix for the Grand Rapids, MI accuracy assessment.

	Reference Data					
Classification Data	**Tree Canopy**	**Vegetation**	**Impervious**	**Soil / Dry Veg.**	**Water**	**Total Reference Pixels**
Tree Canopy	173	12	0	0	0	185
Vegetation	10	102	3	0	0	115
Impervious	3	1	183	0	0	187
Soil / Dry Veg.	0	0	4	3	0	7
Water	0	0	0	0	6	6
Total	**186**	**115**	**190**	**3**	**6**	**500**

Overall Accuracy = 93%

Producer's Accuracy	
Tree Canopy	93%
Veg. / Open Space	89%
Impervious	96%
Bare Ground / Soil	100%
Water	100%

User's Accuracy	
Tree Canopy	94%
Veg. / Open Space	89%
Impervious	98%
Bare Ground / Soil	43%
Water	100%

Supplemental Maps and Tables

Citywide Urban Tree Canopy (UTC) Metrics

Table 13: UTC, PPA, and Distribution citywide.

Grand Rapids, MI	Total Acres	Land Area (acres)	UTC (acres)	UTC %	PPA Vegetation (acres)	PPA Vegetation %	PPA Impervious (acres)	PPA Impervious %
	28,997	28,532	9,775	34%	7,032	25%	7,158	25%

Ward Urban Tree Canopy (UTC) Metrics

Table 14: UTC, PPA, and Distribution by ward in Grand Rapids, MI.

Ward Number	Total Area (acres)	Land Area (acres)	UTC (acres)	UTC (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
1	10,526	10,205	3,806	37%	39%	2,521	25%	36%
2	10,528	10,425	3,334	32%	34%	2,619	25%	37%
3	7,883	7,843	2,636	34%	27%	1,866	24%	27%
OVERALL	**28,937**	**28,473**	**9,776**	**34%**	**100%**	**7,006**	**25%**	**100%**

Land Cover

Table 15: Land Cover acreage and distribution.

Grand Rapids, MI	Total Acres	Tree Canopy (acres)	Tree Canopy %	Buildings (acres)	Buildings %	Roads (acres)	Roads %
	28,997	9,773	34%	1,862	6%	2,191	8%

Other Impervious (acres)	Other Impervious %	Grass / Open Space (acres)	Grass / Open Space %	Water (acres)	Water %	Soil & Dry Vegetation (acres)	Soil & Dry Vegetation %
7,235	25%	7,365	25%	464	2%	105	0.4%

Maintenance District

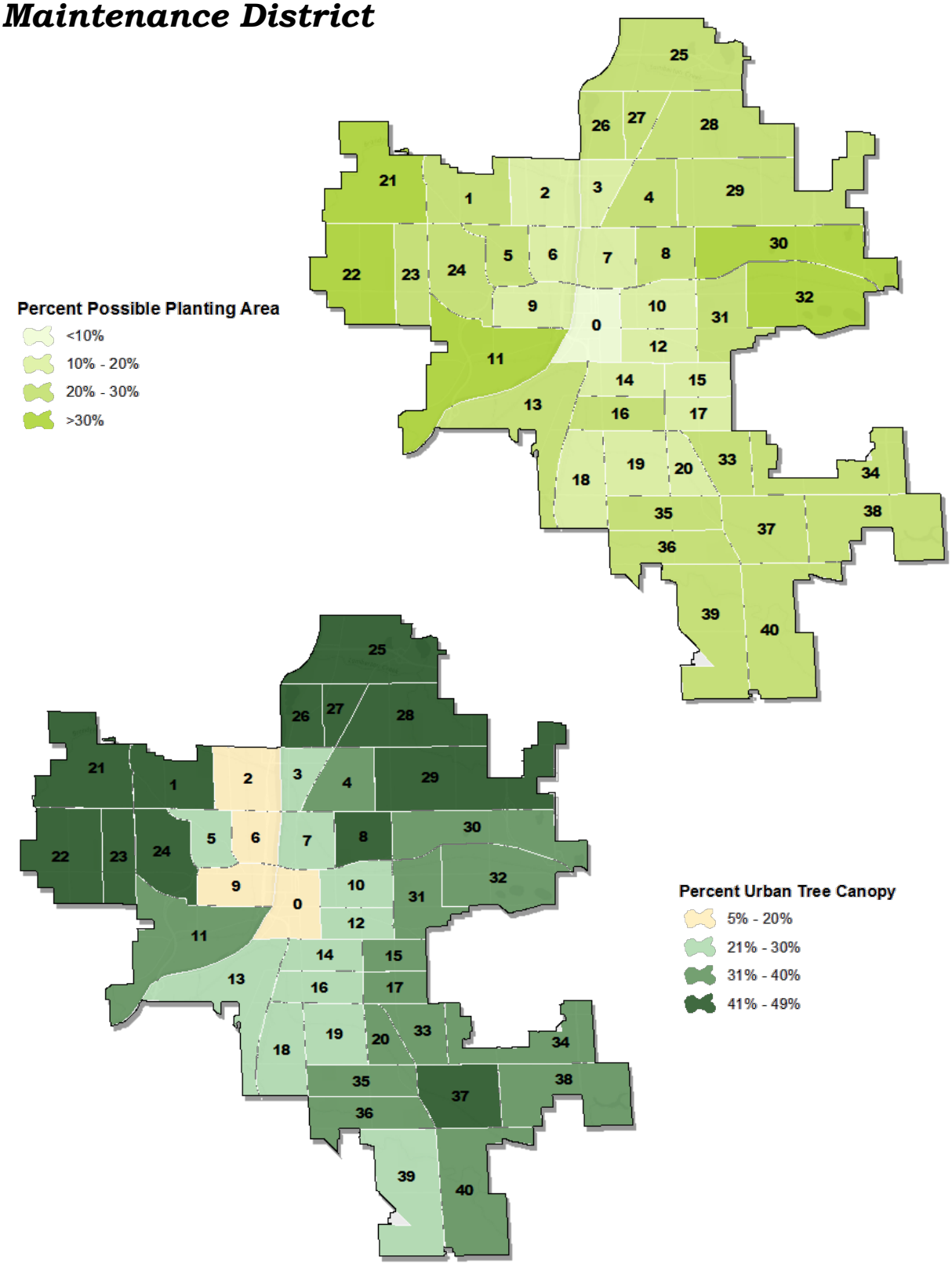


Figure 22: PPA and UTC metrics by city maintenance district.

Table 16: UTC and PPA (acres and %) by maintenance district grid number. Distribution (%) also included.*

GRID_NUM	Total Area (acres)	Land Area (acres)	UTC (acres)	Existing UTC (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
0	540	520	26	5%	0%	38	7%	1%
1	697	693	305	44%	3%	184	26%	3%
2	652	609	99	16%	1%	114	19%	2%
3	352	324	92	28%	1%	56	17%	1%
4	562	562	192	34%	2%	135	24%	2%
5	398	398	109	27%	1%	85	21%	1%
6	372	342	53	16%	1%	51	15%	1%
7	484	458	121	27%	1%	82	18%	1%
8	442	442	180	41%	2%	104	24%	1%
9	487	472	88	19%	1%	88	19%	1%
10	489	489	127	26%	1%	87	18%	1%
11	1434	1428	453	32%	5%	560	39%	8%
12	357	357	106	30%	1%	50	14%	1%
13	1137	1137	242	21%	2%	242	21%	3%
14	381	381	78	20%	1%	68	18%	1%
15	316	316	95	30%	1%	58	18%	1%
16	434	434	108	25%	1%	87	20%	1%
17	317	317	112	35%	1%	60	19%	1%
18	652	652	141	22%	1%	106	16%	2%
19	571	571	152	27%	2%	114	20%	2%
20	302	302	96	32%	1%	55	18%	1%
21	1080	1074	495	46%	5%	337	31%	5%
22	1009	1005	490	49%	5%	311	31%	4%
23	478	478	218	46%	2%	123	26%	2%
24	708	708	312	44%	3%	175	25%	2%
25	1256	1173	579	49%	6%	271	23%	4%
26	413	357	158	44%	2%	93	26%	1%
27	284	284	122	43%	1%	68	24%	1%
28	1123	1117	464	42%	5%	315	28%	4%
29	1638	1623	664	41%	7%	458	28%	7%
30	1119	1088	383	35%	4%	339	31%	5%
31	635	630	201	32%	2%	129	21%	2%
32	1062	1014	398	39%	4%	312	31%	4%
33	449	449	170	38%	2%	94	21%	1%
34	813	806	304	38%	3%	213	26%	3%
35	536	536	175	33%	2%	108	20%	2%
36	643	642	223	35%	2%	143	22%	2%
37	757	757	314	42%	3%	198	26%	3%
38	1098	1074	325	30%	3%	257	24%	4%
39	1202	1198	358	30%	4%	287	24%	4%
40	1216	1212	430	35%	4%	350	29%	5%
OVERALL	28,890	28,426	9,757	34%	100%	7,005	25%	100%

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

Neighborhood

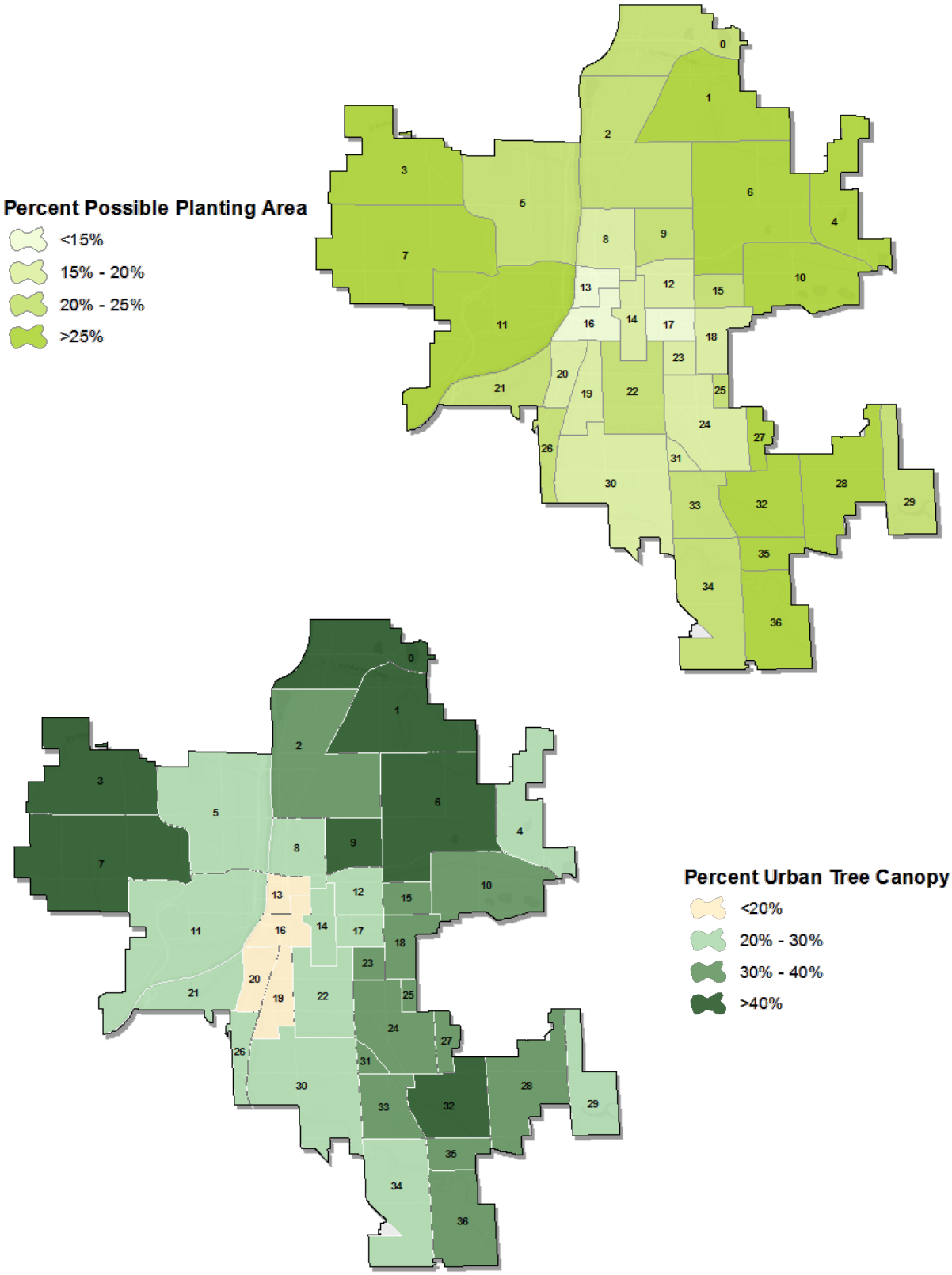


Figure 23: PPA and UTC metrics by neighborhood.

Table 17: UTC, PPA and Distribution by neighborhood.*

Neighborhood	Total Area (acres)	Land Area (acres)	UTC (acres)	Existing UTC (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
Alger Heights	524	523	176	34%	2%	115	22%	2%
Baxter	158	158	53	33%	1%	27	17%	0%
Belknap Lookout	515	488	125	26%	1%	85	17%	1%
Black Hills	576	576	127	22%	1%	138	24%	2%
Creston	1776	1687	627	37%	6%	392	23%	6%
Downtown	200	185	7	4%	0%	10	6%	0%
East Hills	236	236	70	30%	1%	34	14%	0%
Eastern-Burton	96	96	33	35%	0%	18	18%	0%
Eastgate	189	188	70	37%	1%	53	28%	1%
Eastown	391	390	133	34%	1%	70	18%	1%
Fulton Heights	239	239	82	35%	1%	58	24%	1%
Garfield Park	1575	1574	471	30%	5%	295	19%	4%
Grandville	279	279	49	18%	1%	49	17%	1%
Heritage Hill	310	310	92	30%	1%	50	16%	1%
Highland Park	439	439	180	41%	2%	104	24%	1%
John Ball Park	2106	2083	617	30%	6%	685	33%	10%
Ken-O-Sha Park	1178	1174	341	29%	3%	286	24%	4%
Lake Eastbrook	639	612	183	30%	2%	136	22%	2%
Leffingwell-Twin Lakes	870	840	251	30%	3%	273	32%	4%
Michigan Oaks	1081	1034	411	40%	4%	315	31%	5%
Midtown	356	356	92	26%	1%	66	18%	1%
Millbank	862	858	326	38%	3%	262	31%	4%
North End	1317	1311	577	44%	6%	349	27%	5%
North Park	1063	983	468	48%	5%	238	24%	3%
Northeast	1876	1855	749	40%	8%	513	28%	7%
Oldtown-Heartside	329	325	18	6%	0%	27	8%	0%
Ottawa Hills	79	79	28	36%	0%	17	21%	0%
Richmond-Oakleigh	1387	1381	631	46%	6%	420	30%	6%
Ridgemoor Park	1086	1084	346	32%	4%	277	26%	4%
Roosevelt Park	275	275	66	24%	1%	58	21%	1%
Shangrai-La	277	277	103	37%	1%	73	26%	1%
Shawmut Hills	2061	2058	961	47%	10%	575	28%	8%
Shawnee Park	818	818	345	42%	4%	210	26%	3%
Southeast Community	754	754	197	26%	2%	154	20%	2%
Southeast End	893	893	318	36%	3%	175	20%	3%
Southwest	356	356	36	10%	0%	56	16%	1%
West Grand	1764	1694	421	25%	4%	341	20%	5%
OVERALL	**28930**	**28467**	**9780**	**34%**	**100%**	**7003**	**25%**	**100%**

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

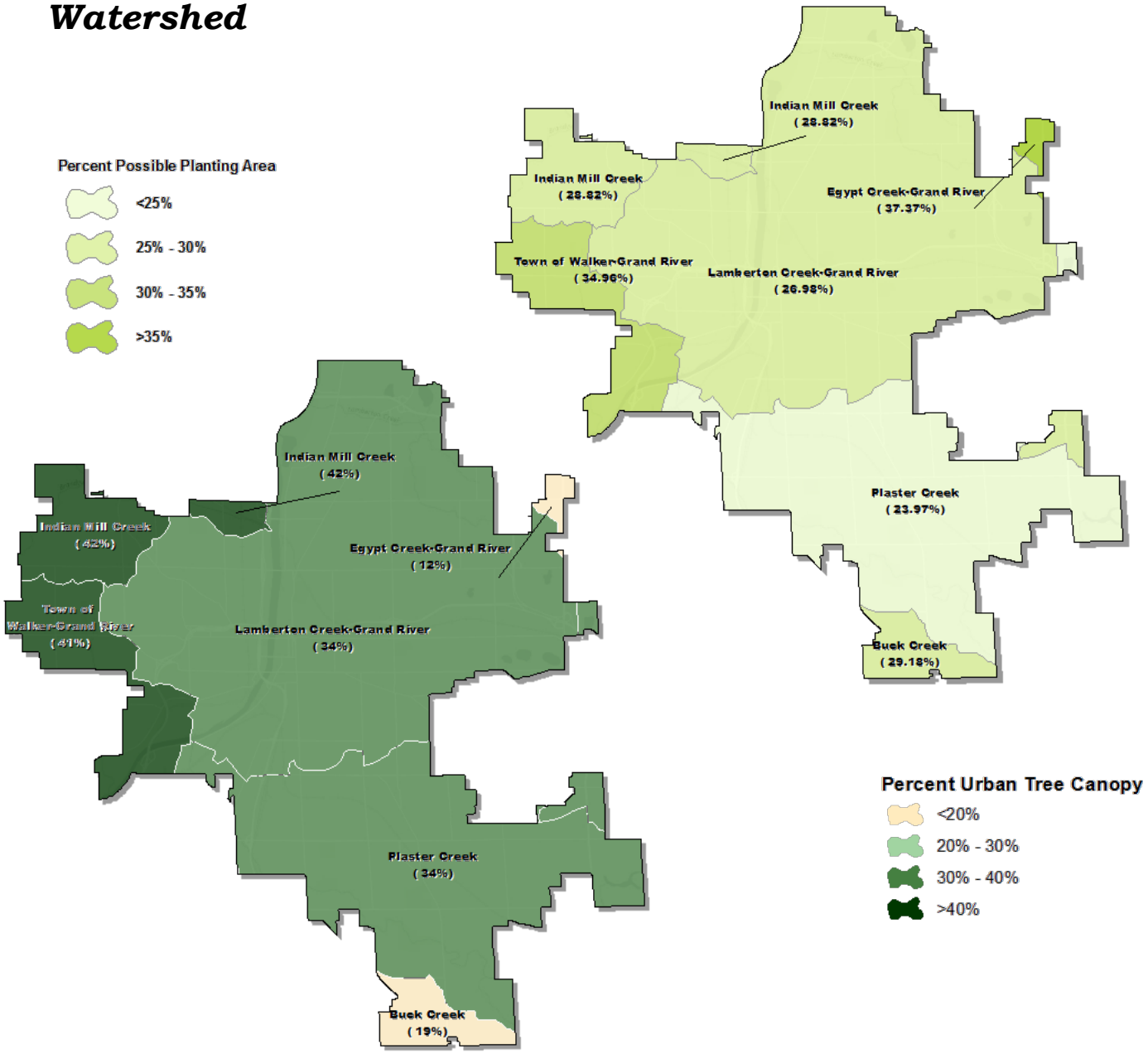


Figure 24: PPA and UTC metrics by USGS HUC-12 Watershed boundary.

Table 18: UTC, PPA, and Distribution by watershed.*

Watershed	Total Area (acres)	Land Area (acres)	UTC (acres)	Existing UTC (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
Egypt Creek-Grand River	187	182	21	12%	0%	63	35%	1%
Plaster Creek	8149	8103	2717	34%	28%	1828	23%	26%
Indian Mill Creek	1885	1880	792	42%	8%	536	29%	8%
Town of Walker-Grand River	2076	2073	857	41%	9%	721	35%	10%
Buck Creek	825	821	154	19%	2%	232	28%	3%
Lamberton Creek-Grand River	15875	15474	5234	34%	54%	3652	24%	52%
OVERALL	**28997**	**28532**	**9775**	**34%**	**100%**	**7032**	**25%**	**100%**

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

Park

Table 19: UTC, PPA, and Distribution for all parks greater than or equal to 10 acres. For full table, see UTC Spreadsheet.*

Park	Total Area (acres)	Land Area (acres)	UTC (acres)	UTC (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
Millennium Park	198	198	94	47%	14%	86	44%	18%
Butterworth Park	196	196	25	13%	4%	162	83%	33%
Riverside Park	190	166	82	50%	12%	54	33%	11%
John Ball Park	112	111	66	60%	10%	27	24%	6%
Huff Park	89	89	51	58%	8%	26	30%	5%
Ken-O-Sha Park	85	83	77	93%	12%	4	5%	1%
Ball Perkins Park	79	76	71	93%	11%	6	7%	1%
Blandford Nature Center	61	60	47	78%	7%	12	20%	2%
Richmond Park	56	53	35	67%	5%	10	18%	2%
MacKay-Jaycee Park	46	46	12	27%	2%	15	34%	3%
Garfield Park	30	30	13	42%	2%	11	36%	2%
Belknap Park	28	28	7	25%	1%	9	32%	2%
Highland Park	26	26	10	40%	2%	13	52%	3%
Plaster Creek Family Park	23	23	7	31%	1%	6	27%	1%
Bike Park	22	22	10	47%	2%	5	23%	1%
Ottawa Hills High School	21	21	2	11%	0%	6	30%	1%
Hillcrest Park	19	19	8	41%	1%	8	41%	2%
Martin Luther King Park	17	17	4	26%	1%	4	23%	1%
Clemente Park	14	14	7	51%	1%	3	20%	1%
Lincoln Park	12	12	5	39%	1%	6	48%	1%
Briggs Park	12	12	5	39%	1%	3	22%	1%
Fuller Park	11	11	5	44%	1%	3	31%	1%
Kensington Park	11	11	7	64%	1%	3	29%	1%
Mulick Park	10	10	4	41%	1%	3	35%	1%
Oxford Park	10	10	9	90%	1%	1	6%	0%
OVERALL	1377	1342	664	49%	100%	486	36%	100%

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

Zoning

Table 20: UTC, PPA, and Distribution for zoning classes in Grand Rapids, MI.*

Zoning Class	Total Acres	Land Area (acres)	UTC (acres)	Existing UTC (%)	Distribution (%)	PPA (acres)	PPA %	Distribution (%)
City Center	553	553	21	4%	0%	33	6%	0%
Commercial	692	688	66	10%	1%	92	13%	1%
Industrial Campus	527	511	152	30%	2%	141	28%	2%
Industrial Transportation	2,017	2,011	223	11%	2%	329	16%	5%
Low-Density Residential	17,086	16,967	7,066	42%	74%	4,330	26%	65%
Mixed-Density Residential	2,168	2,139	760	36%	8%	544	25%	8%
Neighborhood Office Service	432	428	91	21%	1%	107	25%	2%
Open Space	2,066	2,032	856	42%	9%	722	36%	11%
Planned Redevelopment District	801	787	238	30%	2%	226	29%	3%
Traditional Business Area	700	700	60	9%	1%	61	9%	1%
Transit Oriented Development	1.1	1.1	0.1	8%	0%	0.1	6%	0%
Transitional City Center	794	792	65	8%	1%	89	11%	1%
OVERALL	27,837	27,609	9,600	35%	100%	6,675	24%	100%

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

Right of Way (ROW)

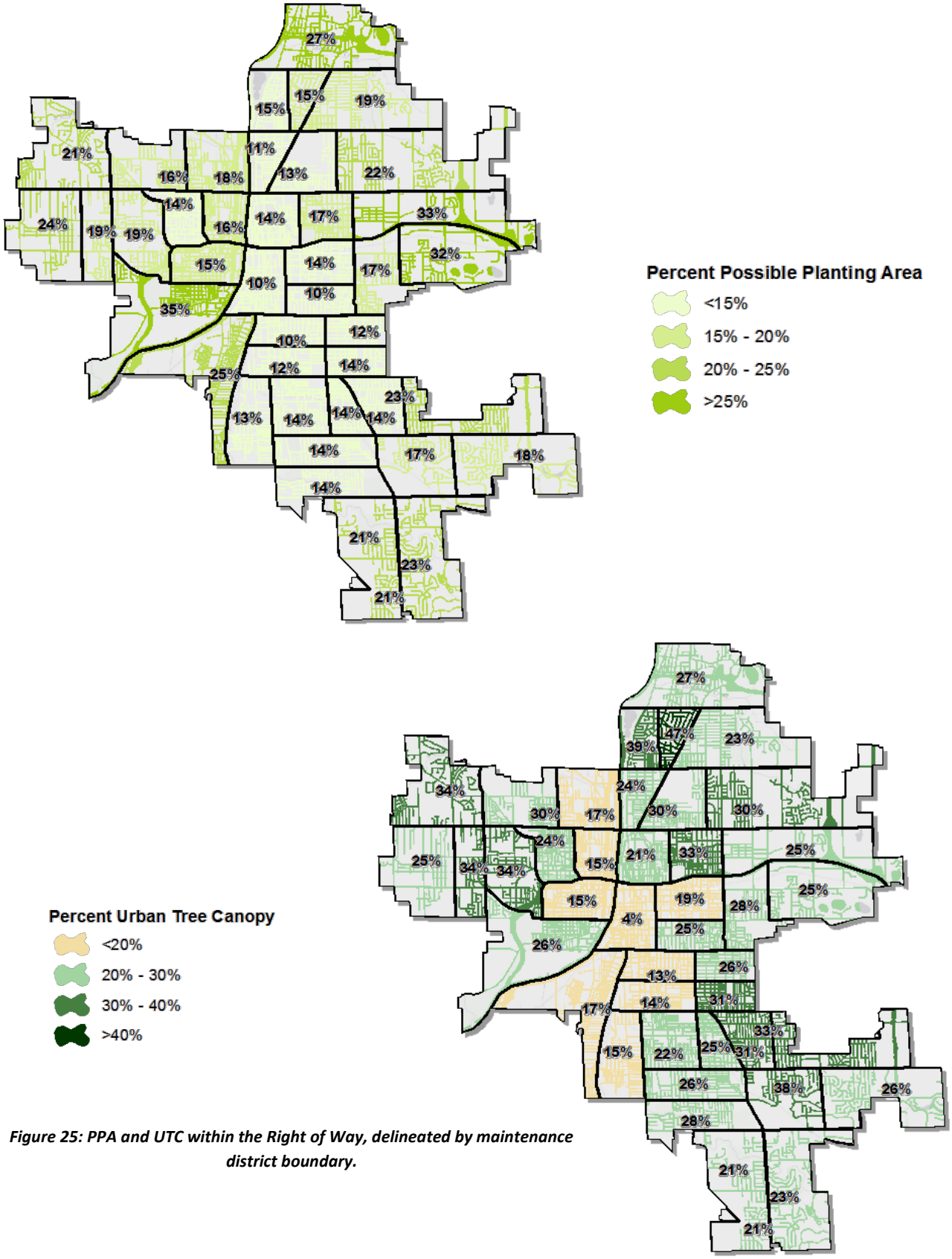


Figure 25: PPA and UTC within the Right of Way, delineated by maintenance district boundary.

Table 21: UTC, PPA, and Distribution for Right of Way by maintenance district.*

Grid Number	Total Area (acres)	Land Area (acres)	UTC (acres)	Existing UTC in ROW (%)	Distribution (%)	PPA (acres)	PPA (%)	Distribution (%)
0	195	176	7	4%	1%	18	10%	2%
1	108	108	32	30%	2%	18	16%	2%
2	203	162	28	17%	2%	29	18%	3%
3	106	79	19	24%	1%	9	11%	1%
4	100	100	30	30%	2%	13	13%	1%
5	129	129	32	24%	2%	18	14%	2%
6	151	122	18	15%	1%	20	16%	2%
7	165	140	29	21%	2%	20	14%	2%
8	115	115	37	33%	3%	19	17%	2%
9	189	174	26	15%	2%	27	15%	2%
10	135	135	26	19%	2%	19	14%	2%
11	286	281	73	26%	5%	98	35%	9%
12	91	91	23	25%	2%	9	10%	1%
13	288	288	48	17%	3%	71	25%	7%
14	107	107	14	13%	1%	11	10%	1%
15	82	82	21	26%	2%	10	12%	1%
16	103	103	14	13%	1%	13	12%	1%
17	94	94	29	31%	2%	14	14%	1%
18	128	128	19	15%	1%	17	13%	2%
19	142	142	31	21%	2%	19	14%	2%
20	85	85	22	25%	2%	12	14%	1%
21	129	129	44	34%	3%	27	21%	2%
22	116	116	30	25%	2%	28	24%	3%
23	83	83	29	34%	2%	16	19%	1%
24	151	151	51	34%	4%	28	19%	3%
25	317	240	65	27%	5%	65	27%	6%
26	105	72	28	39%	2%	11	15%	1%
27	73	73	34	47%	2%	11	15%	1%
28	166	166	38	23%	3%	31	19%	3%
29	218	218	66	30%	5%	47	22%	4%
30	224	213	54	25%	4%	71	33%	7%
31	121	121	34	28%	2%	20	17%	2%
32	218	188	47	25%	3%	60	32%	6%
33	114	114	35	31%	3%	16	14%	1%
34	141	141	47	33%	3%	32	23%	3%
35	122	122	32	26%	2%	18	14%	2%
36	103	103	29	28%	2%	14	14%	1%
37	100	100	38	38%	3%	17	17%	2%
38	141	141	37	26%	3%	26	18%	2%
39	133	133	27	21%	2%	28	21%	3%
40	168	168	39	23%	3%	39	23%	4%
OVERALL	**5,946**	**5,633**	**1,382**	**25%**	**100%**	**1,086**	**19%**	**100%**

*UTC refers to Urban Tree Canopy and PPA refers to Possible Planting Area

Ecosystem Benefits

Below is a more comprehensive list of ecosystem services and benefits provided by urban trees. These examples illustrate the myriad reasons why urban tree canopy preservation and growth are important to the City of Grand Rapids.

Environmental

Air quality:
Trees absorb, trap, offset, and hold pollutants such as particulates, ozone, sulfur dioxide, carbon monoxide, and CO2.

Water quality:
Soil aeration, evapotranspiration, and rainfall interception by trees improves water quality.

Erosion control:
Tree roots hold soil together along stream banks and slopes.

Wildlife habitat:
Trees promote urban biodiversity.

Economic

Property value:
Each 10% increase in tree cover increases home prices by $1,300+ (Sander, Polasky, & Haight, 2010).

Energy conservation:
Trees lower energy demand through summer shade and winter wind block, offsetting power plant emissions.

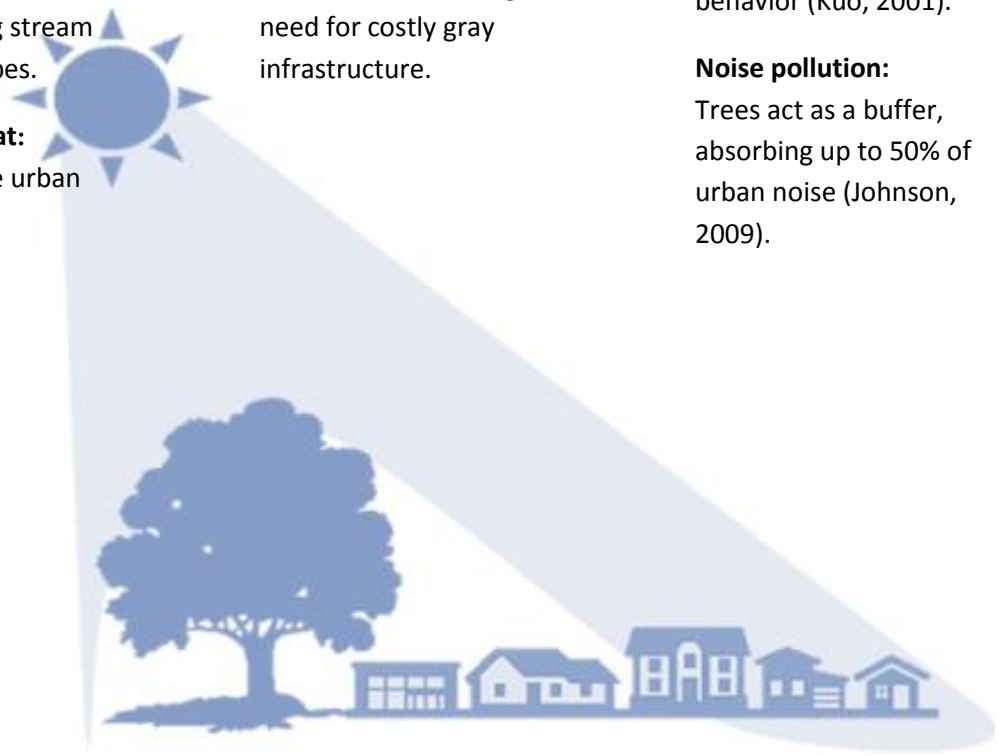
Stormwater mitigation:
Urban forests intercept stormwater, reducing the need for costly gray infrastructure.

Social

Public health:
Trees diminish asthma symptoms and reduce UV-B exposure by about 50% (Shade: Healthy Trees, Healthy Cities, Healthy People, 2004).

Crime and domestic violence:
Urban areas with greater canopy directly correlate with lower levels of fear, fewer incivilities, and less violent and aggressive behavior (Kuo, 2001).

Noise pollution:
Trees act as a buffer, absorbing up to 50% of urban noise (Johnson, 2009).



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