2020 UTC Assessment & Change Analysis

City of Hyattsville, Maryland

Prepared for:

City of Hyattsville
Department of Public Works
4310 Gallatin Street
Hyattsville, Maryland 20781

Prepared by:

Davey Resource Group, Inc.
295 S. Water Street, Suite 300
Kent, Ohio 44240
800-828-8312

July 2020

Executive Summary

This report was developed for the City of Hyattsville, Maryland by Davey Resource Group, Inc. "DRG". The primary components of this project include a GIS assessment of Hyattsville's urban tree canopy (UTC) and a summary report of the findings. The purpose of this summary report is to review and analyze the GIS findings to identify trends and to provide tools, data, and resources to guide future community forest management and reforestation efforts.

Urban Tree Canopy (UTC) refers to the layer of tree leaves, branches, and stems that provide tree coverage of the ground when viewed from above. The UTC provides myriad benefits to the surrounding community: trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. Trees also provide numerous economic, psychological, social, and health benefits. Trees can increase residential property values, increase consumer spending within business districts, and recent studies have linked higher levels of tree canopy to lower levels of cardiovascular and pulmonary disease.

It is not enough to simply plant more trees to increase canopy cover and benefits. Planning and funding for tree care and management, public outreach, and education must complement planting efforts to ensure the success of new plantings. The city only has direct influence over a component of urban forest. To help ensure the benefits desired are being realized, a management strategy towards maintaining a healthy urban forest must involve partnerships in both public and private sectors. To make a difference, the City of Hyattsville, its residents, and partners can support the urban forestry program by promoting the benefits that trees offer to the community, fulfilling routine maintenance for both public and private trees, and maximizing the space available for new trees.

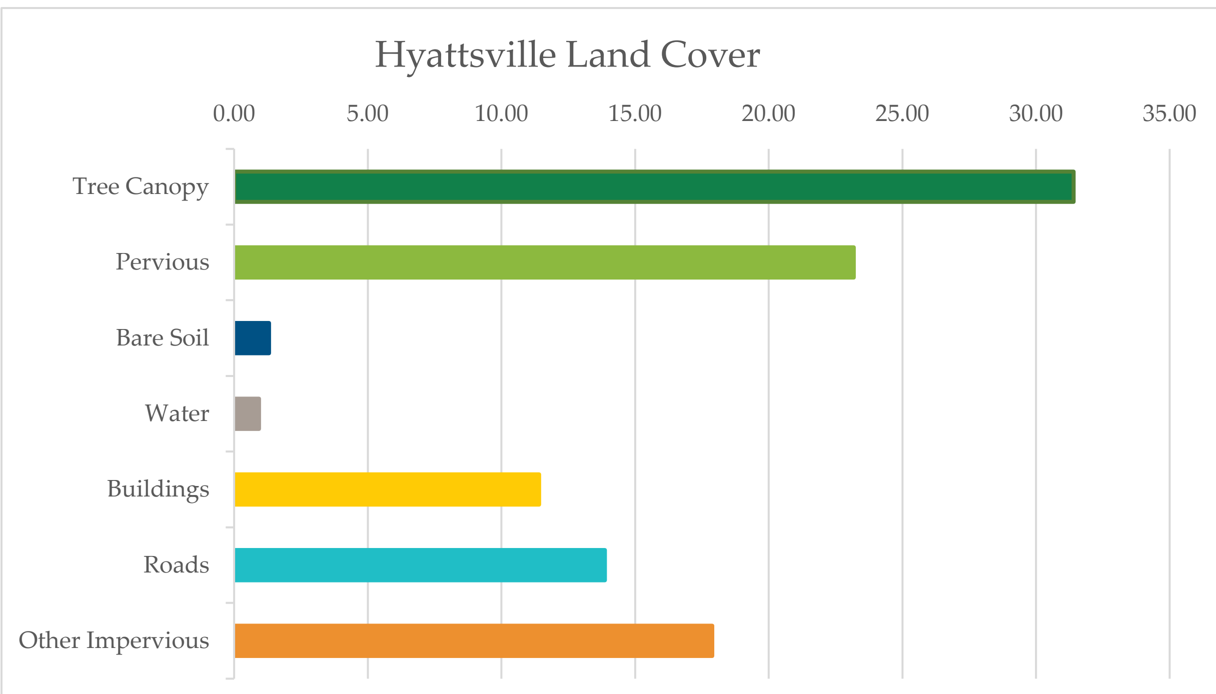

Figure 1. Hyattsville land cover distribution by percentage of city area.

Hyattsville UTC: Key Findings:

- Tree canopy covers 31.41% of the city's 1,745 acres.
- Impervious surfaces (buildings, roads, and other types of impervious land cover) comprise a total of 43.17% of Hyattsville's total area.
- Hyattsville experienced a net loss of 236 canopy acres from 2009 (785 acres) to 2018 (548 acres), which is a 30% decrease in canopy acreage.
- If all suitable and realistic locations within the city were planted and covered in tree canopy, Hyattsville's maximum potential UTC would reach 53.87% coverage (940 canopy acres).
- Three primary reasons for the city's canopy loss over the past decade are thought to be land development, emerald ash borer (EAB), and natural tree mortality.
- The value of Hyattsville's UTC in 2018 was estimated to be approximately $3,028,144.
- Tree canopy in Hyattsville removed an estimated 41,343 pounds of pollutants and 740 tons of carbon from the air while slowing 8 million gallons of stormwater from entering storm drains during peak storm events.

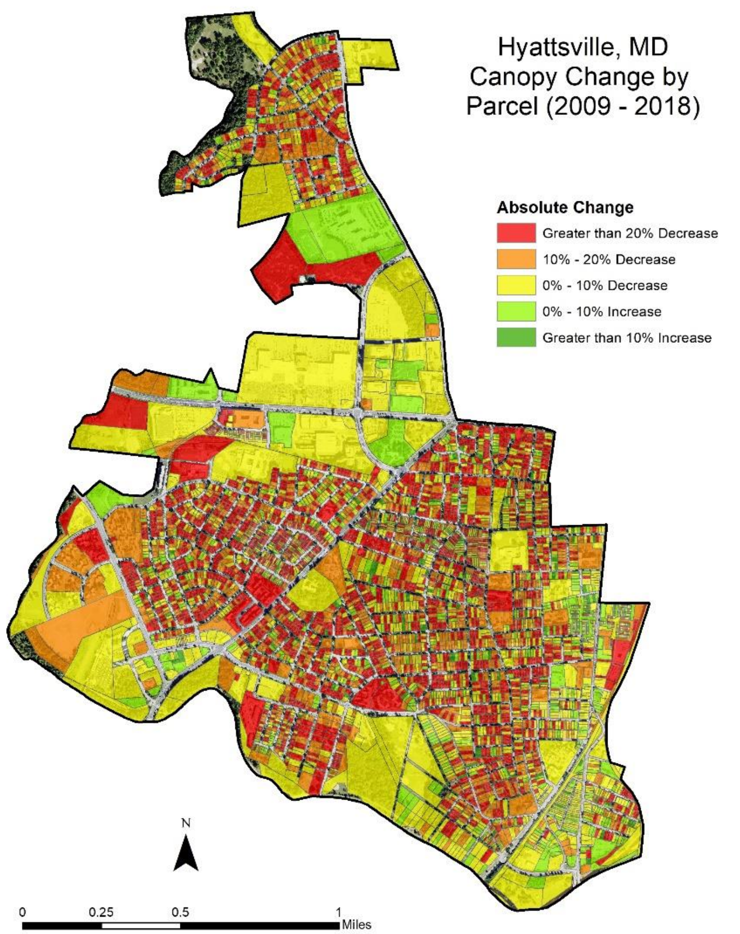

Figure 2. Hyattsville tree canopy change by parcel, 2009–2018.

Table of Contents

TABLES

FIGURES

APPENDIX

Introduction

Populated environments can have significant impacts on water quality. During significant storm events, water runs across impervious surfaces (e.g., streets, sidewalks, buildings), absorbing and carrying with it any particulates and pollutants that may be present. Eventually, this stormwater is intercepted by a series of drains or catch-basins before it ends up in the Potomac River and ultimately the Chesapeake Bay. The more stormwater that flows through this system, the greater the potential for pollution and particulate matter to accumulate in the water. Finding ways to reduce the amount of stormwater runoff or even slow its interception through measures such as reducing impervious surface area and capturing stormwater can significantly reduce pollution and improve water turbidity.

Trees have a substantial impact on water quality. Consider standing under a tree after a rainstorm; even a small breeze can shake loose numerous water droplets from the canopy. During a rainstorm, the leaves and trunk of a tree capture large amounts of water droplets, which would otherwise quickly reach the ground and accumulate into stormwater runoff. While it may not seem like one tree can hold much water, the aggregate impact of stormwater retention across an entire community forest is appreciable. Through these processes, trees have become widely recognized for their ability to manage stormwater in our communities.

Beyond stormwater, trees have been linked to environmental, social, and economic benefits. Trees have been shown to increase property values by as much as 15%. Business districts with high levels of canopy coverage can experience as much as a 12% increase in consumer spending[1]. Recent studies have also linked higher levels of tree canopy to lower levels of cardiovascular and pulmonary disease[2]. One study in California even found that tree canopy over roads was projected to save as much as $0.66 per square foot in road repair costs over a 30-year timeframe[3]. In short, optimal tree canopy is a significant asset that addresses multiple community goals and priorities.

Despite the advances in peer-reviewed research studying the environmental and socioeconomic benefits of urban trees, the Hyattsville community still faces significant challenges. Invasive species like emerald ash borer (EAB), Asian longhorned beetle, and gypsy moth have had significant impacts on community forests, while climate change and intensified storm systems are increasingly threatening urban forests. Beyond environmental concerns, new land development, in-fill development, and urban infrastructure repair can also impact community tree cover as trees are removed or damaged.

The city readily acknowledges the many and varied benefits of a vigorous tree canopy. To maximize these benefits, a community forest must be properly cared for and managed. In recognition of this principle, the city and its partners are embarking on a process to collect and analyze meaningful data, develop comprehensive strategies, and work together to protect, enhance, and expand the City of Hyattsville community forest.

[1] K. Wolf (August 2007). *City Trees and Property Values*. Arborist News 16, 4: p. 34–36.

[2] G. Donovan et al. (February 2013). *The Relationship between trees and human health: evidence from the spread of emerald ash borer*. American Journal of Preventative Medicine 44(2): 139–145.

[3] E.G. McPherson and J. Muchnick (November 2005). *Effects of Street Tree Shade on Asphalt Concrete Pavement Performance*. Journal of Arboriculture 31(6):303.310.

Project Background

Photograph 1. Hyattsville Municipal Building

In 2008, the city received an urban tree canopy (UTC) assessment performed by the University of Vermont's Spatial Analysis Laboratory (SAL) which utilized 2007 imagery from the National Agriculture Imagery Program (NAIP). On September 26, 2019, the City of Hyattsville issued RFP #DPW19-013 seeking bids from contractors to perform an updated UTC assessment utilizing 2018 NAIP imagery. In its RFP, the city requested that the updated UTC assessment employ similar procedures and methodology as the 2007/2008 study to create a baseline and benchmark of the city's tree canopy and other land cover types. Additionally, the RFP requested that the updated UTC include a canopy change analysis studying canopy gain and loss within city limits and other specific spatial boundaries, including city parks, wards, city and county parks, and parcels.

On January 28, 2020, the City of Hyattsville awarded the RFP for the *2020 UTC Assessment & Change Analysis Report* to DRG. The report, contained herein and presented below, includes a professional summary of the updated UTC assessment and canopy change analysis (e.g., results, findings, maps, metrics, tables) along with broad recommendations for preserving and enhancing tree canopy. The information derived from the assessment will be used to:

1. Establish a UTC baseline of known accuracy (% coverage).
2. Establish classification methodology that the city can later use to track canopy gains and losses over time.
3. Allow for the city to develop a sound urban forestry management plan based on the current UTC to establish priorities and objectives that will provide collective ecosystem benefits including:
    a. Management and maintenance of the existing canopy.
    b. Planning and prioritization of tree planting efforts.
    c. Preservation of existing public and private trees.

The UTC data, maps, and other management tools (e.g., tree inventories and management plans) are all necessary components that assist and guide community reforestation efforts to maximize ecological benefits and urban forest sustainability. As management progresses, Hyattsville is encouraged to reference these results, utilize these data for additional analyses, and continue to seek new tools and information to measure progress, report accomplishments, and inform management decisions.

Methodology

The following section briefly summarizes the methodology used for the various analyses presented within this report. Detailed methodologies for each type of assessment are presented in Appendix A.

LAND COVER CLASSIFICATION

The 2018 National Agricultural Imagery Program (NAIP) leaf-on, multispectral imagery acquired and processed by the United States Department of Agriculture was used as the primary source to identify the city's current land cover. Remote sensing and GIS software extensions provided the automated feature-extraction tool used to generate the baseline percentage of the final existing tree canopy and land cover layers.

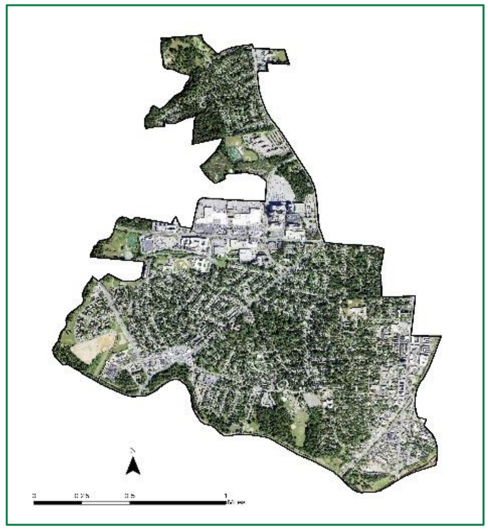

Figure 3. Subject area: Hyattsville, MD.

Land cover data were generated for seven separate classifications: tree canopy, pervious surfaces, buildings, roads, other impervious surfaces, bare soils, and open water.

Tree canopy cover is the area of land surface that is covered by the tree's leaf-covered branches as seen from above.

Pervious surfaces allow rainfall to infiltrate the soil and include grass and low-lying vegetation, as typically found in parks, golf courses, and residential lawns.

Impervious surfaces are areas that do not allow rainfall to infiltrate. For this analysis, impervious surfaces were broken into three separate classifications—Buildings, Roads, and Other Impervious.

Bare soil includes areas such as vacant lots, construction sites, and baseball infields.

Open water includes all lakes, ponds, streams, wetlands, and other mappable water features.

LAND USE CLASSIFICATION

Land use classifications were extrapolated from the city of Hyattsville's parcel data from the data field labeled MNCPPC_USE. The land use classifications are agriculture, commercial, forest, high density residential, industrial, institutional, low density residential, medium density residential, other developed lands, transportation, and water.

SPATIAL BOUNDARIES

Levels of canopy coverage were analyzed utilizing the following geographic boundaries, as specified by the city in RFP #DPW19-013: city limits, city & county parks, wards, land use, and parcels.

CANOPY CHANGE OVER TIME

For the Hyattsville, MD UTC change assessment study, we examined all datasets derived from the years of 2007, 2009, 2014, and 2018. We reached out to Jarlath O'Neill Dunne from the University of Vermont Spatial Analysis Laboratory to request the tree canopy dataset that was used in the 2008 UTC report completed by Vermont. After a discussion with Mr. O'Neill Dunne, it was determined that the 2007 dataset would be insufficient to accurately measure temporal tree canopy change because, at the time, there were no established protocols on level of detail, resolution, or classification. Mr. O'Neill Dunne recommended that DRG not use the 2007 data and instead referred DRG to the 2009 land cover data that did incorporate established protocols to measure future change.

On a visual review, DRG concurred with the assessment of Mr. O'Neill-Dunne in that the spatial accuracy of the 2007 data is insufficient to properly conduct the change assessment. As such, DRG strongly recommended that the 2009 data source be the data source used to measure canopy change for the *2020 UTC Assessment and Canopy Change Analysis*. The City of Hyattsville agreed with the recommendation of DRG and the University of Vermont Spatial Analysis Lab.

All data in the DRG report utilized the 2009 tree canopy and a new 2018 dataset created by DRG. As a quality control measure, DRG compared their internally derived 2018 dataset with a 2018 tree canopy dataset hosted by MNCPPC. Both datasets report tree canopy levels near 30% in 2018 within minor percentage differences, confirming the validity of DRG protocols.

POSSIBLE AND PREFERRED PLANTABLE AREAS

This UTC analysis considered site design and environmental factors to identify the amount of possible and preferred plantable area within the city. Both public and private property were included in the analysis. Possible plantable area can be considered analogous to "Possible UTC" as defined and utilized in the 2007 study by the University of Vermont. For this analysis, DRG considers grass, low-lying vegetation, and bare soil as possible planting areas.

However, a possible planting area does not necessarily indicate that the area is a suitable or realistic planting location, primarily due to the intended use of the site. Examples include golf courses, cemeteries, sports fields, and fairgrounds; these are locations designed and intended to be open and free from trees and canopy cover. Potential realistic plantable areas, referred to here as preferred plantable areas, are determined by excluding pervious areas which are unsuitable for planting.

Urban Tree Canopy Assessment Results

Based on the most recent aerial imagery from 2018, Hyattsville's current urban tree canopy is 31%, which compares similarly with other cities of varying sizes within the region (Table 1). Using the 2009 data, the tree canopy measured 45%. Over the course of ten years, 2009 to 2018, the overall size of Hyattsville's tree canopy shrank by over 30%, which equates to a net loss of 236.45 acres of canopy (Table 3). This loss in canopy is, at least in part, due to the introduction of EAB, recent land development projects such as the Riverfront at West Hyattsville Metro, and general tree loss due in both the public and private sector due to aging canopy.

Tree canopy is just one of seven land cover classifications generated by this assessment. Additional land cover data, including pervious surfaces, roads, buildings, other impervious, bare soils, and water, were quantified using Hyattsville's city boundary as the project area (Table 2). This information can be used to gain an understanding of Hyattsville's tree canopy distribution. Table 1 provides a comparison of similar cities' UTC and perspective of their goals and corresponding goal target dates.

The analysis measured tree canopy within Hyattsville and looked specifically at the level of existing UTC, possible UTC, and canopy change over time. Once the overall canopy analysis was completed, the data were segmented and examined further to identify trends. Levels of analysis include:

- Land Use
- City & County Parks
- Wards
- Census Blocks
- Parcels

While this report presents general findings and trends of Hyattsville's tree canopy, these data can be examined and analyzed in a multitude of ways. Hyattsville is encouraged to reference and apply these data as new ideas, interests, and priorities arise.

Table 1. Canopy Coverage Comparison

Location	UTC	Year	Population	UTC Goal	Goal Target Date
Alexandria, VA	30%	2007	144,301	40%	2040
Annapolis, MD	41%	2006	39,174	50%	2036
Baltimore, MD	28%	2015	619,493	40%	2030
Bowie, MD	42%	-	58,682	45%	-
Brunswick, MD	38%	2007	6,364	45%	2020
Cumberland, MD	27%	2007	19,480	45%	2020
Frederick, MD	20%	2014	72,146	40%	-
Hyattsville, MD	31%	2018	18,243	-	-
Middletown, MD	18%	2017	4,198	25%	2025
Washington, DC	38%	2016	705749	40%	2032
Average UTC of the ten cities = 31%					

EXISTING UTC

Existing UTC is computed by simply summarizing all features identified in imagery analysis as tree canopy. For the City of Hyattsville, existing UTC in 2018 is measured at 548 acres, totaling 31.41% of the city's area.

Table 2. Land Cover Classification Distribution

2018 Land Cover	Land Cover Size (Acres)	Land Cover (%)
Tree Canopy	548	31.41%
Pervious Surfaces	405	23.18%
Buildings	199	11.41%
Roads	242	13.87%
Other Impervious	312	17.89%
Bare Soil	23	1.31%
Open Water	16	0.93%
Total (City Limits)	1,745	100%

POSSIBLE AND MAXIMUM UTC

This assessment defines Possible UTC as land where it is both biophysically feasible and realistic to establish tree canopy. In general, this measure includes pervious surface cover and bare soils. However, not all pervious surfaces or bare soils are suitable for establishing new tree canopy. Examples of unsuitable pervious and bare soil areas include golf courses, cemeteries, sports fields, and fairgrounds. Possible UTC excludes pervious surfaces and bare soils that are deemed not suitable for planting.

Hyattsville contains 392 acres of land deemed suitable area for future planting efforts and therefore categorized as possible UTC (Table 3). If these areas, which include both public and private lands, were fully planted, Hyattsville could achieve a maximum tree canopy of 940 acres, which translates to a maximum UTC of 53.87%. Since this measure includes both public and private lands, it is unlikely Hyattsville can achieve maximum UTC, as it would require 100% participation from all private landholders. However, knowledge of both existing and possible UTC is helpful for goal setting and planning future planting efforts.

Table 3. Hyattsville's Existing, Possible, and Maximum UTC

2018 Tree Canopy	Acres	Percentage
Existing	548	31.41%
Possible	392	22.46%
Maximum	940	53.87%

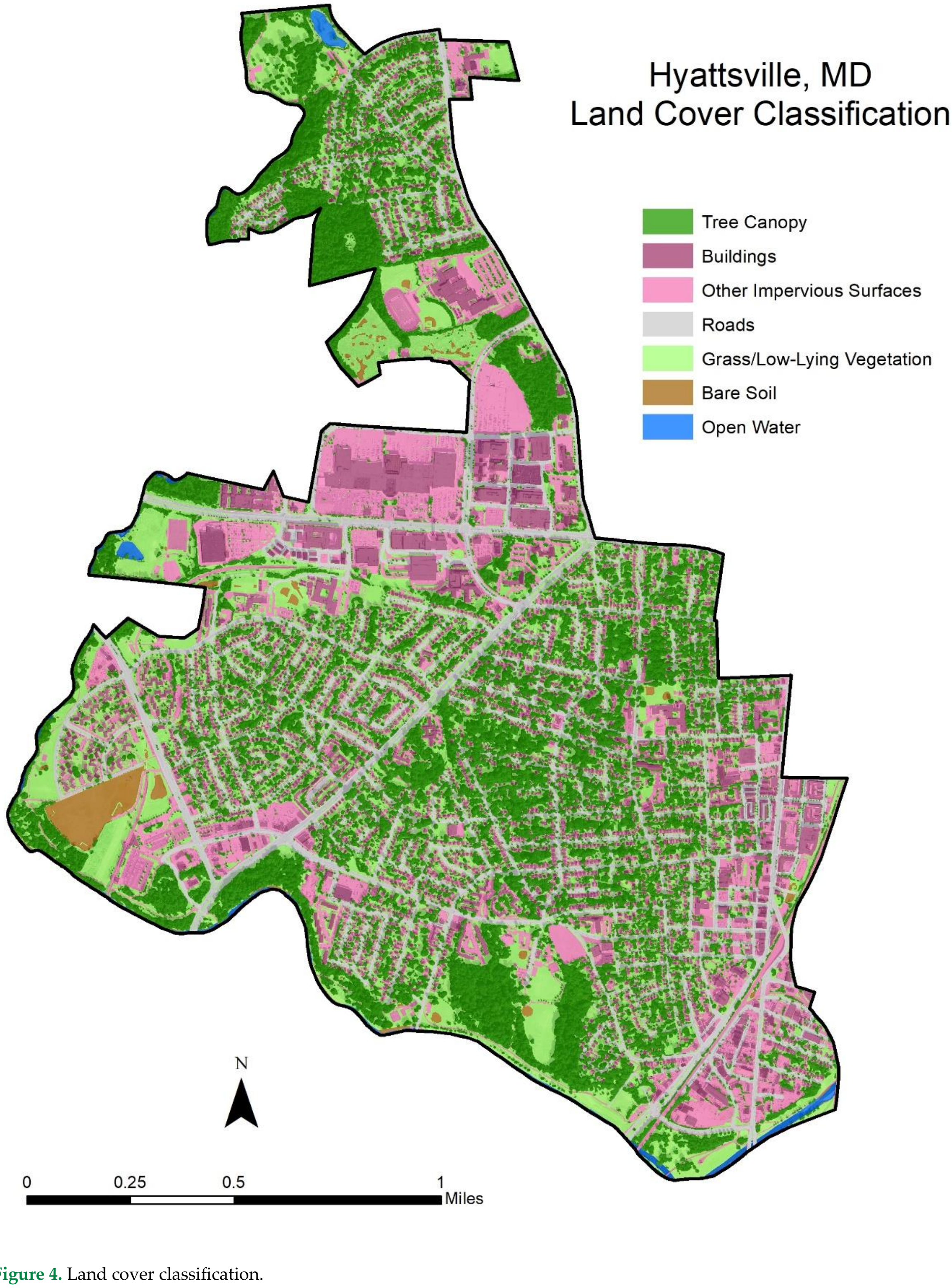

Figure 4. Land cover classification.

CANOPY CHANGE OVER TIME

Results from the 2009 UTC dataset were compared to that of the 2018 UTC data. Between 2009 and 2018, the City of Hyattsville lost over 236 acres of tree canopy, dropping UTC from 44.95% to 31.41% (Table 4). The significant loss in Hyattsville's tree canopy is hypothesized to be due to three primary factors:

1. Land development
2. Emerald ash borer
3. Natural loss of mature canopy at levels that outpace new plantings

The following sections will explore Hyattsville's tree canopy in greater detail using varying levels of analysis, including land use, city and county parks, election wards, parcels, and census block groups. For each level of analysis, we examine levels of existing canopy coverage, possible canopy coverage, maximum potential coverage, and canopy change over time.

Table 4. Canopy Change Over Time (2009–2018)

	Canopy Acres	Canopy Coverage
Tree Canopy 2009	784.69	44.95%
Tree Canopy 2018	548.24	31.41%
Change Over Time	-236.46	-13.95%

LAND USE

Tree canopy levels tend to correlate with land use types. In most communities, commercial areas tend to have lower levels of tree canopy and residential areas tend to exhibit the highest levels of canopy coverage. This pattern holds true for the City of Hyattsville; the percentage of canopy cover in commercial areas is 7% while medium/low density residential areas have the highest levels of canopy cover at 43% (Table 5).

Photograph 2. Example of Medium/Low Density Residential Land Use area within Hyattsville, MD.

Opportunities should be pursued to increase canopy cover in all areas, though suitable planting locations in commercial areas may be limited. High levels of impervious surface often restrict available locations, particularly within commercial locations. Open space/recreational areas typically have an abundance of grass/low-lying vegetation, which may seem ideal for planting, but often represent maintained parks and playgrounds, sports fields, community gardens, or other areas intentionally cultivated or designed to have lower tree canopy levels.

Table 5. Land Use: Existing, Possible, and Maximum UTC

Land Use Classification	Total Acres	Existing UTC		Possible UTC		Maximum UTC	
		Acres	%	Acres	%	Acres	%
Commercial	198	15	7%	30	15%	44	22%
High Density Residential	102	19	19%	25	25%	44	44%
Med/Low Density Residential	583	248	43%	162	28%	410	70%
Open Space/Recreational	257	134	52%	80	31%	214	83%
Other Developed Lands	200	46	23%	38	19%	85	42%
Transportation	388	79	20%	53	14%	132	34%
Water	17	7	42%	4	23%	11	65%
Total	1,746	548	31%	392	22%	940	54%

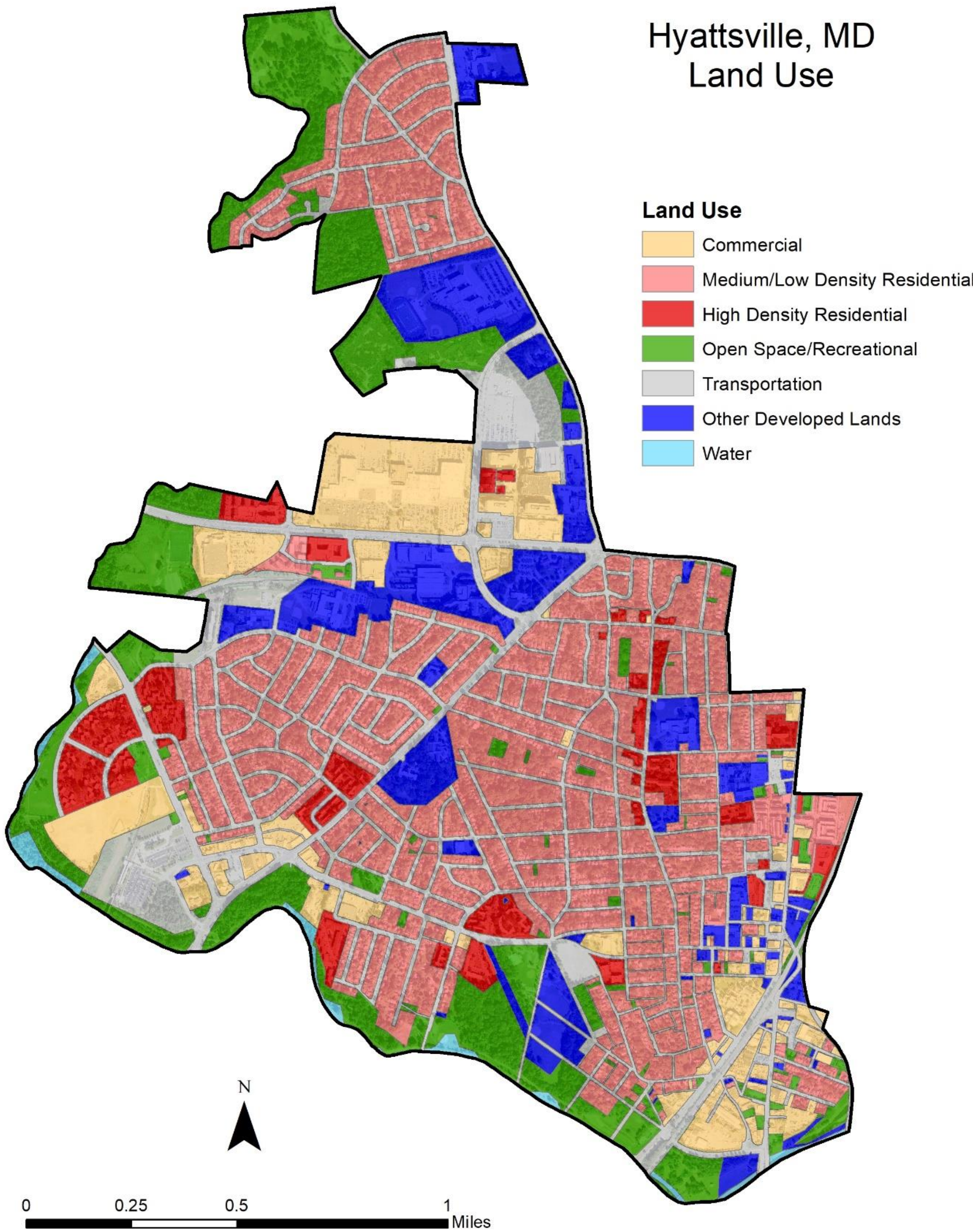

Figure 5. Land use classification distribution (2018).

Table 6 presents Hyattsville's tree canopy change over time, categorized by land use. A heat map (Figure 6) presents a visualization of the table. Key findings include:

- All land use areas lost canopy coverage from the period 2009–2018, for a total loss of 236 canopy acres.
- Medium/low density residential land use areas experienced the largest loss in tree canopy, losing 107 canopy acres, declining by 18% in UTC.
- Commercial use areas contain the smallest amount of canopy cover (7%) and experienced the smallest decline in UTC (a decrease of 4 percentage points).

Table 6. Land Use: Canopy Change Over Time

Land Use Class	Total Acres	Canopy Coverage					
		2018		2009		UTC Change	
		Acres	%	Acres	%	Acres	%
Commercial	198	15	7%	23	11%	-8	-4%
High Density Residential	102	19	19%	35	35%	-16	-16%
Med/Low Density Residential	583	248	43%	355	61%	-107	-18%
Open Space/Recreational	257	134	52%	169	66%	-35	-14%
Other Developed Lands	200	46	23%	55	28%	-9	-5%
Transportation	388	79	20%	138	36%	-59	-15%
Water	17	7	42%	9	50%	-2	-8%
Total	1,746	548	31%	785	45%	-236	

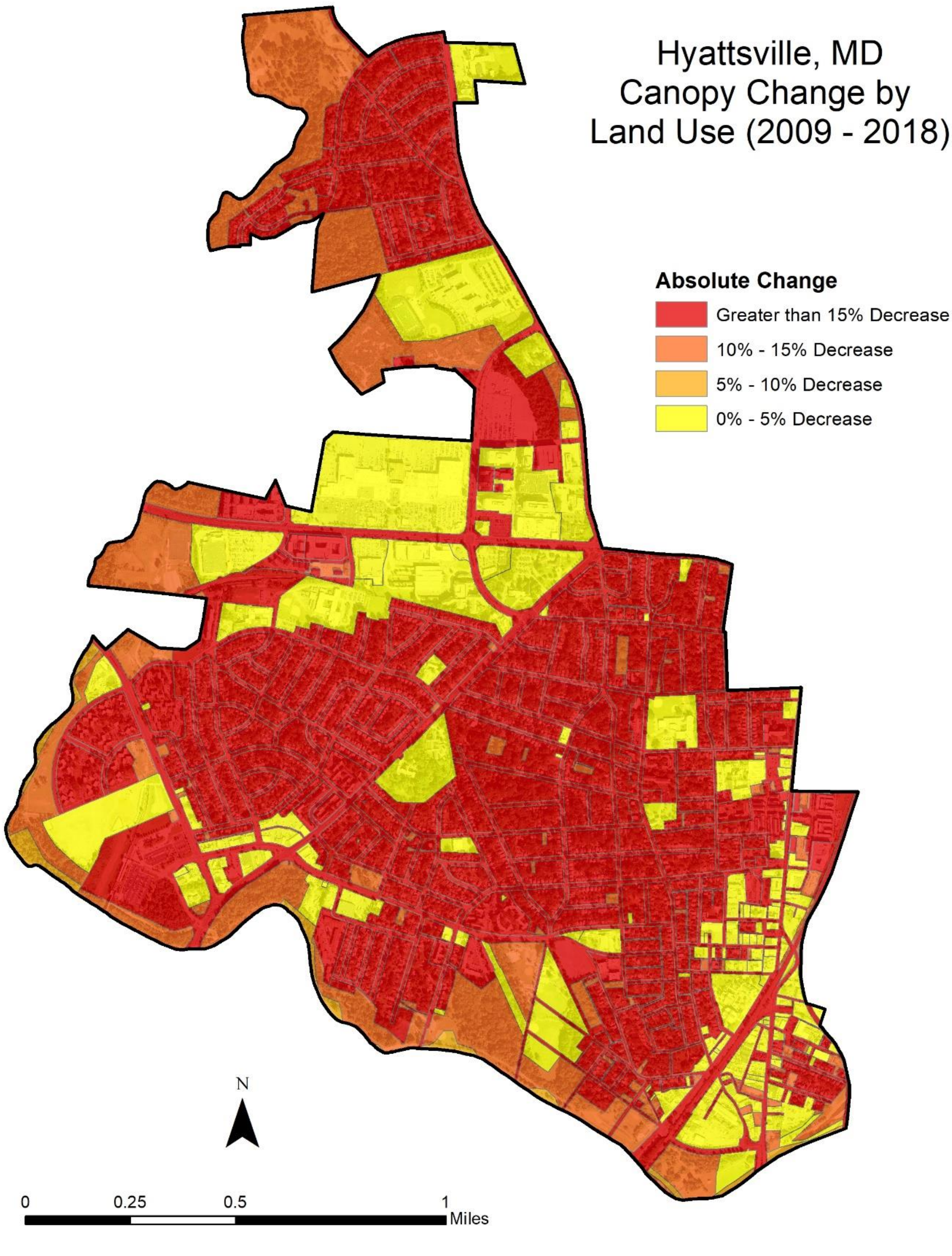

Figure 6. Canopy change by land use (2009–2018).

PARKS

The City of Hyattsville contains 13 city parks and 17 county parks encompassing a total of 298 acres. Tables 7 and 8 summarize the findings of the analysis, and Figures 7 and 8 present a visualization of canopy coverage and canopy change among Hyattsville's city- and county-maintained parks. Key findings from the analysis include:

- City and county parks in Hyattsville have a combined canopy coverage of 47% (140 acres).
- City parks contain 24 canopy acres for a total of 30% coverage, and county parks contain 116 canopy acres for a total of 53% canopy coverage.
- Maximum combined canopy coverage can reach 77% if all 88 preferred plantable acres are utilized.
- Since 2009, canopy coverage decreased by 11% within city parks (from 41% to 30%) and by 8% within county parks (from 61% to 53%).
- Total combined canopy loss since 2009 totaled 26 acres.
- The three parks with the greatest percentage of canopy loss are all city parks: McClanahan Park, Melrose Park Trail, and Emerson Street Food Forest. However, all three of these parks are less than 1 acre in size, so the overall impact on the urban forest is minimal.
- The largest city park, University Hills Duck Pond, experienced a net loss of 4 canopy acres, while the largest county park, Northwest Stream Valley, lost 8 acres of canopy.

The findings from the parks analysis are consistent with expectations; city parks tend to have more open areas and more amenities such as sports fields, and thus have lower rates of canopy coverage than county parks which often tend to be more wooded and left to their natural state. Hyattsville's city parks should be closely evaluated for opportunities for new plantings. Analysis by DRG found 27 preferred plantable acres within city parks. If all 27 acres were fully utilized for new plantings, Hyattsville can obtain a maximum canopy coverage of 63% within city parks.

Photograph 3. Champion Oak in Magruder Park, Hyattsville, MD.

Table 7. City & County Parks: Existing, Possible, and Maximum UTC

Land Use	Total Acres	Existing UTC		Possible UTC		Maximum UTC	
		Acres	Percent	Acres	Percent	Acres	Percent
City Parks	81	24	30%	27	33%	51	63%
County Parks	217	116	53%	61	28%	177	82%
Total	298	140	47%	88	30%	228	77%

Table 8. City & County Parks: Canopy Change Over Time

Park Name	Park Type	Total Acreage	2009 Canopy		2018 Canopy		Absolute Change
			Acres	%	Acres	%	
McClanahan Park	City	0	0	89%	0	35%	-54%
Melrose Park Trail	City	0	0	81%	0	33%	-48%
Emerson Street Food Forest	City	0	0	56%	0	8%	-48%
Queenstown Park	County	0	0	39%	0	10%	-29%
Hyatt Park	County	2	1	67%	1	44%	-23%
Melrose Park	County	1	1	50%	0	28%	-22%
Lane Manor Park Building	County	3	1	47%	1	26%	-21%
Hyatt Park	City	1	1	61%	1	42%	-19%
Burlington Park	City	0	0	83%	0	66%	-17%
Robert J. King Memorial Park	City	0	0	37%	0	20%	-17%
Heurich Park	City	22	7	32%	4	17%	-15%
Nicholson Park	City	0	0	68%	0	55%	-13%
Heurich Park	County	28	10	37%	7	24%	-13%
University Hills Duck Pond	City	33	19	57%	15	44%	-12%
Prince George's Plaza	County	2	1	61%	1	51%	-11%
Deitz Park	City	2	2	100%	1	90%	-10%
Hyattsville-Dietz Park	County	2	2	100%	1	90%	-10%
Hamilton Park	County	8	4	47%	3	37%	-10%
Thirty-eighth Avenue Park	County	7	2	32%	2	22%	-10%
Kirkwood Park	County	9	3	30%	2	21%	-10%
NW Branch Stream Valley	County	88	68	77%	60	68%	-9%
Rhode Island Ave Trolley Trl	County	1	1	62%	0	53%	-9%
Melrose Park	City	3	0	14%	0	6%	-8%
University Hills Park	County	7	2	31%	2	26%	-5%
Magruder Park	City	20	4	19%	3	15%	-5%
Anacostia River Stream Valley	County	50	28	56%	27	53%	-3%
Magruder Woods Park	County	2	2	100%	2	98%	-2%
Rosemary Terrace Park	County	7	7	100%	7	100%	0%
Hamilton Splash Park	County	0	0	6%	0	6%	0%
Centennial Park	City	0	0	21%	0	31%	10%
Total	City	81	33	41%	24	30%	-11%
Total	County	217	133	61%	116	53%	-8%
Total	All	298	166	56%	140	47%	-9%

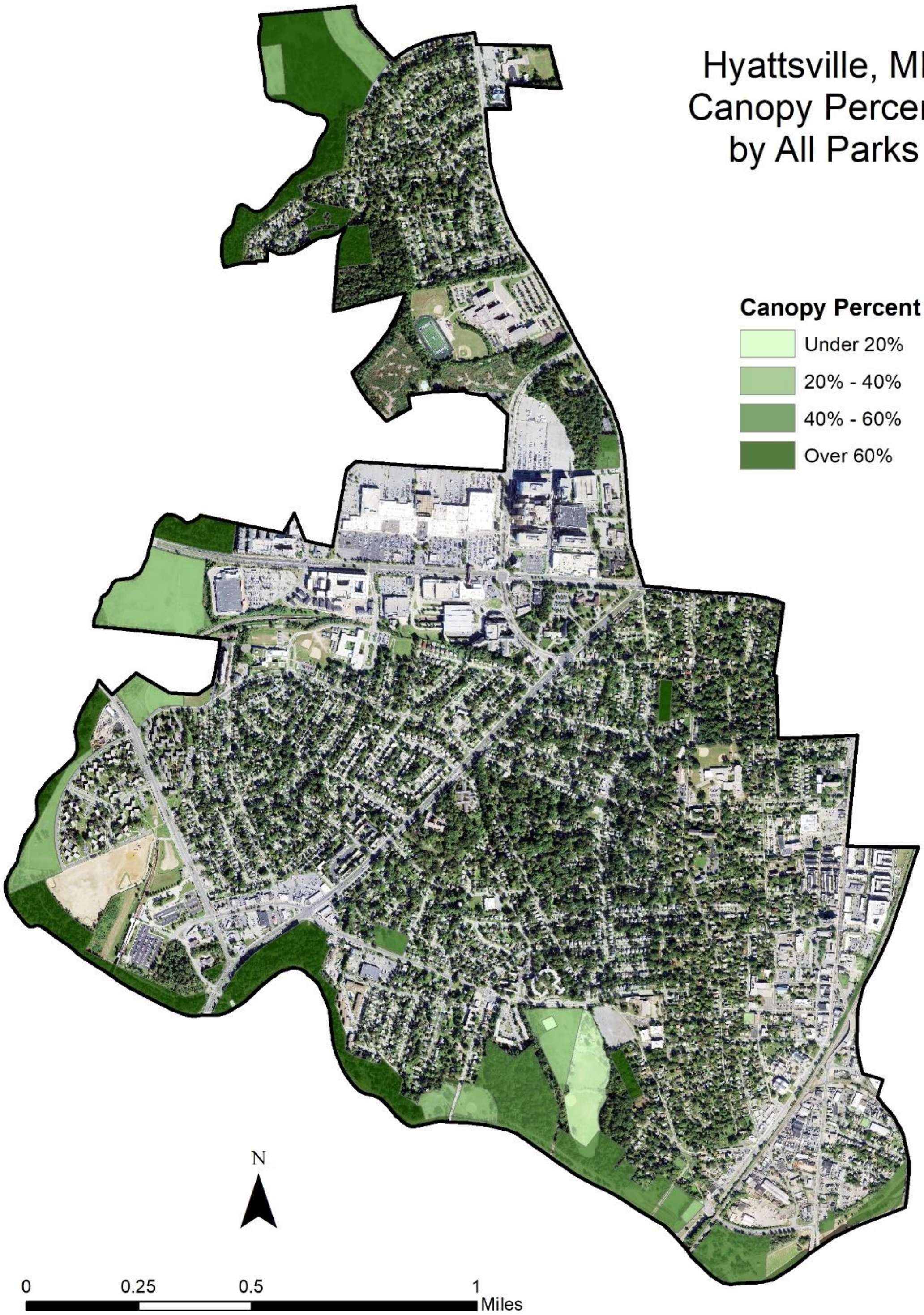

Figure 7. Parks: canopy percentage distribution.

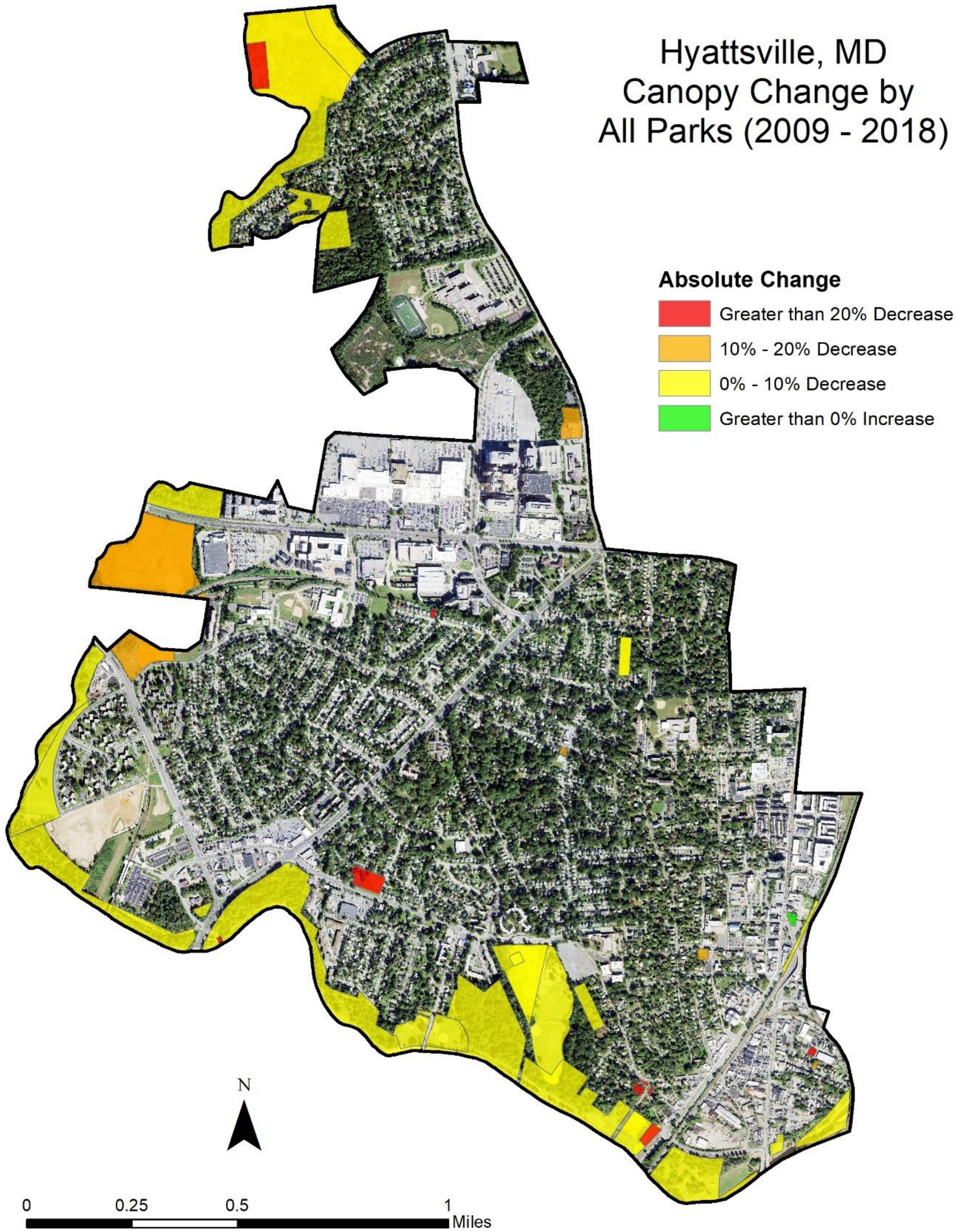

Figure 8. Parks: canopy change, 2009–2018.

CITY ELECTION WARDS

The City of Hyattsville contains a total of five election wards. Table 9 summarizes the existing, possible, and maximum UTC for each ward, and Table 10 presents the results of the canopy change analysis looking at the period from 2009 to 2018. Visualizations of the analyses are presented below and exhibit the level of existing canopy coverage (Figure 9) and the amount of canopy change (Figure 10) within each election ward. Key findings include:

- Ward 2 has the highest level of UTC among the election wards (43% canopy coverage).
- Ward 3 contains the highest gross acreage of canopy (174 acres).
- Ward 4 has the smallest amount of UTC both in terms of gross acreage (49 acres) and level of UTC (28%).

Table 9. Election Wards: Existing, Possible, and Maximum UTC

Election Ward	Total Acres	Existing UTC		Possible UTC		Maximum UTC	
		Acres	%	Acres	%	Acres	%
Ward 1	446	137	31%	81	18%	218	49%
Ward 2	255	110	43%	53	21%	163	64%
Ward 3	585	174	30%	120	20%	294	50%
Ward 4	178	49	28%	52	29%	101	57%
Ward 5	279	78	28%	85	31%	164	59%
Total	1,746	548	31%	392	22%	940	54%

- From 2009–2018, all five election wards experienced a double digit decrease in canopy coverage.
- The largest decline in UTC came in Ward 4, dropping by 19 percentage points from 47% in 2009 to 28% in 2018.
- The smallest decrease in tree canopy came in Ward 1, losing 46 canopy acres which dropped coverage from 41% to 31%.

Table 10. Election Wards: Canopy Change Over Time

Election Ward	Total Acres	Canopy Coverage					
		2018		2009		Change	
		Acres	%	Acres	%	Acres	%
Ward 1	446	137	31%	183	41%	-46	-10%
Ward 2	255	110	43%	157	61%	-47	-18%
Ward 3	585	174	30%	245	42%	-71	-12%
Ward 4	178	49	28%	84	47%	-35	-19%
Ward 5	279	78	28%	115	41%	-37	-13%
Total	1,746	548		785		-236	

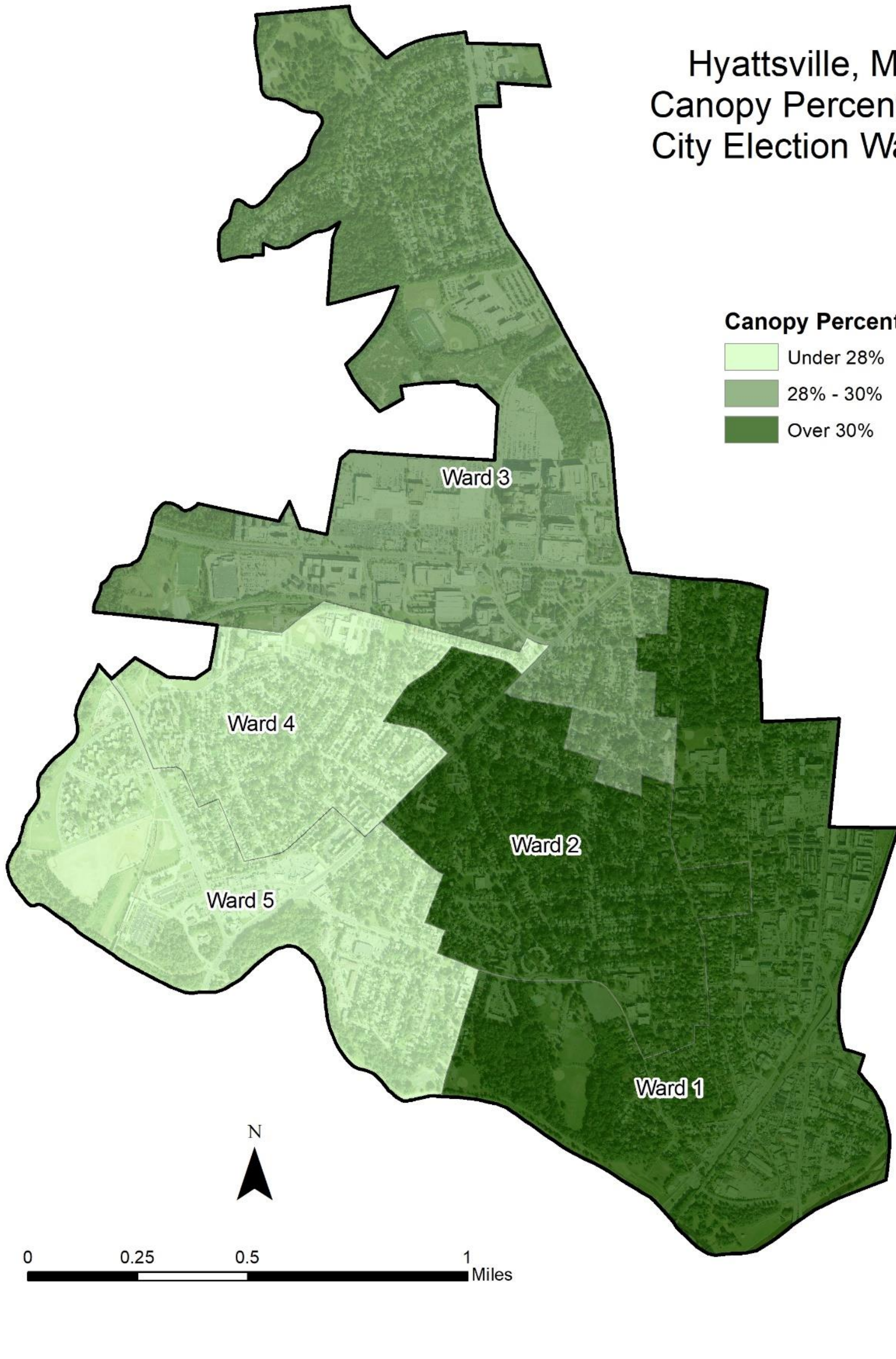

Figure 9. Election wards: canopy coverage distribution.

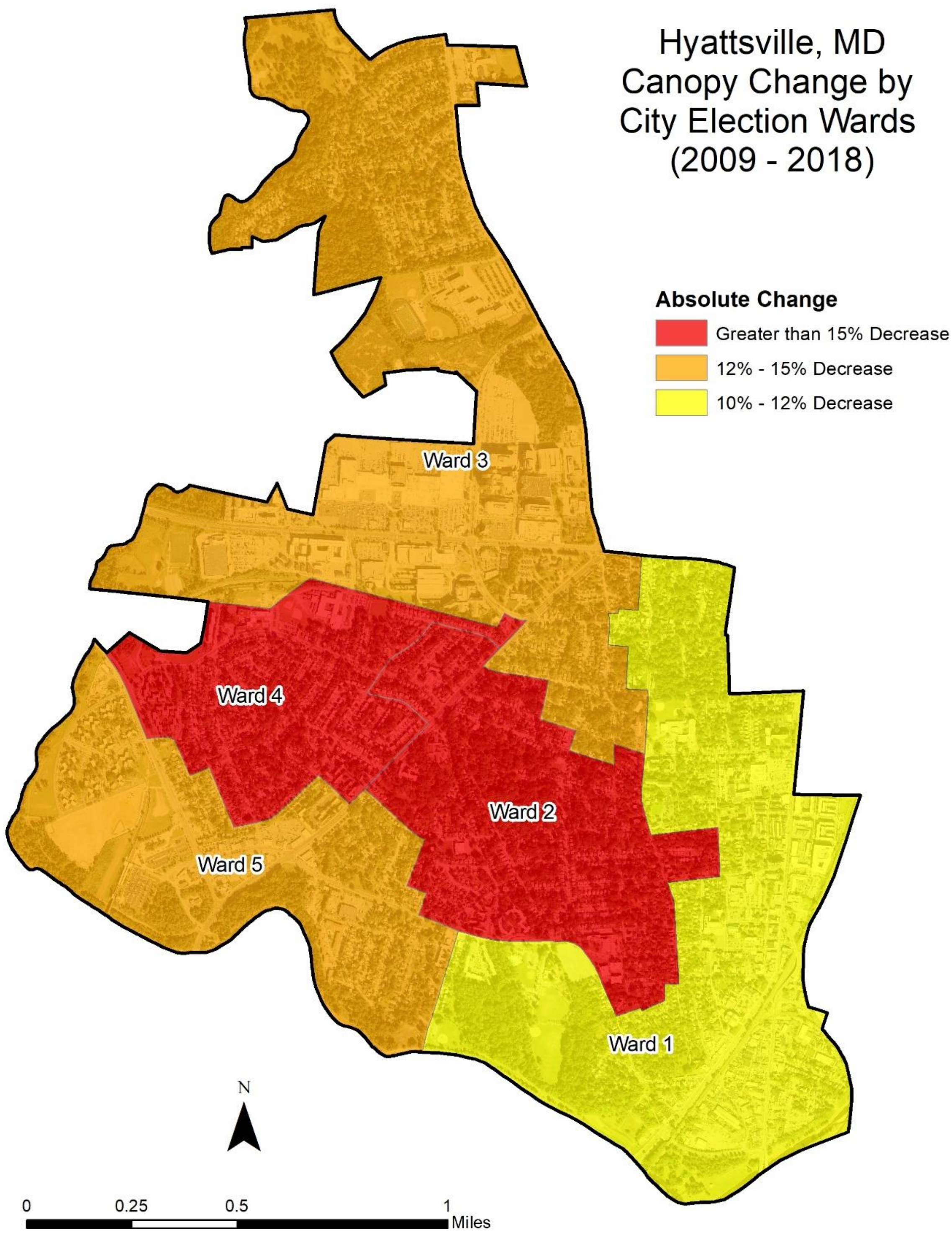

Figure 10. Election wards: canopy change, 2009-2018.

CENSUS BLOCK GROUPS

Analysis of tree canopy by census block can be used as a supplemental tool in determining how to allocate resources for neighborhood-specific urban forestry initiatives. Census blocks with higher levels of canopy coverage may be looked to as success stories, while blocks with less coverage can be identified and prioritized for new planting efforts.

Table 11 presents the existing, possible, and maximum UTC for Hyattsville's ten largest census blocks, in terms of total area, and Table 12 demonstrates how the amount and level of canopy coverage within those ten census blocks changed from 2009 to 2018. Accompanying visualizations of the census block analyses are presented below in Figures 11 and 12. Key findings include:

- Hyattsville's ten largest census blocks comprise 1,515 acres, accounting for 87% of Hyattsville's total land area.
- On average, Hyattsville's ten largest block groups are 151 acres in size with 46 existing canopy acres and 34 possible canopy acres.
- The largest census block (ID# 240338060001) has a UTC of 20%, which is significantly less than the city average of 31%.
- The blocks with the highest levels of canopy coverage are in the northern part of the city and in the center of the city, both of which are medium/low density residential areas.
- The census block groups with the least amount of canopy coverage appear to be in areas classified for commercial and transportation land use.
- The census blocks of greatest canopy change since 2009 appear located nearby Northwestern High School.
- The census block group(s) located north of Hamilton Street and east of Queens Chapel Road consists primarily of medium/low density residential land use and appears to have a greater than 20% absolute decrease in canopy coverage.

Table 11. Existing, Possible, and Maximum UTC of Hyattsville's Ten Largest Census Blocks

Census Block ID	Total Acres	Existing UTC		Possible UTC		Maximum UTC	
		Acres	%	Acres	%	Acres	%
240338060001	247	50	20%	67	27%	117	47%
240338062002	190	78	41%	38	20%	117	61%
240338063001	178	28	16%	26	15%	55	31%
240338061001	148	70	47%	31	21%	101	68%
240338062001	147	61	42%	30	21%	92	62%
240338059082	132	19	15%	9	7%	28	21%
240338059091	131	60	46%	37	28%	97	74%
240338051012	130	29	22%	54	41%	83	64%
240338060002	108	29	27%	28	26%	57	53%
240338061002	105	38	36%	22	21%	60	57%
Total	1,515	463	31%	342	23%	805	54%
Average	151	46		34		81	

Table 12. Canopy Change Over Time: Hyattsville's Ten Largest Census Blocks

Census Block ID	Total Acres	Canopy Coverage					
		2018		2009		Change	
		Acres	%	Acres	%	Acres	%
240338060001	247	50	20%	85	34%	-36	-14%
240338062002	190	78	41%	102	54%	-24	-13%
240338063001	178	28	16%	40	23%	-12	-7%
240338061001	148	70	47%	96	65%	-26	-18%
240338062001	147	61	42%	86	59%	-25	-17%
240338059082	132	19	15%	24	19%	-5	-4%
240338059091	131	60	46%	81	62%	-21	-16%
240338051012	130	29	22%	40	31%	-11	-9%
240338060002	108	29	27%	50	46%	-21	-20%
240338061002	105	38	36%	59	57%	-22	-21%
Total	1,515	463	31%	665	44%	-202	-13%
Average	151	46		66		-20	

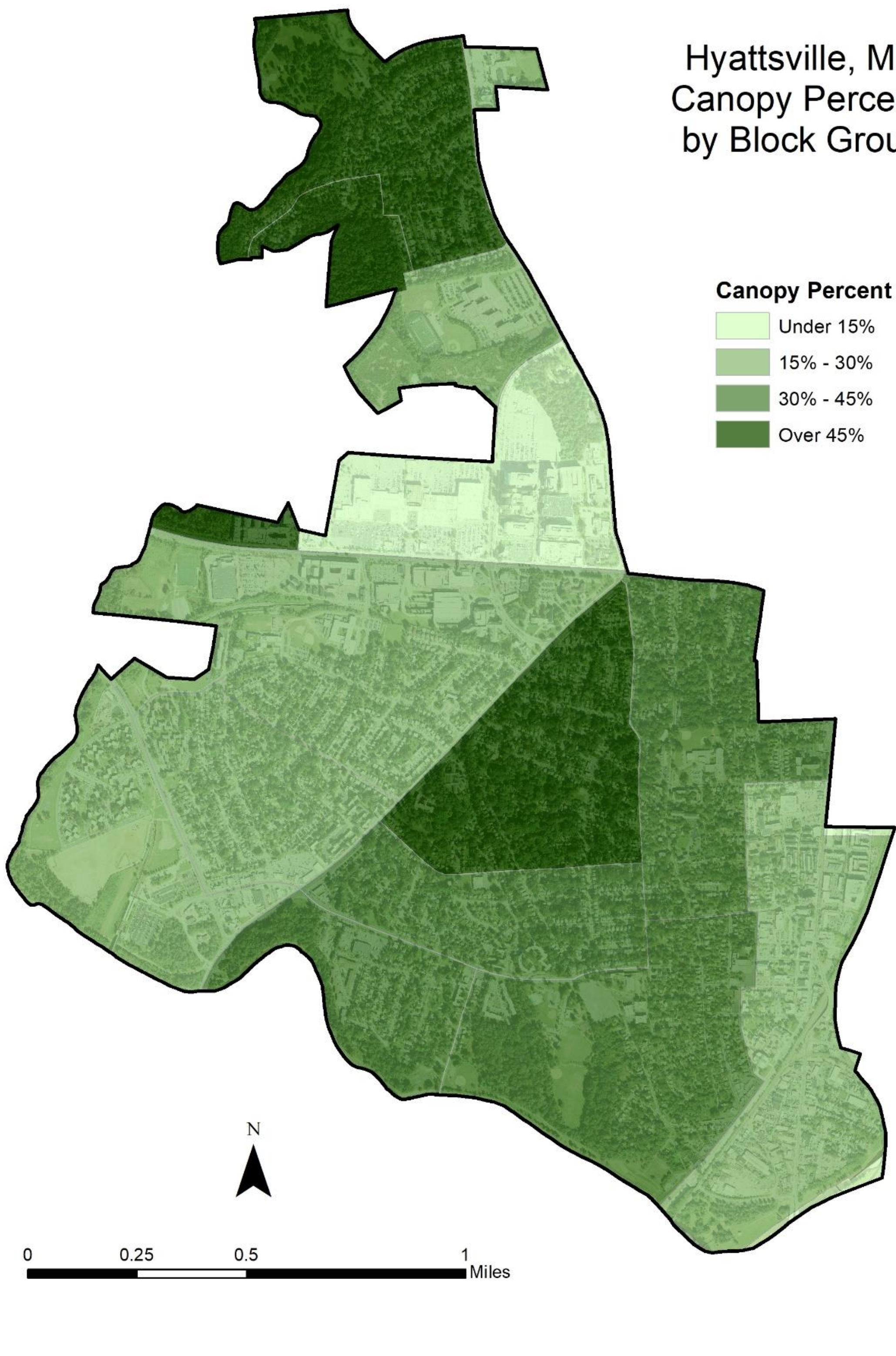

Figure 11. Census block groups: canopy coverage distribution.

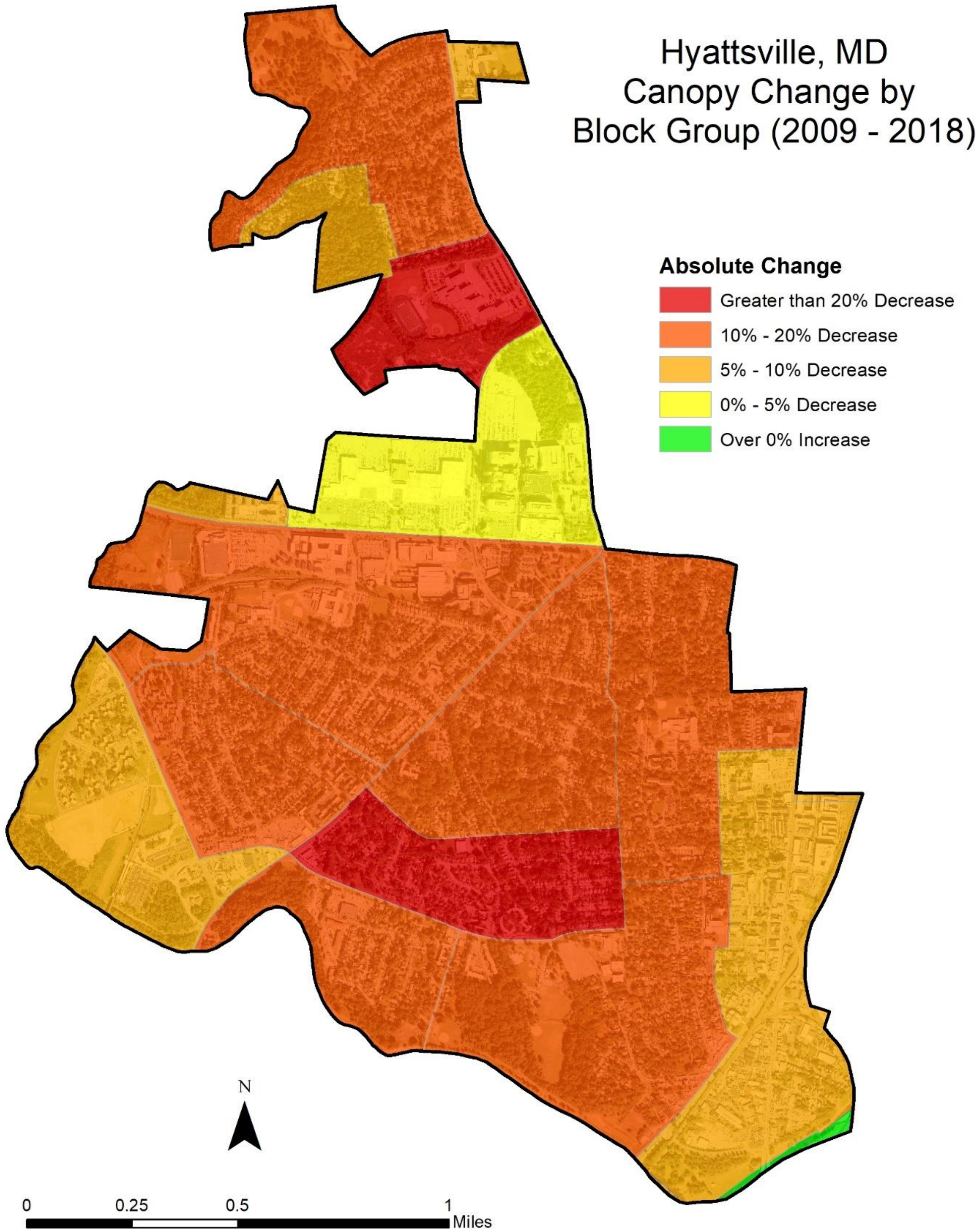

Figure 12. Census block groups: canopy change over time.

PARCELS

Analysis of tree canopy coverage by parcel can be particularly useful for urban forestry planners; parcel-level information includes data on land ownership, which can be helpful when strategically planning new planting initiatives. City planners can use this information to identify landowners and potentially work together to reestablish canopy. Land ownership history can also tell the "canopy story" of a given parcel, which is helpful in identifying areas of success and in explaining why a given parcel may have lost significant amounts of canopy cover.

Table 13 presents the existing, possible, and maximum UTC for Hyattsville's ten largest parcels, and Table 14 demonstrates how the amount and level of canopy coverage within those ten parcels changed from 2009 to 2018. Accompanying visualizations of the canopy parcel analyses are presented below in Figures 13 and 14. Key findings include:

- The average size of Hyattsville's ten largest parcels is 21.5 acres, of which 3.9 acres are tree canopy (18%), which is significantly less than the citywide UTC of 31%. Many of the larger parcels appear to be located within areas of commercial land use which may account for the lower UTC levels.
- The southwestern area of the city contains several larger parcels with less than 20% canopy cover. Several of these parcels are high-density residential (Kirkwood Apartments) and one larger parcel, which is currently an area of bare soil, is the future location of the Riverfront at West Hyattsville Metro.
- The parcels with the highest levels of canopy cover appear to be city and county parks located near the perimeter of the city and single-family residential homes located closer to the geographic center of Hyattsville.
- The largest reductions in canopy cover appear concentrated within areas of medium/low residential land use. Smaller lots tend to have fewer trees; as such, the loss of even one tree can have a significant impact on canopy cover. It is speculated that the wide distribution of canopy loss here is because of emerald ash borer and natural loss of mature tree canopy.

Table 13. Existing, Possible, and Maximum UTC of Hyattsville's Ten Largest Parcels

Parcel ID	Total Acres	Existing UTC		Possible UTC		Maximum UTC	
		Acres	%	Acres	%	Acres	%
136520	50.8	2.2	4%	1.6	3%	3.7	7%
136258	28.7	4.2	15%	3.2	11%	7.4	26%
325767	22.2	1.7	8%	5.0	23%	6.7	30%
111570	19.8	0.4	2%	18.1	91%	18.5	93%
136429	19.7	7.4	37%	0.8	4%	8.2	41%
93456	16.7	14.3	86%	1.7	10%	16.0	96%
114104	15.9	1.7	11%	5.9	37%	7.6	48%
111574	14.2	1.0	7%	7.9	56%	8.9	63%
368016	13.9	4.2	30%	9.5	68%	13.7	99%
362235	13.2	1.4	10%	1.8	14%	3.2	24%
Total	215.1	38.5	18%	55.3	26%	93.8	44%
Average	21.5	3.9		5.5		9.4	

Table 14. Canopy Change Over Time: Hyattsville's Ten Largest Parcels

Parcel ID	Total Acres	Canopy Coverage					
		2018		2009		Change	
		Acres	%	Acres	%	Acres	%
136520	50.8	2.2	4%	3.1	6%	-0.9	-2%
136258	28.7	4.2	15%	3.1	11%	1.1	4%
325767	22.2	1.7	8%	2.1	9%	-0.3	-2%
111570	19.8	0.4	2%	2.4	12%	-2.0	-10%
136429	19.7	7.4	37%	8.1	41%	-0.7	-4%
93456	16.7	14.3	86%	14.5	87%	-0.2	-1%
114104	15.9	1.7	11%	2.4	15%	-0.7	-4%
111574	14.2	1.0	7%	1.6	11%	-0.6	-4%
368016	13.9	4.2	30%	13.7	99%	-9.5	-69%
362235	13.2	1.4	10%	1.9	14%	-0.5	-4%
Total	215.1	38.5	18%	52.9	25%	-14.4	-7%
Average	21.5	3.9		5.3		-1.4	

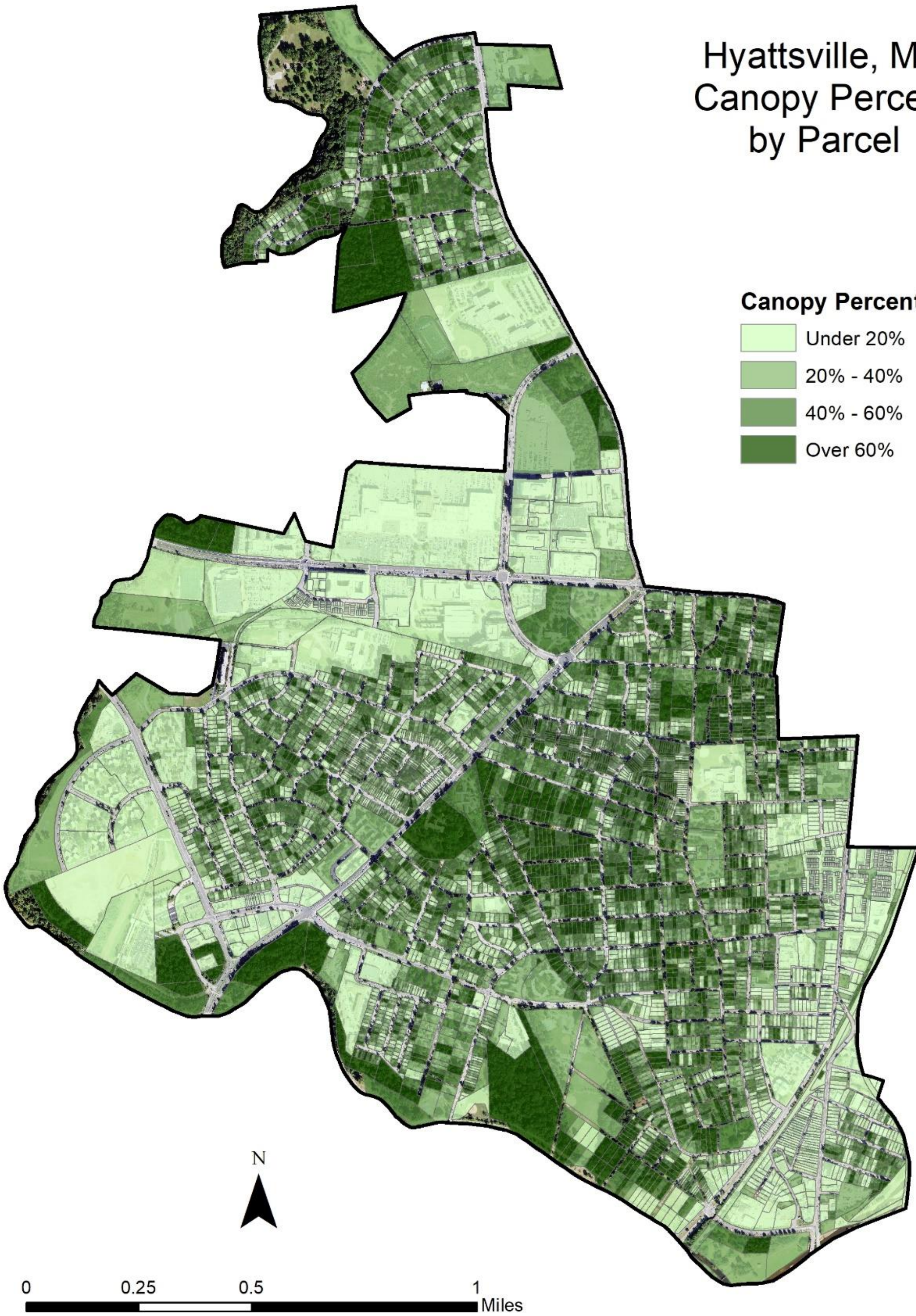

Figure 13. Parcels: canopy coverage distribution.

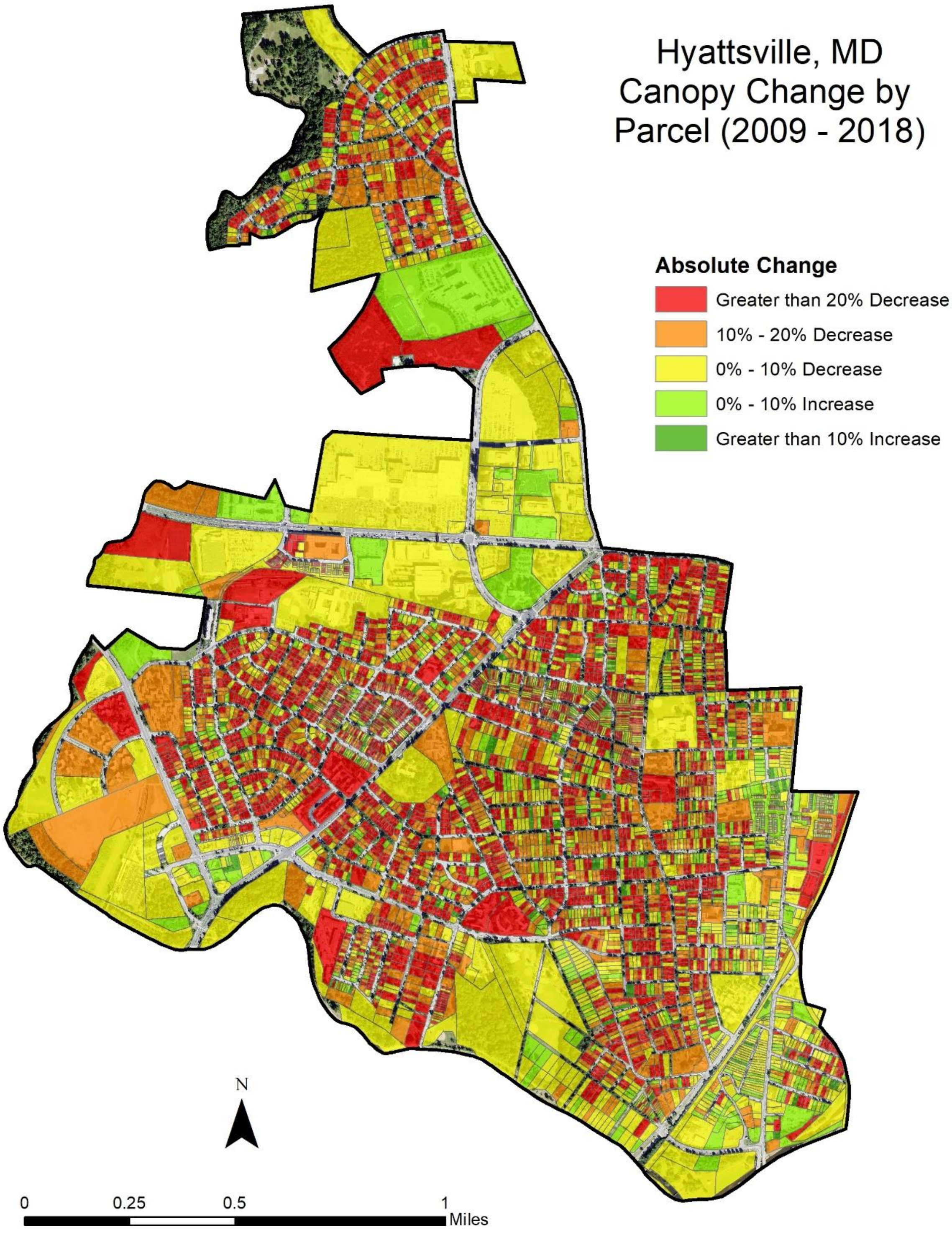

Figure 14. Parcels: canopy change over time.

BENEFITS OF URBAN TREE CANOPY

Trees provide a myriad of benefits to Hyattsville. Trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. In addition, trees provide numerous economic, psychological, and social benefits.

In 2018, Hyattsville's tree canopy provided an approximate value of $3 million in ecosystem benefits, a per capita value of $164. These benefits were quantified using the i-Tree Eco model and i-Tree Hydro hydrologic equations. The i-Tree eco tools models air quality and carbon storage and sequestration, and the i-Tree Hydro tool models stormwater runoff.

With a change in the overall canopy coverage for the city comes a change in the ecosystems benefits those trees provide. While we do not have data on the change in level of benefits over time, Table 15 provides insight into that loss by highlighting the annual value of Hyattsville's UTC, as of 2018.

Table 15. Ecosystem Benefits of the Hyattsville UTC

Ecosystem Benefits	Annual Ecosystem Benefits	
	Quantity	Value
Air: CO (carbon monoxide) removed	934 lbs	$510
Air: NO_2 (nitrogen dioxide) removed	6,593 lbs	$778
Air: O_3 (ozone) removed	26,358 lbs	$17,073
Air: SO_2 (sulfur dioxide) removed	2,019 lbs	$74
Air: PM_{10} particulate matter (dust, soot, etc.) removed	5,439 lbs	$11,707
Carbon sequestered	740 tons	$63,085
Current stored carbon	18,579 tons	$1,584,301
Stormwater: reduction in runoff	7,944,801 gals	$1,350,616
Total Annual Value		$3,028,144

Stormwater Interception

During storm events trees intercept rainfall in their canopy acting as a mini reservoir. Intercepted rainfall evaporates from leaf surfaces or slowly soaks into the ground, reducing and slowing stormwater runoff, and lessening the impacts of rainfall on barren soils. The growth and decomposition of tree roots increases water holding capacity and infiltration rates of soils allowing for greater absorption of rain. Each of these processes greatly reduces the flow and volume of stormwater runoff, reducing flooding and erosion and preventing sediments and pollutants from entering waterways. Infiltrating and treating stormwater runoff on site can reduce runoff and pollutant loads by 20–60%.

Photograph 4. As this tree grows, it will increasingly provide benefits to the community. Trees of all ages and shapes and sizes draw pollutants, sequester carbon from the air, and protect water quality while helping to manage stormwater (Stock Photograph).

Planting trees in and adjacent to rights-of-way provides a unique opportunity to increase the effectiveness of grey and green stormwater systems. Existing stormwater management systems are not always adequate to accommodate runoff. When a system is overtaxed, peak flows can blow manhole covers off the ground, backing up stormwater and causing flooding. Where existing systems are challenged by common stormwater events, planting additional trees is a cost-effective solution to improve functional capacity.

In 2018, Hyattsville’s trees intercepted an estimated 7,944,801 gallons of stormwater; that is enough water to fill twelve Olympic-size swimming pools. This benefit is calculated to provide approximately $1,350,616 in infrastructure value.

Air Quality Improvements

Not only do trees take in carbon dioxide and produce oxygen, but they can also capture fine pollutants and particulate matter on the surfaces of their leaves. Combined, these processes can improve a city’s air quality. Recent studies have shown a strong correlation between total tree canopy and reduced rates of pulmonary and cardiovascular disease.

i-Tree Eco estimates carbon storage and sequestration and air pollutant removal. Air pollutants included in estimates are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10}), and sulfur dioxide (SO_2). Every year, Hyattsville’s urban forest removes 41,343 lbs. of pollutants from the air, including: 934 lbs. of carbon monoxide (CO), 6,593 lbs. of nitrogen dioxide (NO_2), 26,358 lbs. of ozone (O_3), 2,019 lbs. of sulfur dioxide (SO_2), and 5,439 lbs. of dusts, soot, and other particulate matter. Combined, this equates to approximately $1,315,676 in value annually.

Carbon Reduction

As sunlight strikes the Earth's surface, it is reflected into space as infrared radiation (heat). Greenhouse gases (GHGs) absorb some of the infrared radiation before it can be released into space, trapping this heat in the atmosphere, and increasing the Earth's surface temperature. As GHGs increase, the amount of energy radiated back into space is reduced as more heat is trapped in the atmosphere, leading to higher surface temperatures. Changes in the Earth's average temperature may result in changes in weather and land use patterns which can impact human health. Many chemical compounds in the atmosphere act as greenhouse gases, including methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), water vapor, and human-made gases/aerosols. In the last 150 years, due in large part to large-scale industrialization, the level of some GHGs, including CO_2, have increased by 25%.

Urban trees reduce atmospheric CO_2 directly through growth and the sequestration of CO_2 in wood, foliar biomass, and soil. Trees store massive amounts of carbon in their woody tissue. Carbon storage is the volume of carbon stored as wood and foliar mass, and as trees grow, they store more carbon as new wood and starch reserves. When trees die and decay, they release much of the stored carbon back to the atmosphere. In urban environments, most trees that die are removed and chipped or disposed of as firewood, releasing stored carbon. Thus, carbon storage is an indication of the amount of carbon that can be lost if trees die and are left to decompose. In addition to the annual benefits, Hyattsville's tree canopy has amassed 18,579 tons of carbon valued at $1,584,301 for total carbon storage.

Conclusion

Hyattsville's urban forest is an important community asset that provides numerous environmental benefits. With the appropriate care, Hyattsville's urban forest is expected to increase in value over time as the city embarks on significant efforts to protect and expand its urban forest.

Photograph 5. Young trees in front of Post Park Apartments, a high-density residential land use area of Hyattsville, MD

Within the ten years between the studies of 2009 and 2018, Hyattsville's UTC coverage decreased by 14%. In the face of climate change, severe weather events, and invasive pests, urban forests are facing more threats than ever before. To increase the urban tree canopy, it is not enough to simply plant trees. Instead, Hyattsville will need to develop a multifaceted approach to expanding tree cover that includes emphasis on tree planting, maintenance, tree preservation, and community outreach and education to develop wide public support for Hyattsville's efforts.

This analysis was designed to help document Hyattsville's urban forest, quantify the value and benefits that it provides, and develop recommendations for future planting efforts. This study should be considered as a starting point—a place from which to begin conversations and the exploration of opportunities that seek to enhance the city's tree canopy. Based on this analysis, some key recommendations emerge:

- Hyattsville is encouraged to expand its planting palette to include new tree species.
- Many opportunities for impacting Hyattsville's priorities of intercepting stormwater and socioeconomic factors are within core commercial and industrial areas. To meaningfully expand canopy, Hyattsville should explore opportunities to improve infrastructure that supports trees and engage property and business owners in community forestry efforts.
- Planting is only part of the equation to expand tree canopy. Preserving or protecting old established trees can often have a greater impact on urban canopy levels while the newly planted trees are growing. Hyattsville should examine policies to identify any barriers or potential incentives to protecting and expanding tree canopy community wide.
- This report represents one way in which these data can be analyzed. With additional datasets or new questions, these data can further be used to help Hyattsville manage its urban forest. Therefore, Hyattsville is encouraged to continue to use these data to analyze additional relationships and connections that can help develop community objectives, understand challenges, and frame management decisions.

References

i-Tree Canopy. i-Tree Software Suite v6.1. (n.d.). http://www.itreetools.org.

i-Tree Hydro. i-Tree Software Suite v5.0 (beta) (n.d.). http://www.itreetools.org.

2014. Murray, B. 2014. Personal communication. City of Hyattsville, Forestry. December 2014.

O'Neill-Dunne, J. 2007. A Report on the City of Hyattsville's Existing and Possible Tree Canopy. University of Vermont Spatial Analysis Laboratory. Burlington, Vermont. March 16, 2010.

Children living in areas with more street trees have lower prevalence of asthma G S Lovasi,1 J W Quinn,1 K M Neckerman,1 M S Perzanowski,2 and A Rundle3, J Epidemiol Community Health. 2008 Jul; 62(7): 647–649. Published online 2008 May 1. doi: 10.1136/jech.2007.071894

Wolf, K. L. 1998a. "Urban Nature Benefits: Psycho-Social Dimensions of People and Plants." University of Washington, College of Forest Resources Fact Sheet. 1(November).

—. 1998b. "Trees in Business Districts: Positive Effects on Consumer Behavior!" University of Washington College of Forest Resources Fact Sheet. 5(November).

—. 1999. "Grow for the Gold." TreeLink Washington DNR Community Forestry Program. 14(spring).

—. 2000. "Community Image: Roadside Settings and Public Perceptions." University of Washington College of Forest Resources Factsheet. 32(August).

—. 2003. "Public Response to the Urban Forest in Inner-City Business Districts." J. Arbor 29(3):117–126.

—. 2007. "City Trees and Property Values." Arborist News (August):34-36.

—. 2009. "Trees & Urban Streets: Research on Traffic Safety & Livable Communities." http://www.naturewithin.info/urban.html. Accessed November 10, 2011.

Appendix A
Methodology and Accuracy Assessment

DAVEY RESOURCE GROUP CLASSIFICATION METHODOLOGY

DRG utilized an object-based image analysis (OBIA) semi-automated feature extraction method to process and analyze current high-resolution color infrared (CIR) aerial imagery and remotely-sensed data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing your community's existing tree canopy coverage. This supports responsible tree management, facilitates community forestry goal setting, and improves urban resource planning for healthier and more sustainable urban environments.

Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst, an extension of ArcGIS®. Feature Analyst uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual (e.g., texture, size, shape, pattern, and spatial association) characteristics. The land cover results of the extraction process was post-processed and clipped to each project boundary prior to the manual editing process in order to create smaller, manageable, and more efficient file sizes. Secondary source data, high-resolution aerial imagery provided by each UTC city, and custom ArcGIS® tools were used to aid in the final manual editing, quality checking, and quality assurance processes (QA/QC). The manual QA/QC process was implemented to identify, define, and correct any misclassifications or omission errors in the final land cover layer.

Classification Workflow

1. Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2. Gather training set data for all desired land cover classes (canopy, impervious, grass, bare soil, shadows). Water samples are not always needed since hydrologic data are available for most areas. Training data for impervious features were not collected because the city maintained a completed impervious layer.
3. Extract canopy layer only; this decreases the amount of shadow removal from large tree canopy shadows. Fill small holes and smooth to remove rigid edges.
4. Edit and finalize canopy layer at 1:2,000 scale. A point file is created to digitize-in small individual trees that will be missed during the extraction. These points are buffered to represent the tree canopy. This process is done to speed up editing time and improve accuracy by including smaller individual trees.

5. Extract remaining land cover classes using the canopy layer as a mask; this keeps canopy shadows that occur within groups of canopy while decreasing the amount of shadow along edges.
6. Edit the impervious layer to reflect actual impervious features, such as roads, buildings, parking lots, etc. to update features.
7. Use the provided roads and building footprint layers to split the impervious layer into the following categories: buildings, roads, and other impervious surfaces.
8. Using canopy and actual impervious surfaces as a mask; input the bare soils training data and extract them from the imagery. Quickly edit the layer to remove or add any features. DRG tries to delete dry vegetation areas that are associated with lawns, grass/meadows, and agricultural fields.
9. Assemble any hydrological datasets, if provided. Add or remove any water features to create the hydrology class. Perform a feature extraction if no water feature datasets exist.
10. Use geoprocessing tools to clean, repair, and clip all edited land cover layers to remove any self-intersections or topology errors that sometimes occur during editing.
11. Input canopy, impervious, bare soil, and hydrology layers into DRG's Five-Class Land Cover Model to complete the classification. This model generates the pervious (grass/low-lying vegetation) class by taking all other areas not previously classified and combining them.
12. Thoroughly inspect final land cover dataset for any classification errors and correct as needed.
13. Perform accuracy assessment. Repeat Step 11, if needed.

Automated Feature Extraction Files

The automated feature extraction (AFE) files allow other users to run the extraction process by replicating the methodology. Since Feature Analyst does not contain all geoprocessing operations that DRG utilizes, the AFE only accounts for part of the extraction process. Using Feature Analyst, DRG created the training set data, ran the extraction, and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, DRG uses additional geoprocessing tools within ArcGIS®. From the AFE file results, the following steps are taken to prepare the extracted data for manual editing.

1. DRG fills all holes in the canopy that are less than 30 square meters. This eliminates small gaps that were created during the extraction process while still allowing for natural canopy gaps.
2. DRG deletes all features that are less than 9 square meters for canopy (50 square meters for impervious surfaces). This process reduces the amount of small features that could result in incorrect classifications and also helps computer performance.

3. The Repair Geometry, Dissolve, and Multipart to Singlepart (in that order) geoprocessing tools are run to complete the extraction process.
4. The Multipart to Singlepart shapefile is given to GIS personnel for manual editing to add, remove, or reshape features.

Accuracy Assessment Protocol

Determining the accuracy of spatial data is of high importance to DRG and our clients. To achieve to best possible result, DRG manually edits and conducts thorough QA/QC checks on all urban tree canopy and land cover layers. A QA/QC process will be completed using ArcGIS® to identify, clean, and correct any misclassification or topology errors in the final land cover dataset. The initial land cover layer extractions will be edited at a 1:2,000 quality control scale in the urban areas and at a 1:2,500 scale for rural areas utilizing the most current high-resolution aerial imagery to aid in the quality control process.

Land Cover Classification Code Values

Land Cover Classification	Code Value
Tree Canopy	1
Impervious	2
Pervious (Grass/Vegetation)	3
Bare Soil	4
Open Water	5
Buildings	6
Roads	7

To test for accuracy, random plot locations are generated throughout the city area of interest and verified to ensure that the data meet the client standards. Each point will be compared with the most current NAIP high-resolution imagery (reference image) to determine the accuracy of the final land cover layer. Points will be classified as either correct or incorrect and recorded in a classification matrix. Accuracy will be assessed using four metrics: overall accuracy, kappa, quantity disagreement, and allocation disagreement. These metrics are calculated using a custom Excel™ spreadsheet.

Land Cover Accuracy

The following describes DRG's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

1. *Random Point Generation*—Using ArcGIS, 1000 random assessment points are generated.
2. *Point Determination*—Each point is carefully assessed by the GIS analyst for likeness with the aerial photography. To record findings, two new fields, CODE and TRUTH, are added to the accuracy assessment point shapefile. CODE is a numeric value (1–7) assigned to each land cover class and TRUTH is the actual land cover class as identified according to the reference image. If CODE and TRUTH are the same, then the point is counted as a correct classification. Likewise, if the CODE and TRUTH are not the same, then the point is classified as incorrect.

In most cases, distinguishing if a point is correct or incorrect is straightforward. Points will rarely be misclassified by an egregious classification or editing error. Often incorrect points occur where one feature stops and the other begins.

3. *Classification Matrix*—During the accuracy assessment, if a point is considered incorrect, it is given the correct classification in the TRUTH column. Points are first assessed on the NAIP imagery for their correctness using a "blind" assessment—meaning that the analyst does not know the actual classification (the GIS analyst is strictly going off the NAIP imagery to determine cover class). Any incorrect classifications found during the "blind" assessment are scrutinized further using sub-meter imagery provided by the client to determine if the point was incorrectly classified due to the fuzziness of the NAIP imagery or an actual misclassification. After all random points are assessed and recorded; a classification (or confusion) matrix is created. The classification matrix for this project is presented in following table. The table allows for assessment of user's/producer's accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals.

Classification Matrix

Reference Data

Classes	Tree Canopy	Other Impervious Surfaces	Grass & Low-Lying Vegetation	Bare Soils	Open Water	Buildings	Roads	Row Total	Producer's Accuracy	Errors of Omission
Tree Canopy	316	2	10	0	0	0	2	330	95.76%	4.24%
Other Impervious	6	156	14	0	0	1	8	185	84.32%	15.68%
Grass/Vegetation	2	2	208	1	0	0	3	216	96.30%	3.70%
Bare Soils	1	0	2	11	0	0	0	14	78.57%	21.43%
Water	0	0	0	0	11	0	0	11	100.00%	0.00%
Buildings	0	8	0	0	0	108	1	117	92.31%	7.69%
Roads	0	3	1	0	0	0	123	127	96.85%	3.15%
Column Total	325	171	235	12	11	109	137	1000		
User's Accuracy	97.23%	91.23%	88.51%	91.67%	100.00%	99.08%	89.78%		Overall Accuracy	93.30%
Errors of Commission	2.77%	8.77%	11.49%	8.33%	0.00%	0.92%	10.22%		Kappa Coefficient	0.9141

Following are descriptions of each statistic as well as the results from some of the accuracy assessment tests.

Overall Accuracy – Percentage of correctly classified pixels; for example, the sum of the diagonals divided by the total points ((316+156+208+11+11+108+123)/1000 = 93.3%).

User's Accuracy – Probability that a pixel classified on the map actually represents that category on the ground (correct land cover classifications divided by the column total [316/325 = 97.23%]).

Producer's Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [316/330 = 95.76%]).

Kappa Coefficient – A statistical metric used to assess the accuracy of classification data. It has been generally accepted as a better determinant of accuracy partly because it accounts for random chance agreement. A value of 0.80 or greater is regarded as "very good" agreement between the land cover classification and reference image.

Errors of Commission – A pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actually present). This is termed as a false positive. In the matrix below, we can determine that 2.77% of the area classified as canopy is most likely not canopy.

Errors of Omission – A pixel reports the absence of a feature (such as trees) when, in reality, they are actually there. In the matrix below, we can conclude that 4.24% of all canopy classified is actually classified as another land cover class.

Allocation Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than optimal match in the spatial allocation (or position) of the classes.

Quantity Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than perfect match in the proportions (or area) of the classes.

Confidence Intervals – A confidence interval is a type of interval estimate of a population parameter and is used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter based on the observed probability of successes and failures. Since all assessments have innate error, defining a lower and upper bound estimate is essential.

Confidence Intervals

Class	Acreage	Percentage	Lower Bound	Upper Bound
Tree Canopy	548.3	31.4%	30.3%	32.5%
Impervious Surfaces	312.3	17.9%	17.0%	18.8%
Grass & Low-Lying Vegetation	404.8	23.2%	22.2%	24.2%
Bare Soils	22.8	1.3%	1.0%	1.6%
Open Water	16.3	0.9%	0.7%	1.2%
Buildings	199.1	11.4%	10.6%	12.2%
Roads	242.1	13.9%	13.0%	14.7%
Total	1,745.7	100.00%		

Statistical Metrics Summary

Overall Accuracy =	93.30%
Kappa Coefficient =	0.9141
Allocation Disagreement =	4%
Quantity Disagreement =	3%

Accuracy Assessment

Class	User's Accuracy	Lower Bound	Upper Bound	Producer's Accuracy	Lower Bound	Upper Bound
Tree Canopy	97.2%	96.3%	98.1%	95.8%	94.6%	96.9%
Impervious Surfaces	91.2%	89.1%	93.4%	84.3%	81.7%	87.0%
Grass & Low-Lying Vegetation	88.5%	86.4%	90.6%	96.3%	95.0%	97.6%
Bare Soils	91.7%	83.7%	99.6%	78.6%	67.6%	89.5%
Open Water	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Buildings	99.1%	98.2%	100.0%	92.3%	89.8%	94.8%
Roads	89.8%	87.2%	92.4%	96.9%	95.3%	98.4%