Urban Tree Canopy Study

Asheville, North Carolina

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Prepared for:
City of Asheville, North Carolina

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REPORT COVER SHEET

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REPORT NAME: Urban Tree Canopy Study

REPORT PREPARED BY: Davey Resource Group

WHY WAS THIS REPORT NEEDED? The tree canopy study is part two of an identified three-step process to develop a Master Urban Forest Plan. The first step was the completion of the Urban Forest Sustainability and Management Review, completed in 2017.

WHAT WILL BE DONE WITH THE INFORMATION IN THE REPORT? This canopy study identifies the change in tree canopy coverage over the entire city of Asheville during a 10-year period (2008-2018). This information will inform the development of the Master Urban Forest Plan. This plan will be designed to identify trends in canopy coverage and help in the development of strategies to strengthen Asheville's climate resiliency. This coincides with City Council's stated strategic priorities of a clean and healthy environment.

COST OF STUDY: $30,000

FUNDING SOURCE: The project was funded through general funds in PW operations.

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The Public Works Department wishes to thank the Asheville City Council for funding this research and the Asheville Tree Commission for their support with the project.

Introduction

The City of Asheville is the located in western, central North Carolina and is the county seat of Buncombe County. In the last thirty years, the population of Asheville has grown 50% to over 92,000 current residents. The median age of the population is 39 years old and the median annual family income is $44,000. The largest employers are the Mission Health System, Buncombe County Schools, Ingles Markets, and The Biltmore Company. Asheville is located 130 miles northwest of Charlotte, 200 miles northeast of Atlanta, 300 miles east of Nashville and 470 miles southwest of Washington D.C.

Thousands of years before it was known as Asheville, the confluence of the Swannanoa and French Broad rivers was home to ancient native Americans; local archaeological discoveries have carbon dated artifacts to early 8,000 B.C. Early colonial missionaries reported the area as home to the Cherokee people. The area was colonized by Europeans in the early 1780's and was given the name Morristown. In 1797, Morristown was renamed in honor of the sitting Governor Samuel Ashe, a Revolutionary War veteran and the 9th governor of North Carolina serving from 1795 to 1798. In the 1880s the expansion of the railroad into Asheville created a steady increase in population and accompanying industrial revolution. The Great Depression hit the county and city hard, but due to slower economic growth, the central business district of Asheville was spared the removal of significant Art Deco period architecture which many downtowns are lacking today.

Asheville is known as a mountain town situated in the Blue Ridge Mountains. It is classified as *Cfa*, humid subtropical climate in the Koppen classification system. Summers are mild with average high temperatures in the mid-70s and average winter temperatures in the mid-30s. Snowfall is generally less than ten inches per winter season, with ice storms being the largest weather concern during the year. The Blue Ridge Mountains are part of the world's most biologically diverse deciduous forest ecoregion due to the geologic stability of the Appalachian range, untouched by glacial advances. Pines, oaks, hickories, maples, birches, cedars, hemlocks, spruces and firs abound in the region. Trees are of paramount importance to Asheville as the forested mountains surrounding the city create a serene sense of place.

Urban Tree Canopy and Geographic Information Systems

As communities focus more attention on environmental sustainability, it is increasingly important that they understand the vital role that tree play in helping to achieve their goals. Geographic Information Systems (GIS) have become an important tool for urban forest managers to understand and communicate the value and benefits that urban trees provide to the community. Utilizing GIS to map tree canopy, conduct analyses and understand the extent and location of tree canopy is key to identifying ways that trees and urban forest management activities can help meet community sustainability and resiliency goals. These can include:

- Development of planting plans focused on equitable distribution of tree canopy and associated benefits
- Stormwater management
- Water resource and quality management
- Impact and management of invasive species based on tree condition
- Preservation of environmental benefits and sustainability
- Outreach and education

The City of Asheville has partnered with Davey Resource Group, Inc (DRG) to conduct an UTC assessment to better understand the city's urban tree canopy, establish baseline data on the extent of the urban forest, analyze canopy change over time, and quantity benefits. A UTC assessment takes a birds-eye view of the city to measure the layer of leaves, branches and stems that cover the ground. It provides a baseline of information on the current urban tree canopy that the City of Asheville can use to monitor and measure canopy change, and guide management and tree planting efforts to achieve sustainability and resiliency goals. The data from this assessment will be provided to the city to add to their GIS system.

The UTC assessment utilized high-resolution aerial imagery and infrared technology to remotely map all tree canopy and land cover (Figure 3) within the borders of the City of Asheville. The assessment included the measurement of other landcover classifications, including impervious surfaces, pervious surfaces, bare soils, and water to better understand the tree canopy and its relationship within the community.

The results of the study provides a clear picture of the extent and distribution of Asheville's tree canopy. Incorporating the data from the UTC assessment into the city's GIS database will provide a foundation for developing community goals and urban forest policies, and can be used to determine:

- The location and extent of canopy over time
- The location of available planting space (potential planting area)
- The best strategies to increase canopy in underserved areas

The data, combined with existing and emerging urban forestry research and applications, can provide additional guidance for determining a balance between growth and preservation and aid in identifying and assessing urban forestry opportunities

Analysis Purpose

The UTC assessement establishes tree canopy baseline information, quantifies the current contributions of urban trees, and examines canopy gains and losses between 2008 and 2018. The intent of the analysis is to provide Asheville with valuable data that will support efforts in developing community goals, prioritizing tree planting, establishing trees as important asset in the city's infrastructure system, and developing data-backed strategies and plans for Asheville's current and future urban forest. Asheville is encouraged to refer to these results, utilize the data for additional analyses, and continue to seek new tools and information to measure progress, report accomplishments, and inform management decisions.

This study is the first step in developing and supporting Asheville's urban forestry program. The UTC data and maps, along with management tools, such as tree inventories, management plans, and master plans, are important components in developing a sustainable and resilient urban forest. Figure 1 describes the continuum of an urban forestry programs. Asheville's UTC study can be thought of as precursor to an urban forest master plan (UFMP) but is not the same as a tree inventory. A tree inventory is an in field assessment of individual city trees growing along streets and in city park. While a UTC study is an overview of all the trees within the city limits, both public and private trees are evaluated from an aerial perspective

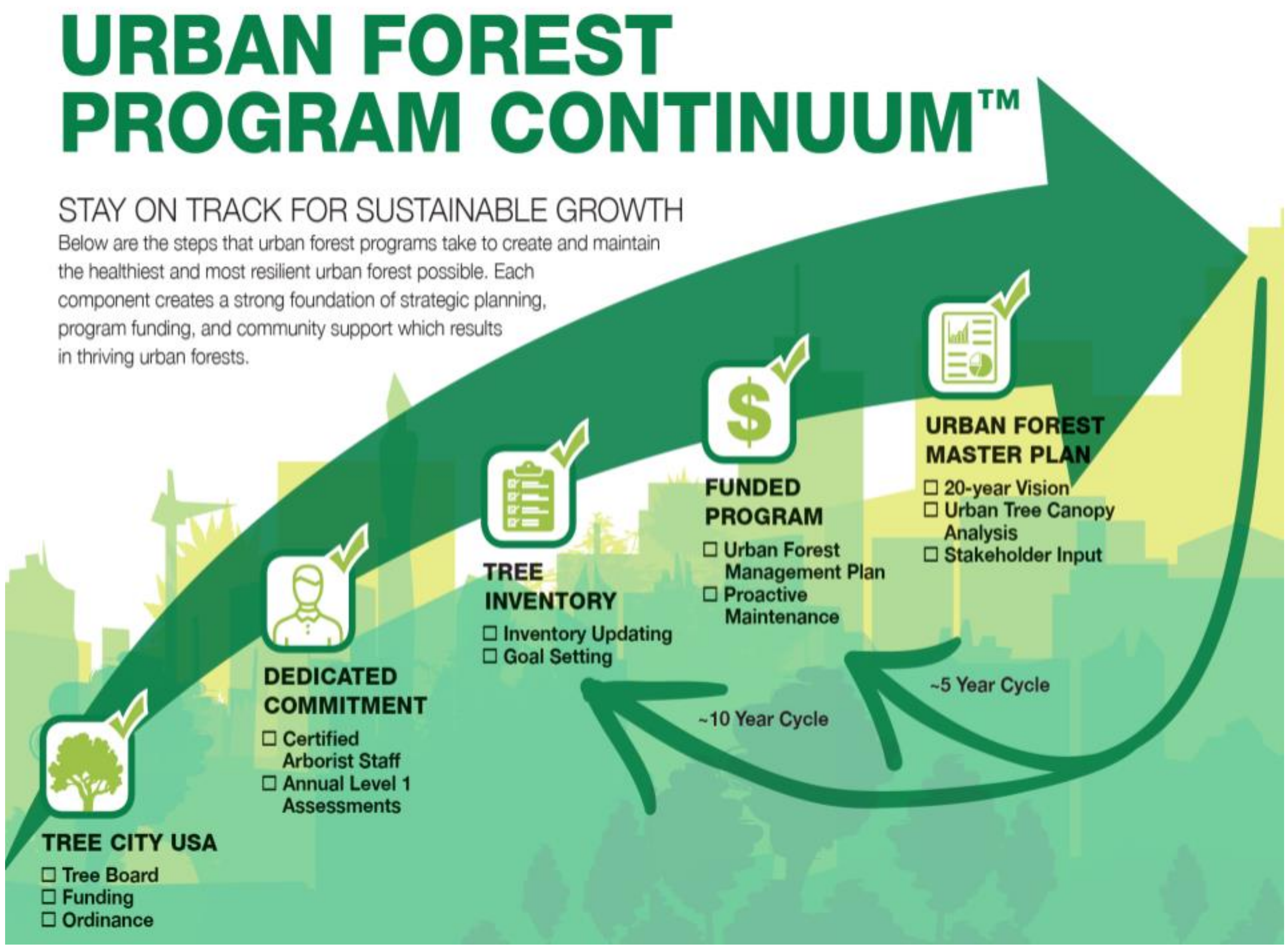


Figure 1: The Urban Forestry Program Continuum: A Guideline for a Successful Urban Forestry Program

Process and Methods

The City of Asheville's UTC analysis was conducted by Davey Resource Group, Inc. (DRG) using a well-established GIS-based process that utilized a variety of data, tools, and analytical methodologies from various sources, including United States Department of Agriculture aerial imagery, i-Tree Tools, census data, remote sensing technology, locally supplied data, scientific studies, and previous canopy analyses. These sources will be briefly mentioned or referenced throughout the remainder of this report.

To begin the analysis a land cover extraction was completed using the 2018 60-cm National Agriculture Imagery Program (NAIP) photography. The canopy data from the land cover extraction were analyzed using i-Tree models to generate an estimate of ecosystem benefits provided by the existing tree canopy. The data was used to develop recommendations to achieve Asheville's goals of using trees to mitigate stormwater, reduce the urban heat island, and improve air quality. As an added level of comparison, an i-Tree Canopy assessment, which closely reflected the results of the land cover extraction, was completed.

Accuracy Standards

DRG manually edits and conducts thorough quality assurance and quality control (QA/QC) checks on all UTC and land cover layers. A QA/QC process is completed using ArcGIS to identify, clean, and correct any misclassification or topology errors in the final land cover dataset. DRG edits the initial land cover extractions in urban and rural areas at a 1:2,000 quality control scale, and woodland/forested areas at a 1:5,000 scale. The project will attain a minimum of 95% user's accuracy for UTC and impervious classes and an overall accuracy of greater than or equal to 94% using a minimum mapping unit of 9 square miles.

Asheville Urban Tree Canopy Findings

The City of Asheville's 2018 city-wide urban tree canopy is 44.5%, which is comparable to other cities in the eastern United States. Table 1 are referenced municipalities with similar demographics, longitude, and size. However, the analysis found that Asheville's tree canopy is declining with a 6.4% loss in tree canopy from 2008 to 2018. There can be many reasons for canopy loss. Every municipality will have identity specific reason for canopy gains or losses. Typically, the main concern is continued growth and land development standards.

To understand the tree canopy distribution across the city and the factors that drive changes in canopy Asheville's aerial images were segmented and examined to identify tree canopy trends:

- city-wide
- by neighborhood
- by census block
- by parcel

Municipality	Tree Canopy (%)
Charlotte, NC	47%
Gainesville, FL	47%
Cookeville, TN	40%
Concord, NH	40%
Winston-Salem, NC	47%
Cambridge, MA	30%
Pittsburgh, PA	40%

Table 1. Comparison of Tree Canopy of Eastern Cities

This report provides an analysis of some of the general findings and trends of Asheville's UTC assessment. However, these data can be examined and analyzed in a multitude of different and more specific ways. Asheville is encouraged to further explore these data as new ideas, interests, or priorities arise. Simply, this study represents only a subset of a vast array of information and findings that can be gleaned from the further analyses of the data generated by this assessment.

Tree Canopy by City Limits 2008 and 2018

Asheville is 29,274 acres overall, in 2008, tree canopy covered 13,912 acres, and in 2018 it covered 13,021 acres. The city lost 891 acres of tree canopy cover, or 6.4% over the ten-year period.

Figure 2 combines the 2008 and 2018 canopy maps to identify the areas of the city where tree canopy was lost, gained or remained the same over the 10-year period. The southwest area of the city saw the greatest canopy loss, especially west of the French Broad River and I-26. Figure 3 is a canopy change shown as percentage of per parcel acreage (2008-2018).

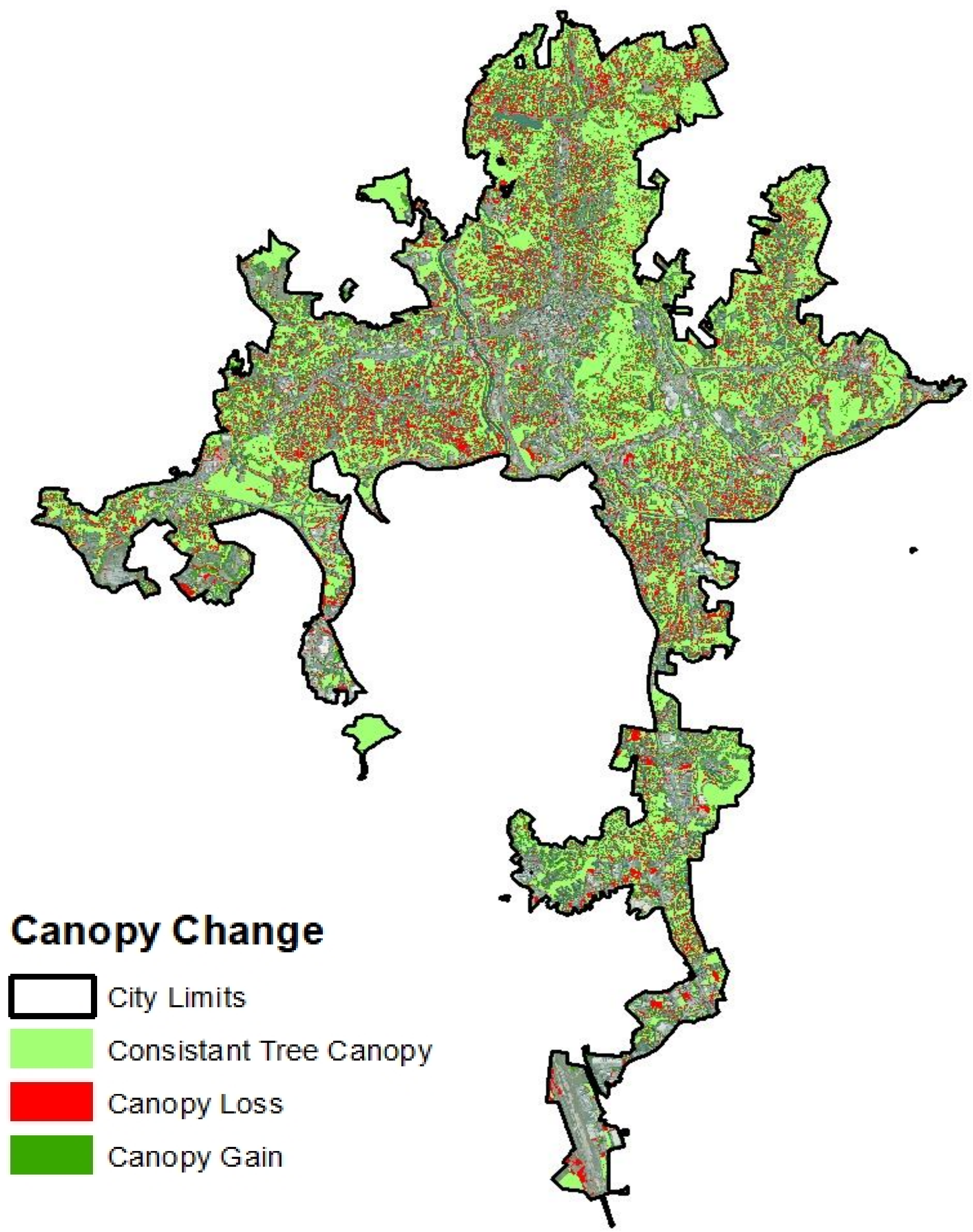


Figure 2. Asheville Tree Canopy Loss or Gain from 2008 to 2018.

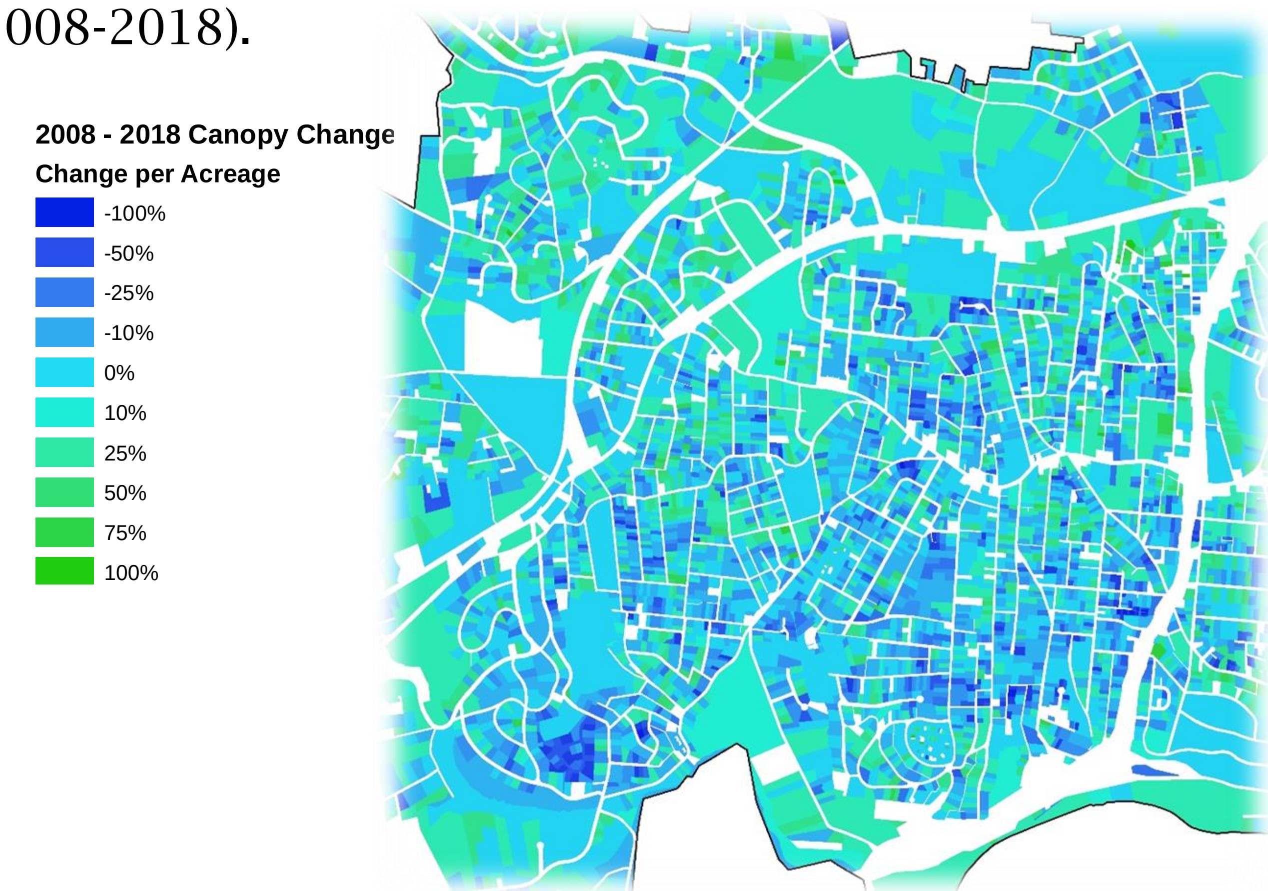


Figure 3. Parcel view inset of changes in canopy per percentage gain or loss 2008-2018.

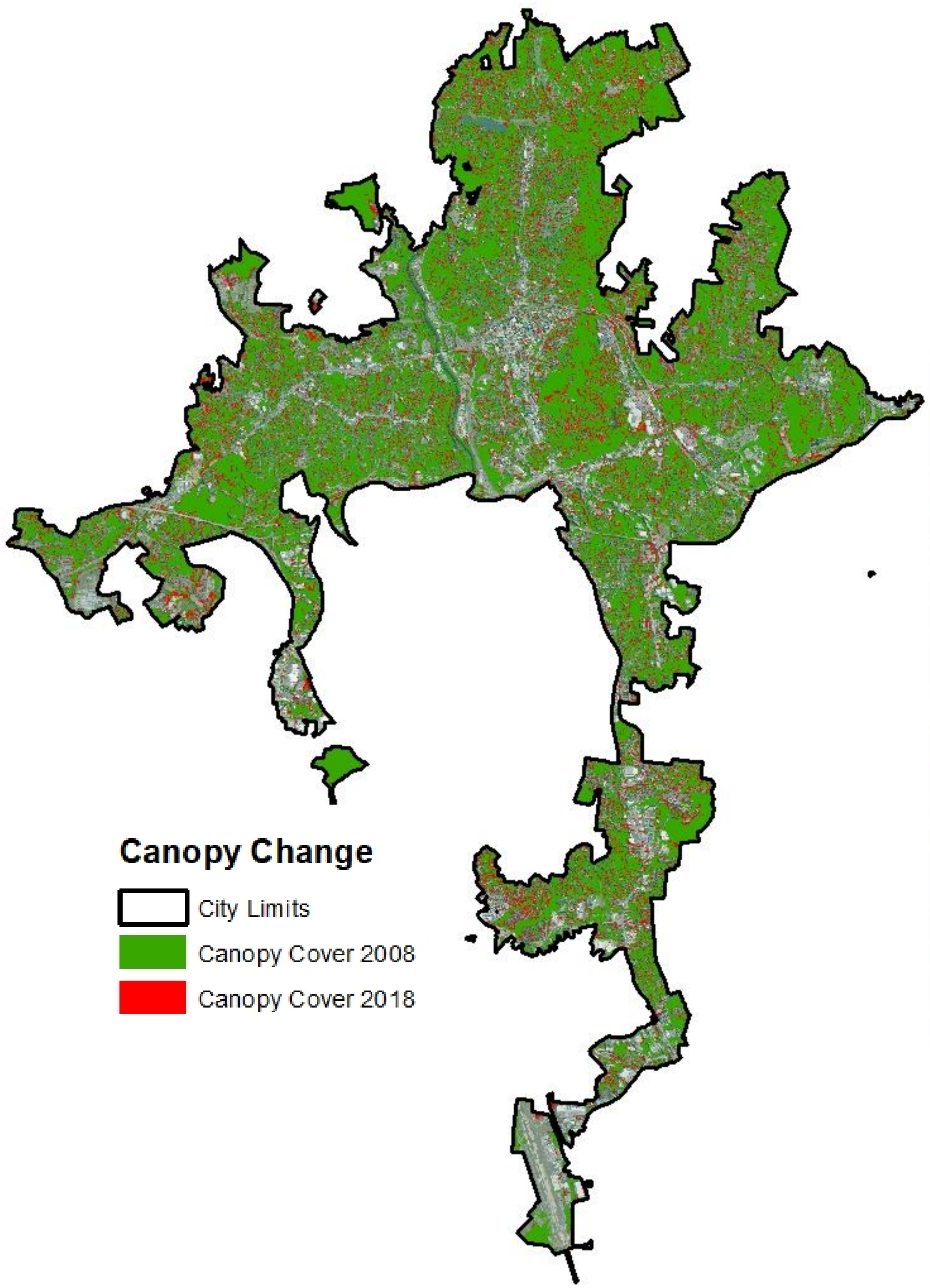


Figure 4. 2008-2018 Asheville Tree Canopy Changes for City Limits

Figure 4 combines the canopy cover data from 2008 and 2018 for the entire city. Figure 4 provides a closer view of central Asheville. In both maps, the 2008 canopy is shown underneath the 2018 canopy. Areas of loss from those ten years can be observed as the lower layer (2008) will show in their respective color.

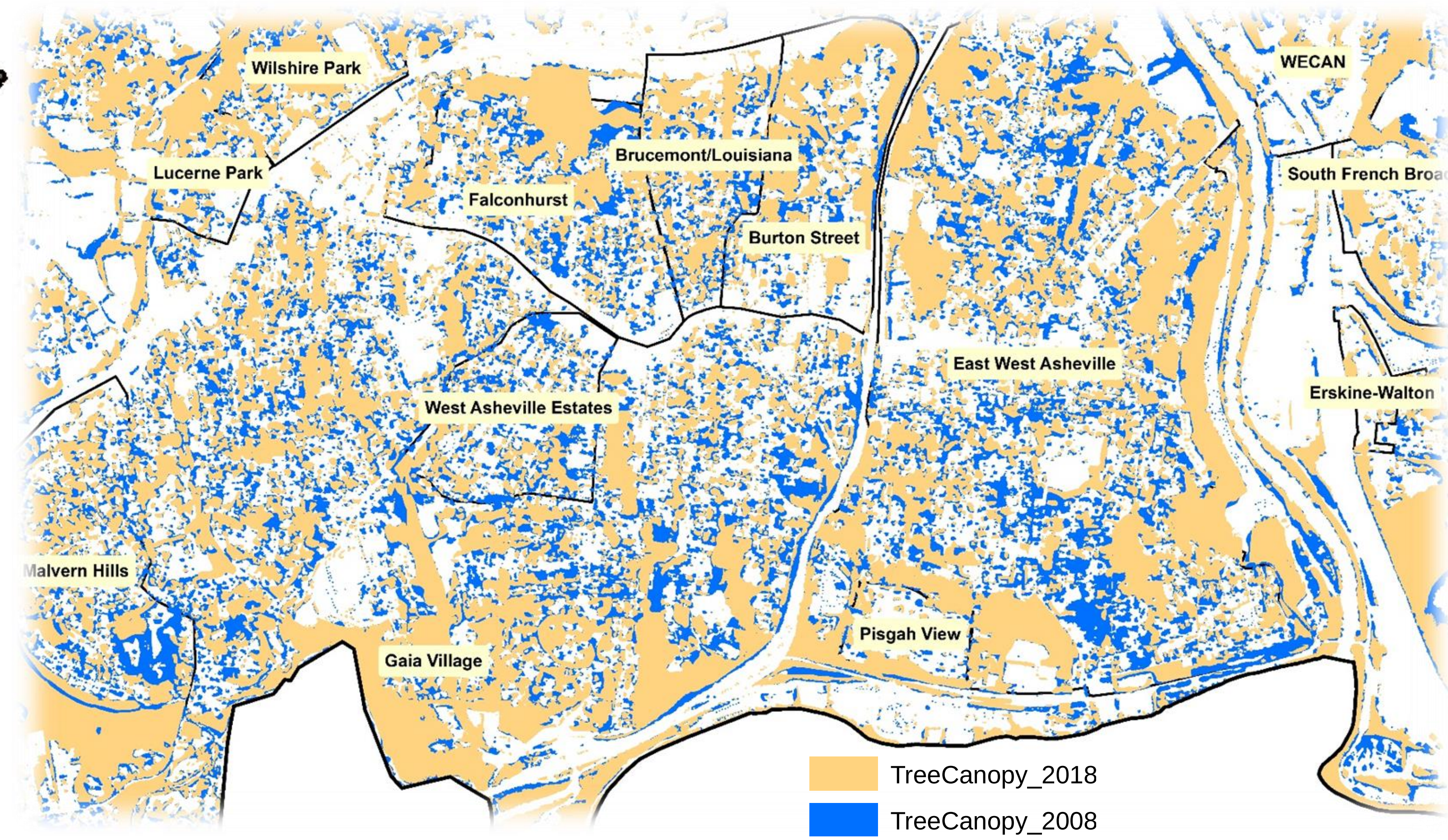


Figure 5. Closeup of Asheville Tree Canopy Layers from 2008 and 2018.

Figure 6 highlights the areas of the city where canopy cover remained the same between 2008 to 2018. The overall change in canopy from 2008 to 2018 was a loss of 6.4%. Figure 7 is an inset of central Asheville depicting any loss or gain per parcel. Losses are those areas with negative change, gains are greater than 0% canopy change. This is a per parcel change map, identifying which parcels are gaining or losing tree canopy.

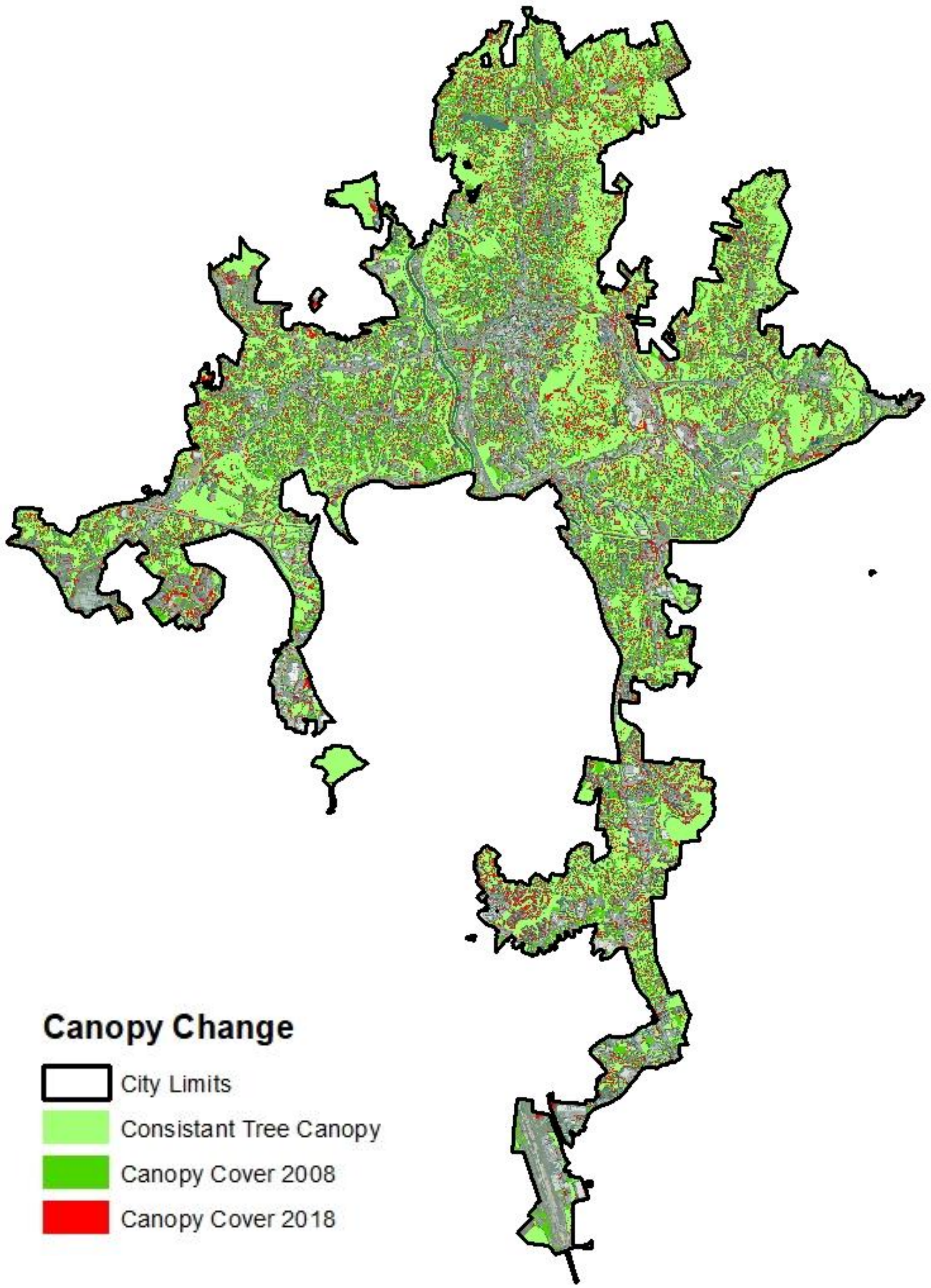


Figure 6. Asheville Tree Canopy Consistency between 2008-2018.

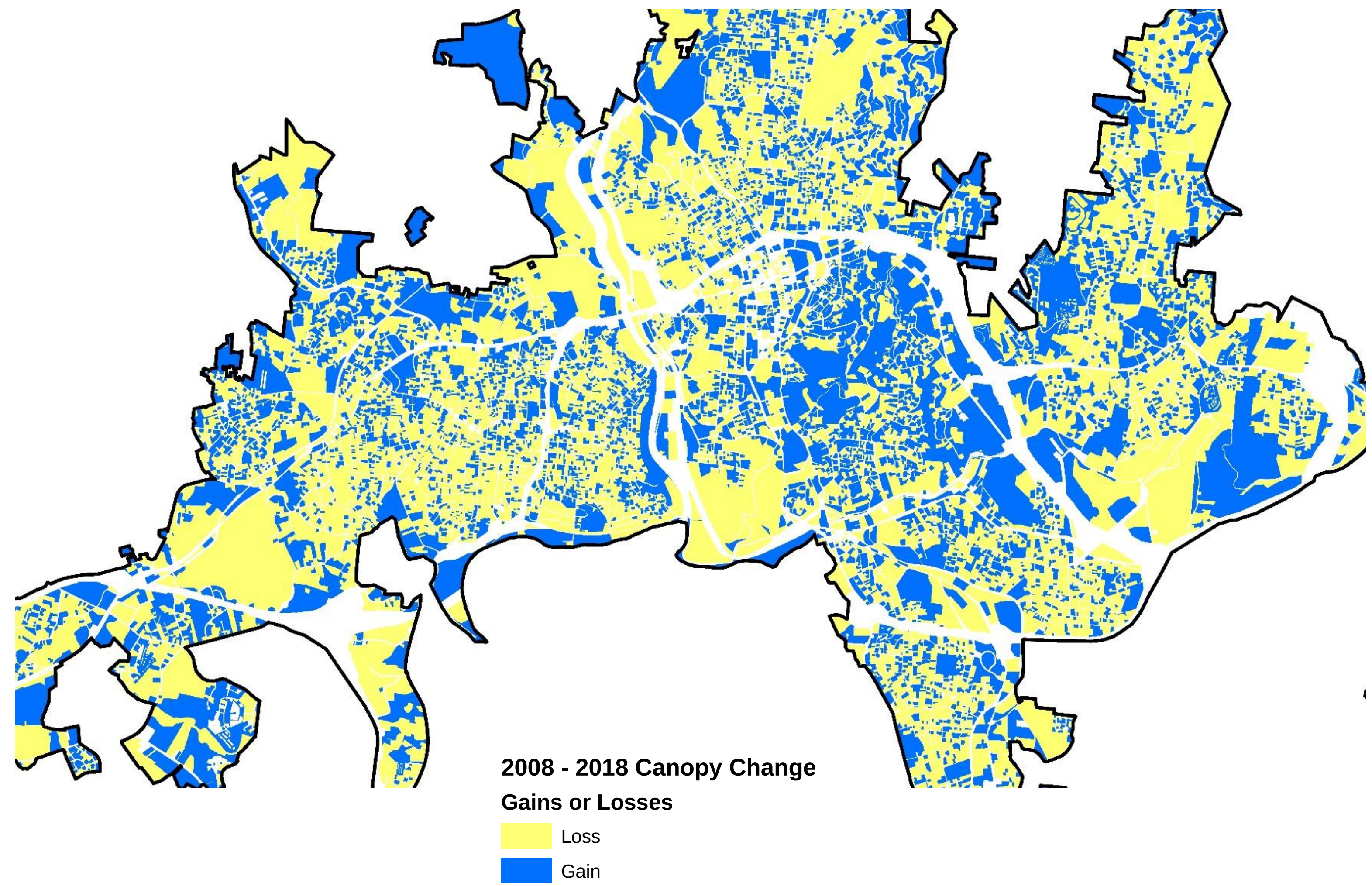
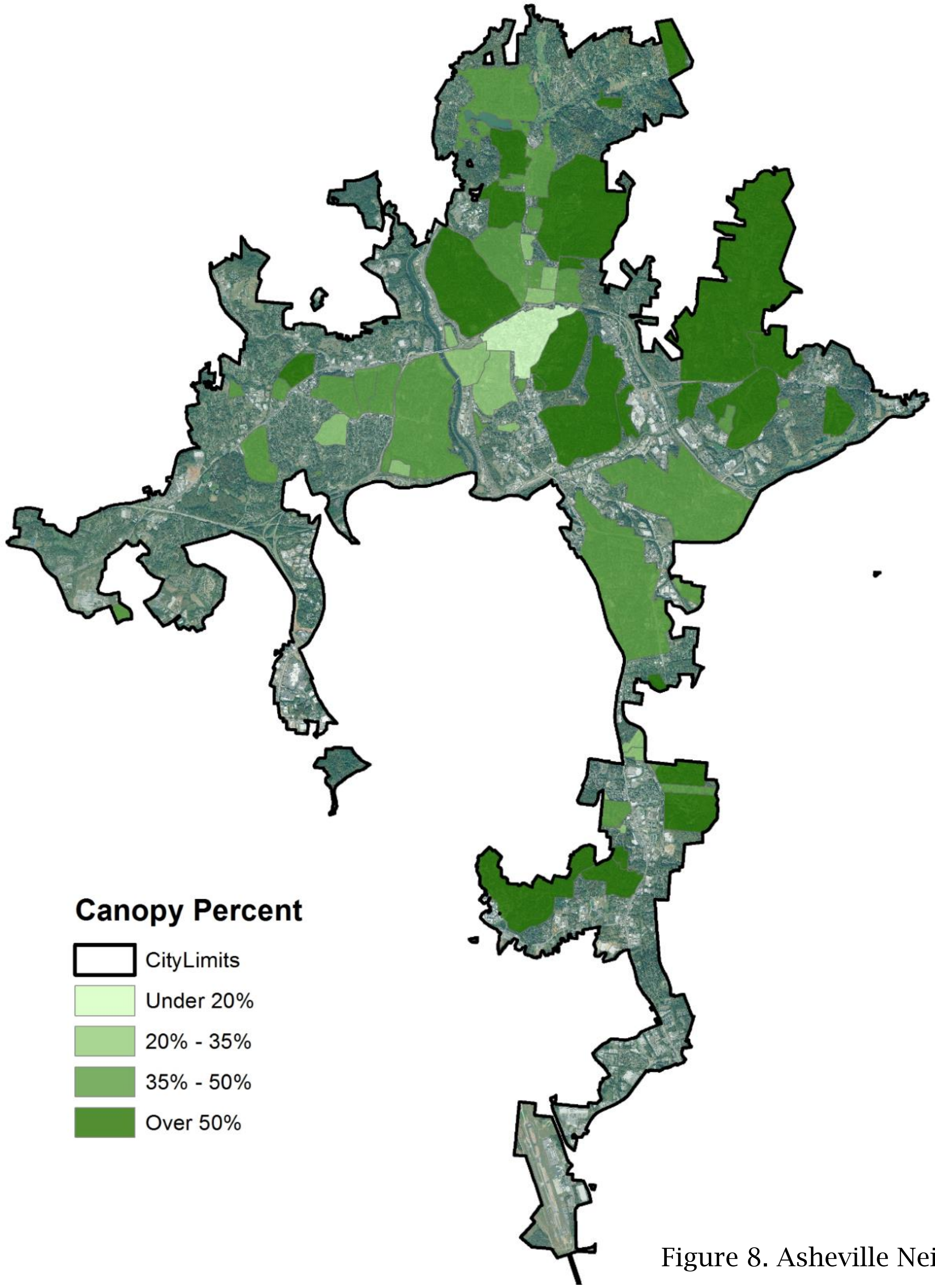


Figure 7. Inset of 2008-2018 Tree Canopy Loss or Gain per Parcel

Tree Canopy by Neighborhood



Tree canopy coverage by neighborhood is shown in Figure 8. Neighborhoods in the eastern areas of the city have higher tree canopy cover than other areas. The age and scale of neighborhoods can play a considerable role in the amount of canopy present. For example, older and smaller neighborhoods may have narrow rights of way and lot lines, leading to higher density and less space for larger tree species.

Figure 8. Asheville Neighborhood Tree Canopy by Percent Cover in 2018.

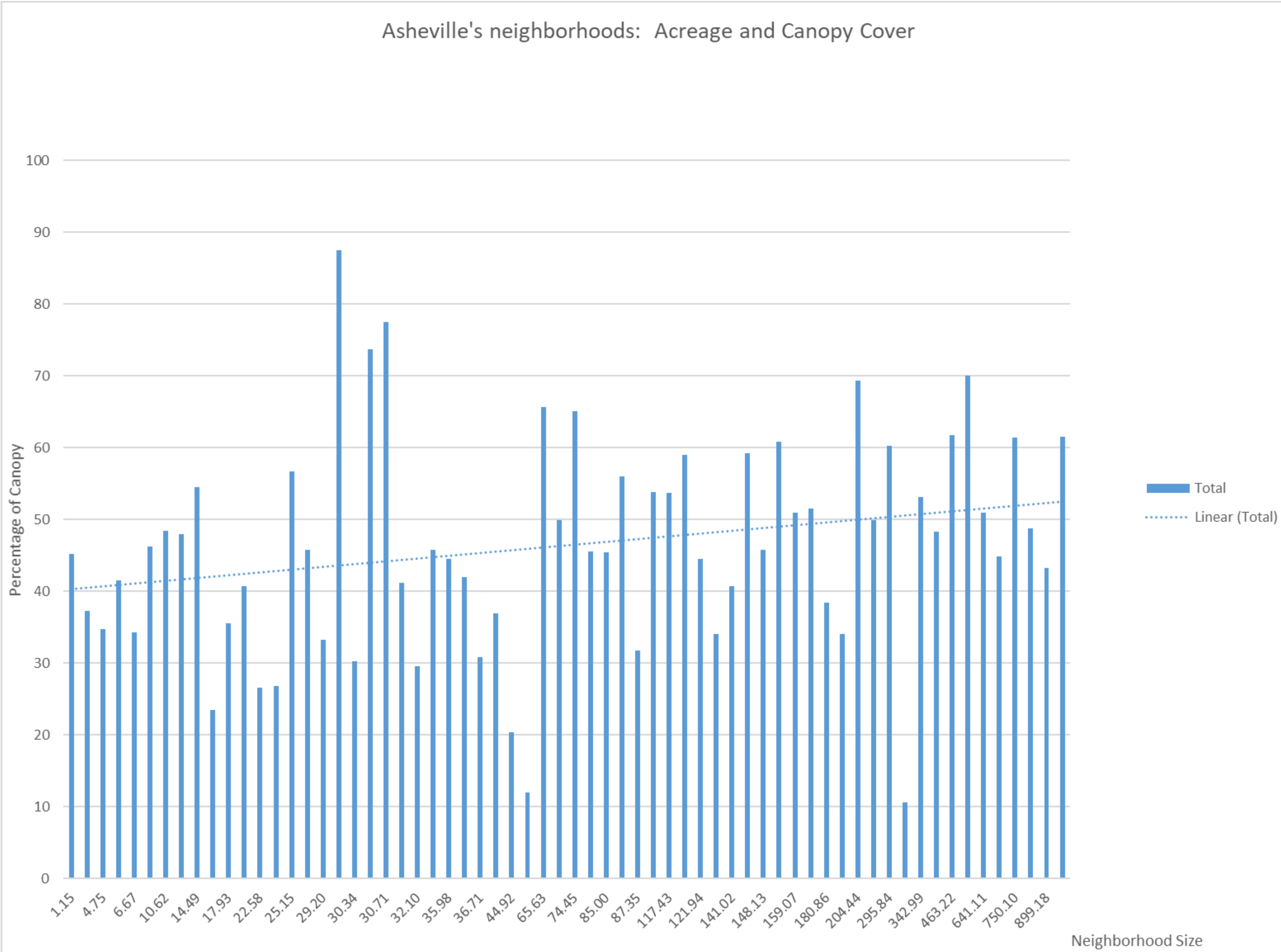


Figure 9. Asheville Neighborhood Tree Canopy Percentages by Neighborhood Acreages

In Figure 9 the graph illustrates the percent canopy cover (2018) for each Asheville neighborhood organized from smallest to largest by acreage. The trend line (dashed horizontal line) shows the majority of neighborhoods are in the 40 to 50 percent canopy cover range. Outliers in the data are instances of dense development or segments of neighborhoods within larger areas of existing tree canopy. Further study can be performed to evaluate site conditions or land regulations which gain or lose tree canopy within residential developments.

Figure 10 provides the percent of tree canopy change by neighborhood from 2008 to 2018 based upon acreage. The City should focus efforts on understanding the causes of canopy loss, especially in areas with significant decreases (greater than 10%). Understanding the causes can help ensure that the downward trend in canopy cover does not continue and can also highlight areas where tree planting and preservation efforts are most needed.

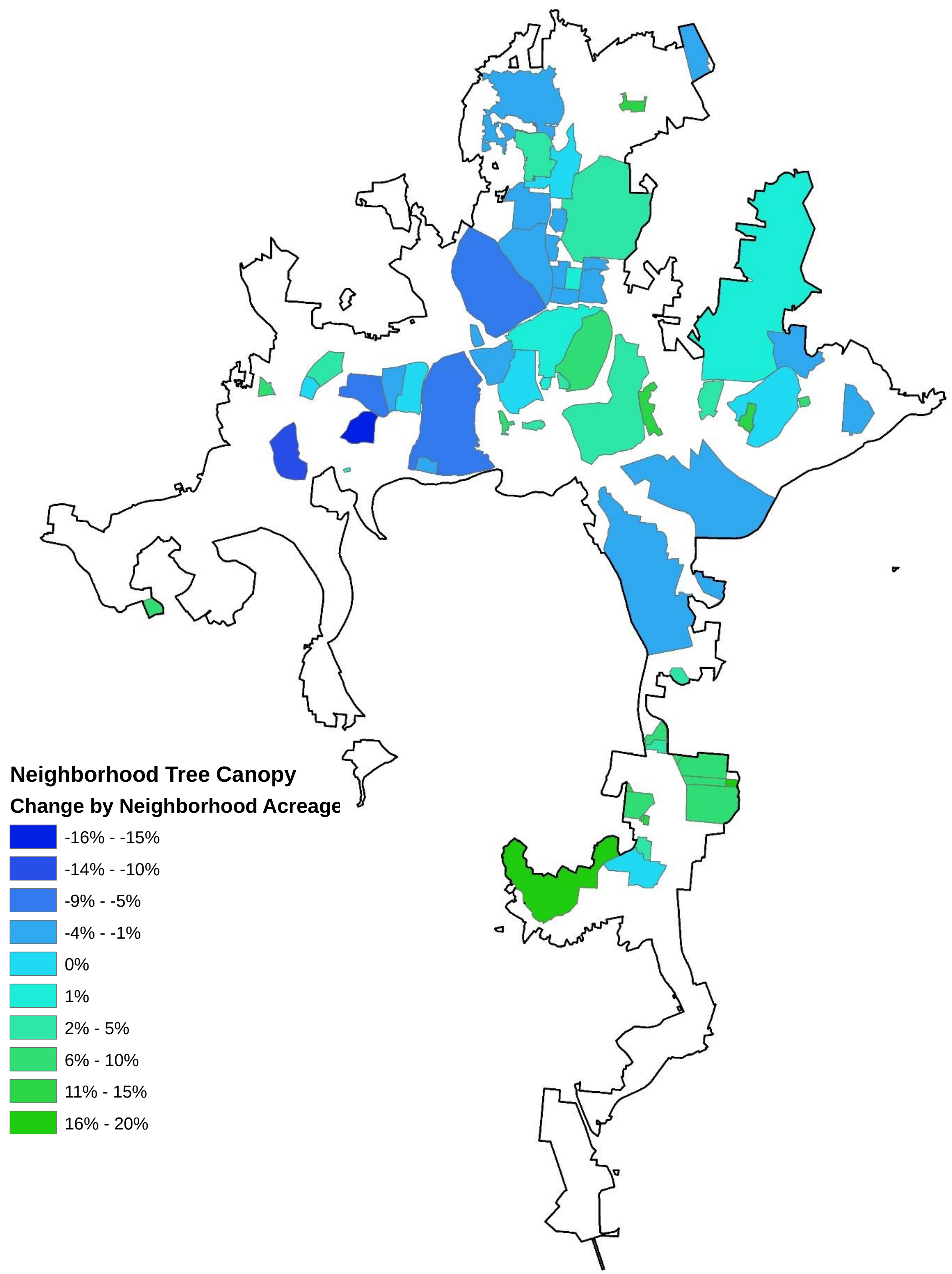


Figure 10. Asheville Tree Canopy Percent Change by Neighborhood Acreage

Figure 11 provides a detailed view of the percent change (loss/gain) in tree canopy cover from 2008 to 2018 in central neighborhoods in Asheville. Generally, neighborhoods to the east showed gains in tree canopy cover, while neighborhoods to the west showed losses. These losses may be attributable to increased development in these neighborhoods. Gains could be natural growth, combined with newer development with stronger tree planting requirements. This study provides a foundation for other research into where tree canopy can be increased to counteract the losses.

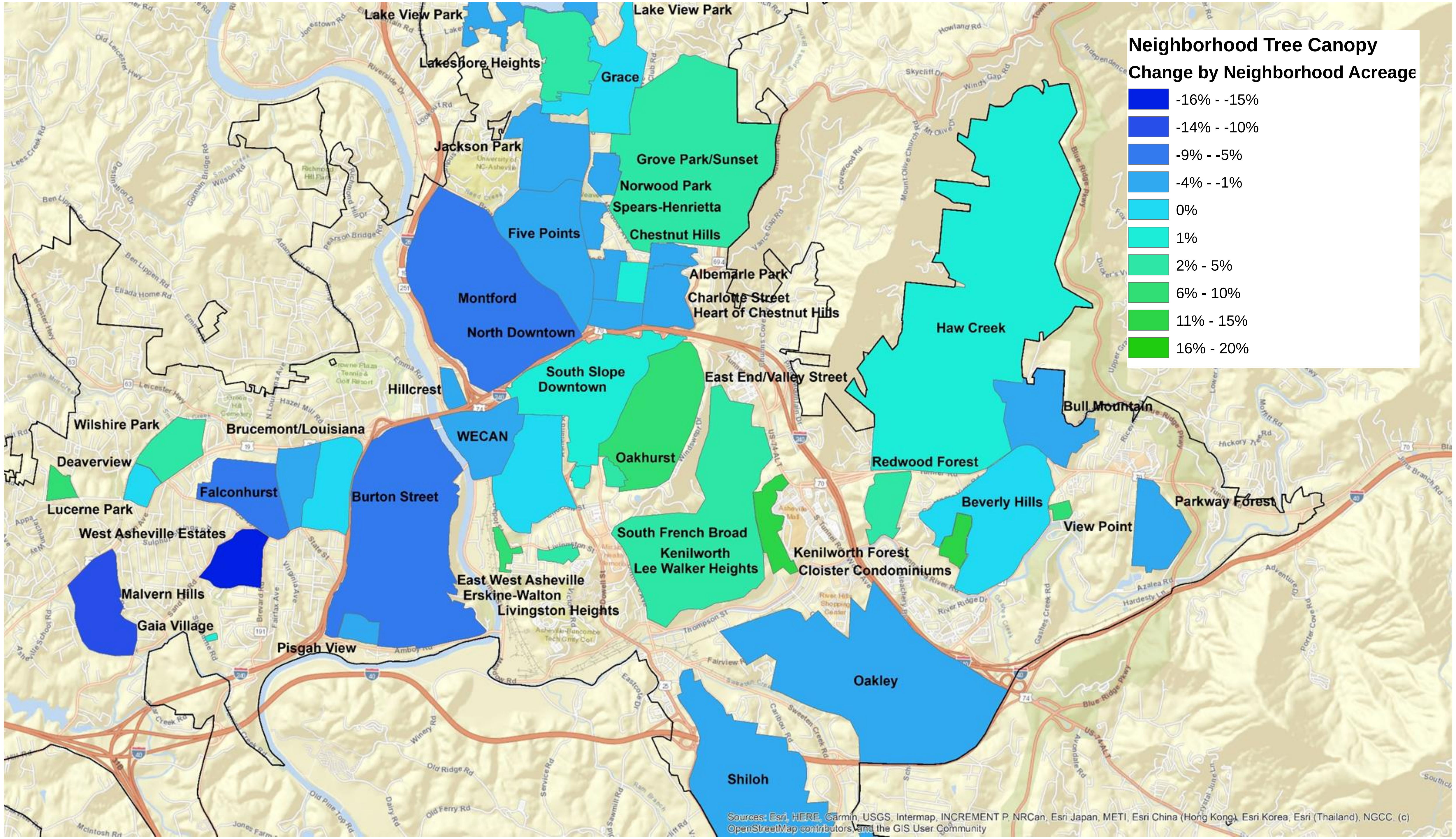


Figure 11. 2008-2018 Inset Image of Asheville Tree Canopy Change by Neighborhood.

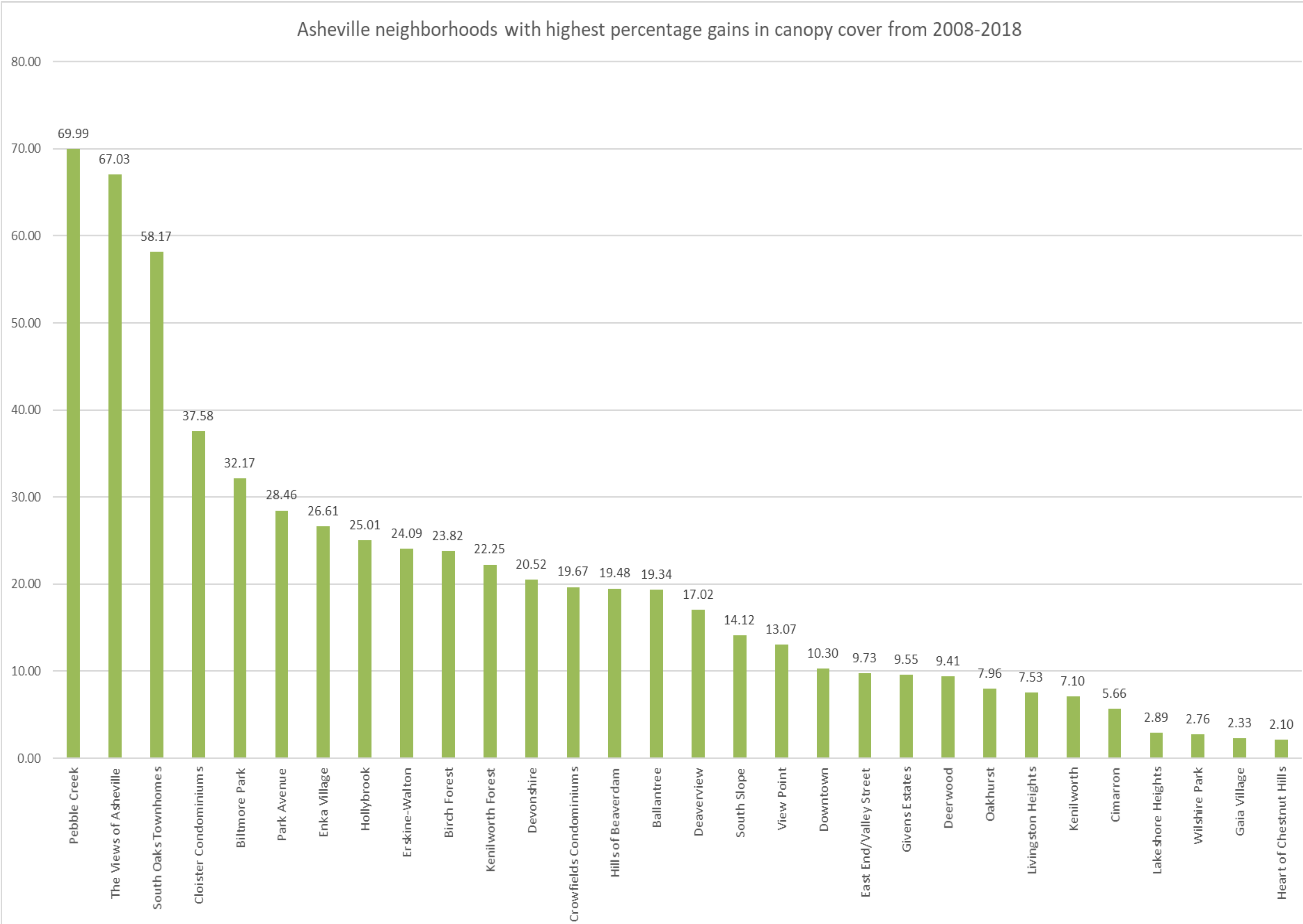


Figure 12. Chart of Asheville Neighborhoods Gaining Tree Canopy from 2008 to 2018.

Neighborhoods with the largest gains in tree canopy between the 2008 and 2018 imagery are shown in Figure 12. Further study can be accomplished by asking questions about these neighborhoods through the lens of tree canopy. Viewing population density or zoning requirements for these neighborhoods can reveal maximum achievable canopy coverages.

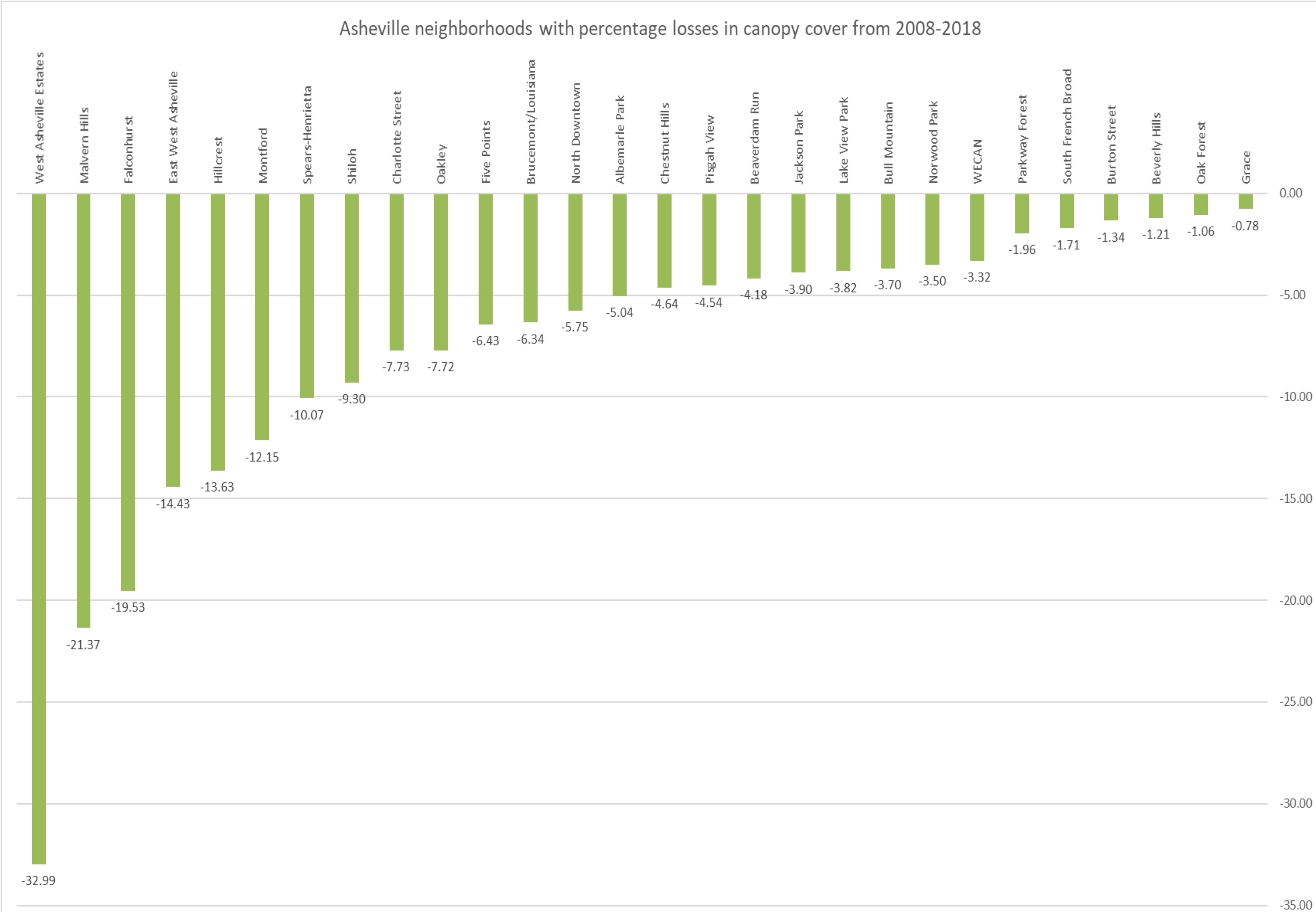


Figure 13. Chart of Asheville Neighborhoods Losing Tree Canopy from 2008 to 2018

Figure 13 shows the Asheville neighborhoods with the largest losses in tree canopy from 2008 to 2018. Similar to Figure 12, review of the land development regulations or zoning requirements for these neighborhoods should provide insight into why the tree canopy has lost coverage. As phases of a development are completed over time, the tree canopy will inherently decrease from a 100% wooded parcel to the final developed sites with improvements. Focused land development regulations which review finished landscaping requirements for tree density is a way to counteract the tree loss.

Tree Canopy by Census Tract

Analyzing tree canopy based on census data is another method of identifying canopy trends and needs within the community. Figure 14 is Asheville's tree canopy coverage change percentage by census block from 2008 to 2018. Figure 15 maps census tracts in relation to percentage of population living below the poverty level for income. Figures 13 and 14 show that census areas with the highest percentage of population below the poverty level also have higher percentages of canopy loss. Further studies into these and other demographic trends can help prioritize tree planting.

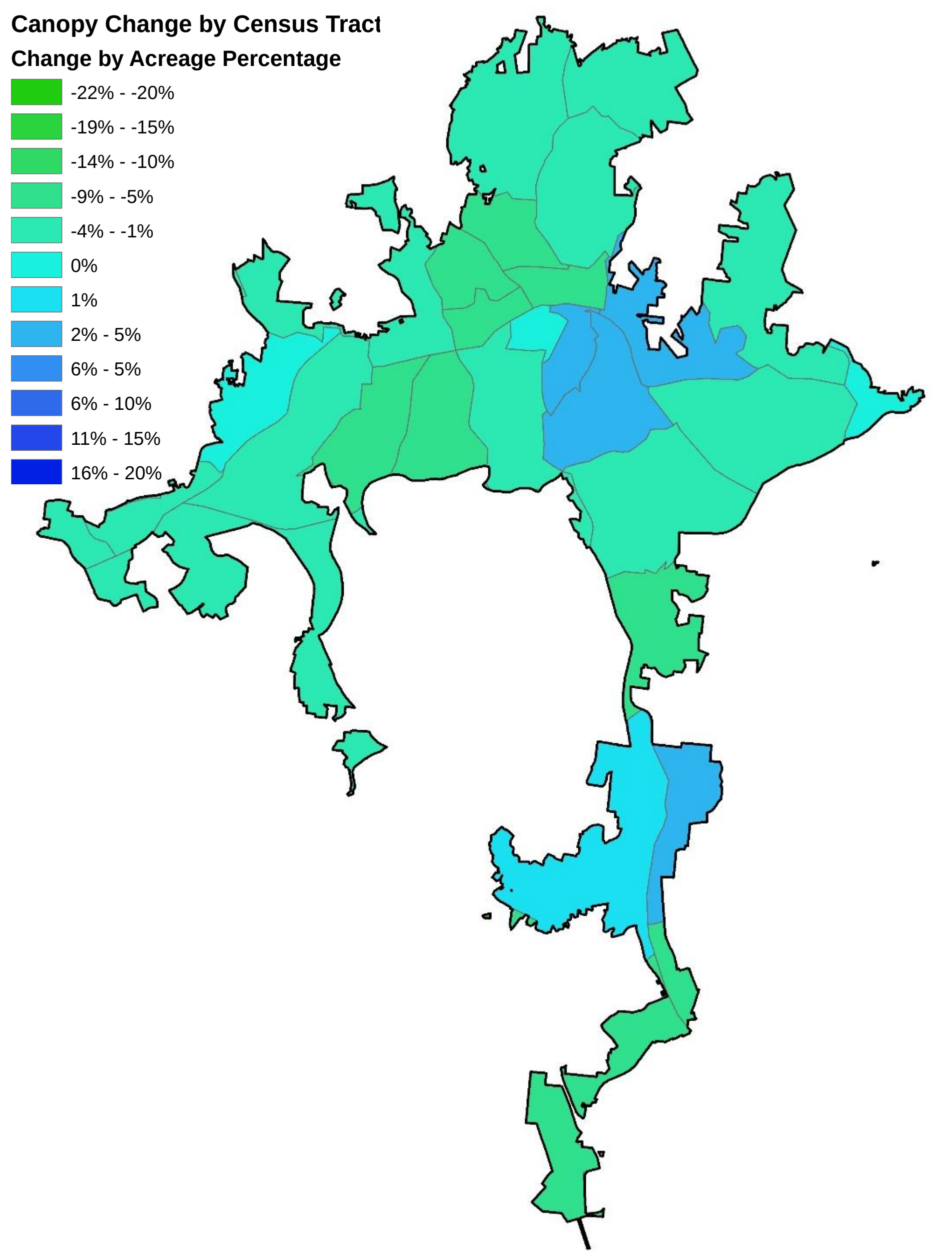


Figure 14. Asheville Tree Canopy Change per Census Tract from 2008 to 2018

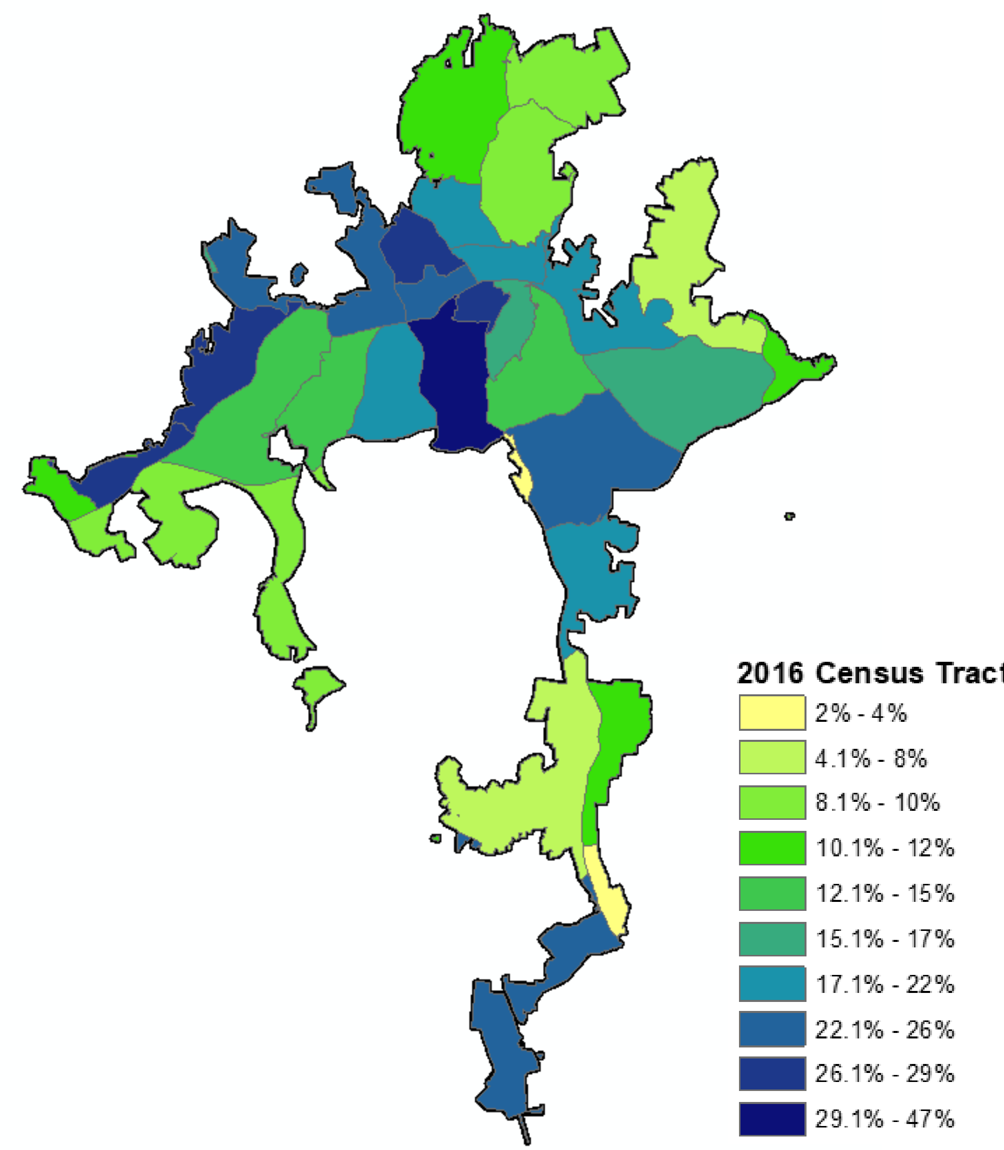


Figure 15. Asheville Percentage of Population Living below the Poverty Level

Tree Canopy by Parcel

Figure 16 illustrates loss of tree canopy from 2008 to 2018 by individual parcel. Figure 17 provides property value by individual parcel in an area of Asheville, areas in white did not have an improvement value listed with the parcel. An analysis of these maps shows that lower valued properties appear to have lost significant canopy coverage between 2008 and 2018. Understanding the relationship between canopy loss and other socio-economic factors can assist Asheville in targeting tree preservation and planting initiatives to areas of the city most in need of canopy cover and the benefits it provides.

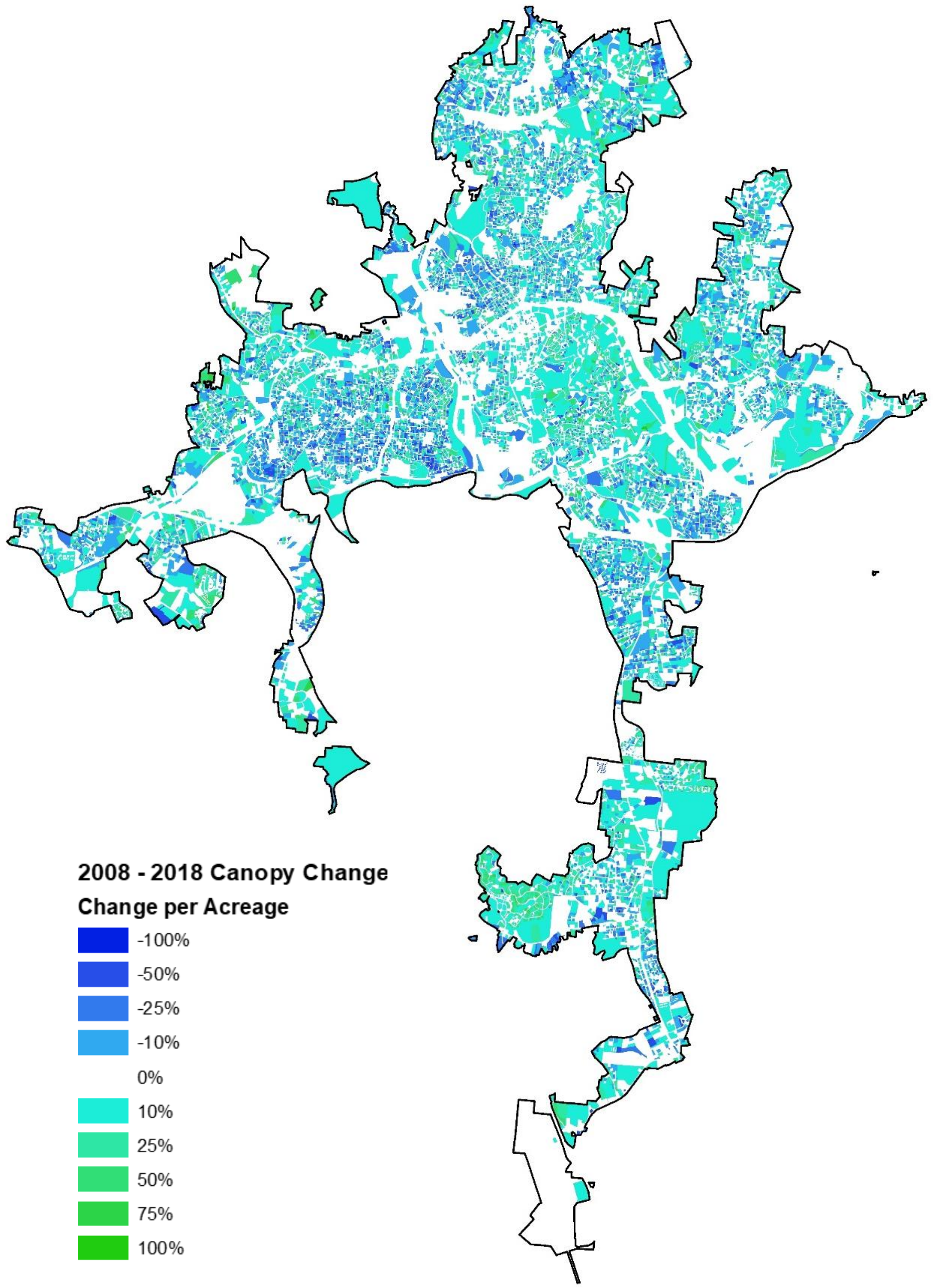


Figure 16. Asheville Overall Change in Percentage of Tree Canopy by Parcel from 2008-2018

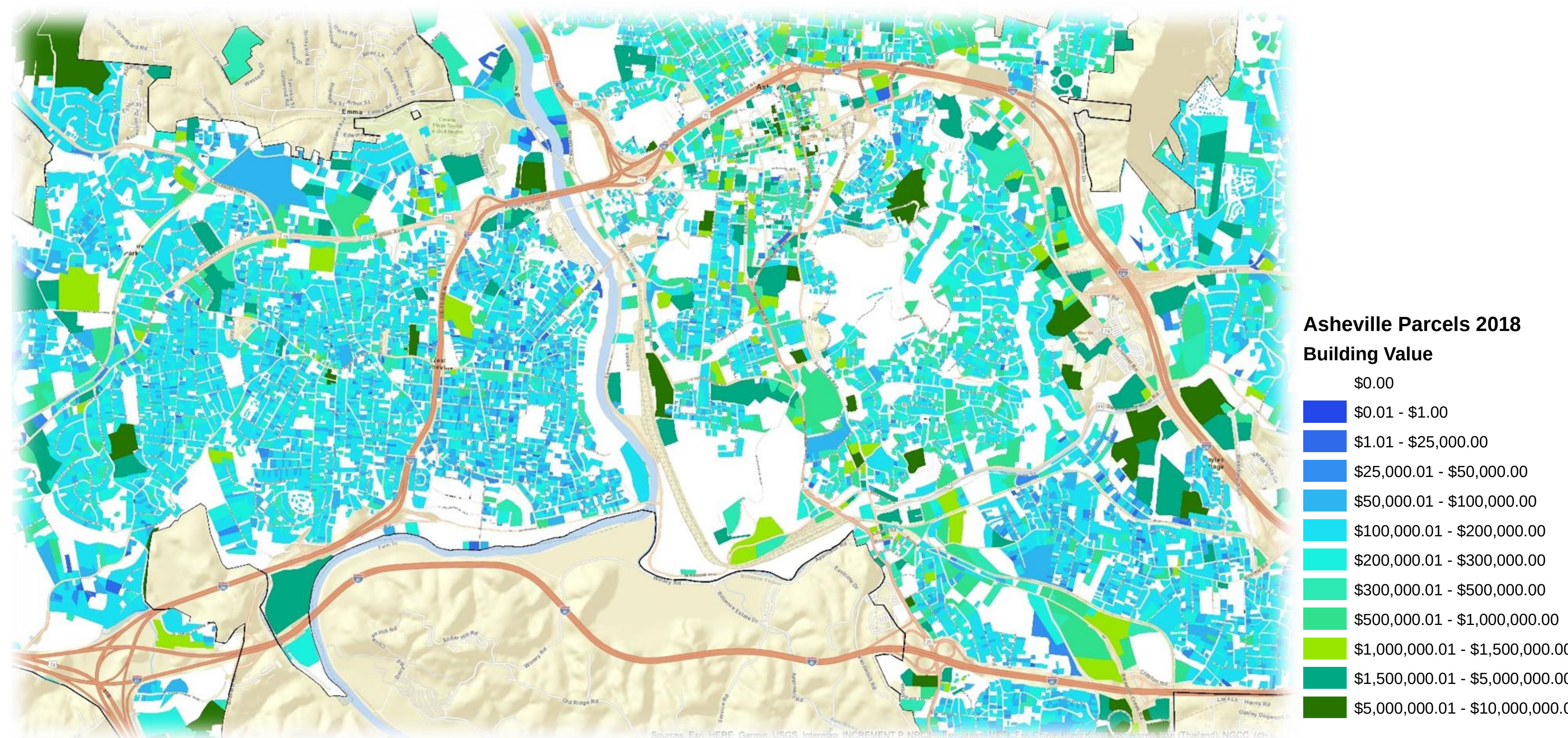


Figure 17. Inset of Improvement Value per Parcel in 2018

Figure 17 is an inset of the per parcel canopy level map. A trend in tree canopy loss can be noted in the downtown area over the last ten years. Parcels to the east had modest gains, but scale must be considered in parcel level mappings. One large tree removed from a smaller parcel could result in a larger overall percentage loss rating. Thinking of this scenario in a different light, this is indicative of how important one large canopy tree can be in a densely populated neighborhood.

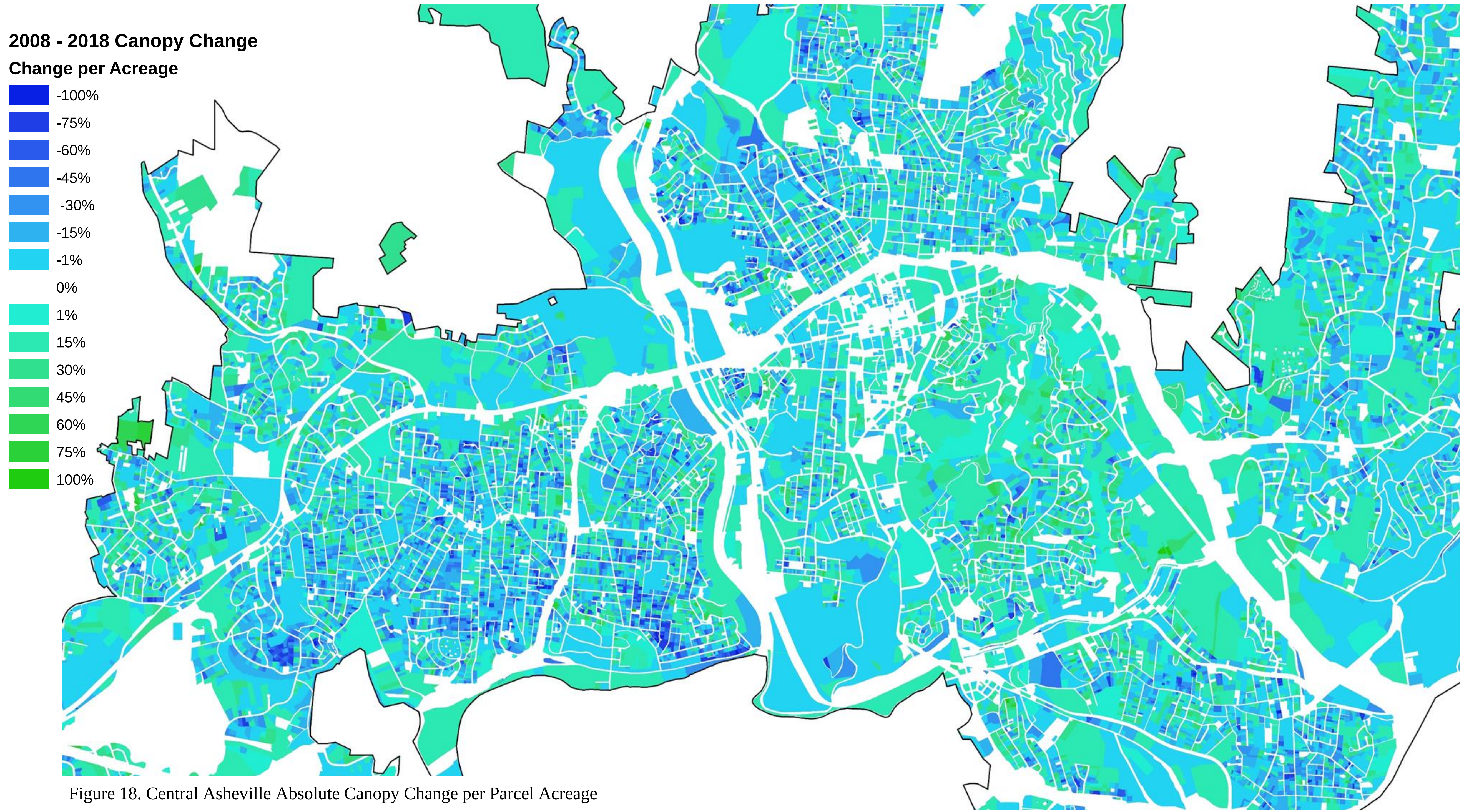


Figure 18. Central Asheville Absolute Canopy Change per Parcel Acreage

i-Tree Landscape Priority Planting

Using i-Tree Landscape, a tool in the USDA Forest Service's i-Tree suite, a priority planting map was created. The Landscape tool evaluated census blocks in Asheville and was created using three equally weighted (33% importance) contrasting parameters. Figure 18 was created from these selected i-Tree settings which are included in i-Tree's existing database using aerial photography and demographic studies:

- Existing Tree Stocking Level
- Tree Cover per Capita
- Population Density

Consistent with the other findings in Asheville's UTC assessment, census blocks that have lost the most tree canopy since 2008 were identified as priority areas for significant tree plantings.

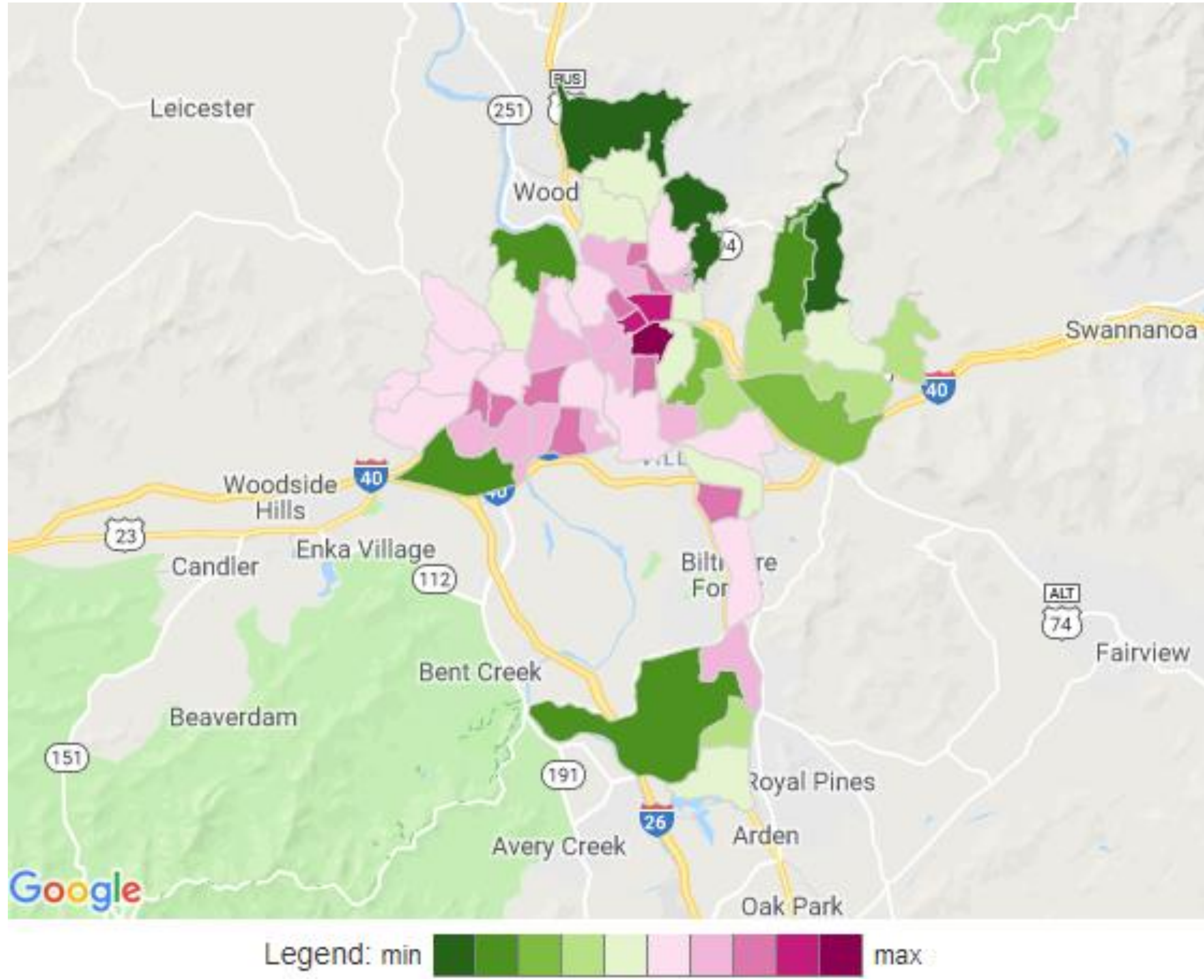


Figure 19. i-Tree Landscape Tool - Priority Planting Map Recommendations per Census Block

Ecosystem Benefits

The USDA Forest Service's i-Tree Tools is a suite of software applications that quantifies the benefits and services, both functional and structural, that trees provide to a community. The functional ecosystem benefits of trees are classified by their ability to provide pollution reduction, while the structural benefits are those which accumulate over the life of the tree.

For functional benefits, pollutants removed by trees from the atmosphere include carbon (C), ozone (O_3), nitrogen dioxide (NO_2), particulate matter up to the tenth of a micron (PM_{10}), and sulfur dioxide (SO_2). During photosynthesis, trees remove carbon dioxide (CO_2) from the atmosphere to form carbohydrates that are used in plant structure/function and return oxygen (O_2) back to the atmosphere as a byproduct. These services are quantifiable within i-Tree through a process that utilizes tree growth algorithms.

Structural values are determined by utilizing comparison-based appraisal methodology of the physical resource - the comparable cost of replacing the specific tree with a similar tree. i-Tree determines these values by utilizing the Council of Tree and Landscape Appraisers equations. Carbon storage is also considered a structural value as it is amassed over the life of the tree, not an annual benefit. In this study, carbon storage and sequestration will be discussed in the same section under functional ecobenefits, although they are separate classes of ecological benefits.

By offering a better understanding of the structure, function, and value of a city's tree resource, i-Tree models provide cities the means to advocate for the necessary resources needed to appropriately manage its trees.

1. How Tree Canopy Benefits Are Calculated:

Tree canopy datasets from 2008 and 2018 were run through the model and then compared as a change analysis.

1.1 Air Quality

The i-Tree Canopy v6.1 Model was used to quantify the value of ecosystem services for air quality. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi 2014).

Within the i-Tree Canopy application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In i-Tree Canopy, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for each of the five listed air pollutants.

1.2 Carbon Storage and Sequestration

The i-Tree Canopy v6.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration can be found in Nowak et al. 2013.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for carbon storage and sequestration.

1.3 Stormwater

The i-Tree Hydro v5.0 Model was used to quantify the value of ecosystem services for stormwater runoff. i-Tree Hydro was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology. This most recent version (v5.0) allows users to report hydrologic data on the city level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the i-Tree Hydro v5.0 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area were included in the project area were used as inputs into the model. Precipitation data from 2005-2012 was modeled within the i-Tree Hydro to best represent the average conditions over an eight-year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alterative Case set tree canopy equal to 0% and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 8.2% based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since i-Tree Hydro does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy. To place a monetary value on storm water reduction, the cost to treat a gallon of storm/wastewater was taken from McPherson et al 1999. This value was $0.089 per gallon.

Ecobenefit Findings

Air Quality Improvements

In 2008, the Asheville canopy coverage offered $282,000 in air pollution removal value and reduced air pollutants by 880,000 pounds. By 2018, the city saw a 6% loss in tree canopy and with that a significant reduction in its ability to clean Asheville's air. The loss of canopy increased the amount of air pollution by 73,000 pounds. The total reduction in air quality was a deficit of -$23,500.

Table 2. Asheville Tree Canopy Loss Presented as Change in Air Quality

Air Quality	2008 Units (lbs)	2008 Value ($)	2018 Units (lbs)	2018 Value ($)	Unit Difference (lbs)	Value Difference ($)
CO	11,520	$1,319	10,560	$1,209	-960	($110)
NO_2	86,240	$2,761	79,060	$2,531	-7,180	($230)
O_3	623,460	$198,630	571,520	$182,077	-51,940	($16,553)
SO_2	9,840	$124	9,020	$114	-820	($10)
PM_{10}	149,080	$79,577	136,660	$72,946	-12,420	($6,631)

Carbon Reduction

Trees store massive amounts of carbon in their woody tissue. Forests—both urban and rural—are an important carbon sink, helping to mitigate climate change. Trees store some of the carbon dioxide (CO_2) they absorb, preventing the CO_2 from reaching the upper atmosphere where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. Trees also sequester some of the CO_2 during growth (Nowak et al. 2013).

The i-Tree calculations consider the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment.

Asheville's 2008 tree canopy sequestered 70,749 tons of carbon, based on reduction amounts of atmospheric carbon. The 6% loss of tree canopy between 2008 and 2018 reduced the capacity of sequester 5,896 tons of carbon. This amount of carbon is equivalent to approximately 2 million gallons of gasoline.

The carbon storage amount reflects the amount of carbon the trees have amassed during their lifetimes. The total carbon storage of the canopy in 2008 was valued at $82,348,000 totaling 1,777,000 tons. The ten years of incremental canopy loss decreased carbon storage benefit by nearly $7 million.

Table 3. Asheville Tree Canopy Loss Presented as Change in Carbon Storage and Sequestration

Carbon	Units (tons) 2008	Value ($) 2008	Units (tons) 2018	Value ($) 2018	Unit Change (Loss)	Value Change (Loss)
Sequestration	70,749	$3,279,027	64,853	3,005,775	-5,896	($273,252)
Storage	1,776,775	$82,348,666	1,628,711	$75,486,277	-148,064	($6,862,389)

Stormwater Runoff and Pollution Control

Trees intercept rainwater by capturing water droplets on their leaves and bark. A tree's expansive root system also absorbs water from the surrounding soil, increasing the soil's water holding capacity. Combined, these processes result in reducing and slowing the amount of stormwater runoff. Without trees, cities would have to invest in significantly more stormwater infrastructure to handle the additional water flow that would otherwise be captured by trees. In the model, i-Tree hydro evaluated canopy loss and estimated the increased amounts of pollutants due the loss of canopy.

The below table illustrates the change in runoff amounts within the ten-year period between 2008 and 2018. For this i-Tree Hydro model, the most recent weather data from 2005 to 2012 was utilized to evaluate the two canopy cover layers – for both 2008 and 2018. The loss of tree canopy resulted in an average increase of 18,000,000 gallons of stormwater control, or equivalent to 27 Olympic swimming pools. The ten-year increase in runoff was over 1,300 gallons per acre or approximately $1,600,000 overall. Increased runoff increases local hydrologic peak flow rates and associated increases in water pollutant loading levels.

Table 4. Asheville Tree Canopy Loss Presented as Changes in Avoided Stormwater Runoff

Avoided Stormwater Runoff Change from 2008 to 2018								
Weather Year	Rainfall	Total Runoff	Total Runoff	Change in Runoff	Avoided Runoff	Avoided Runoff	Change in Avoided Runoff	Change in Avoided Runoff
	(mm)	**(m^3) 2008**	**(m^3) 2018**	**(m^3) '08 to '18**	**(m^3) 2008**	**(m^3) 2018**	**(m^3) '08 to '18**	**Gallons**
2005	1,137	45,422,516	46,606,904	1,184,388	1,254,443	1,158,419	-96,024	-25,366,931
2006	1,037	43,609,009	44,607,283	998,274	896,405	814,955	-81,450	-21,516,889
2007	833	36,687,547	37,455,533	767,986	1,089,405	1,030,507	-58,898	-15,559,202
2008	810	34,358,212	35,102,737	744,525	949,418	902,479	-46,939	-12,399,890
2009	1,418	56,287,610	58,219,160	1,931,551	949,507	866,446	-83,061	-21,942,311
2010	1,030	41,513,785	43,117,837	1,604,052	972,466	910,743	-61,723	-16,305,462
2011	1,114	44,456,738	46,669,921	2,213,183	925,221	869,936	-55,284	-14,604,564
2012	970	40,151,634	41,074,754	923,120	1,004,829	943,602	-61,226	-16,174,248
Average	**1,044**	**42,810,881**	**44,106,766**	**1,295,885**	**1,005,212**	**937,136**	**-68,076**	**-17,983,687**

For the same weather station data period, the UTC data for 2018 and 2008 were contrasted to relate the loss of tree canopy as an increase in potential polluted runoff. The i-Tree hydro model evaluates commonly associated pollutants and measurements such as Total Suspended Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Phosphorus, Soluble Organic Pollutants and Total Kjeldahl Nitrogen. Table 5 offers commonly measured water pollutants total suspended solids, phosphorus, and nitrogen. Note the change columns – all measurements are negative as they reflect losses in the ability of the canopy to retain those pounds of pollutants. The concentrations vary due to changes in annual rainfall. Phosphorus and nitrogen levels are measured as they are main components in eutrophication of water bodies and harmful algal blooms.

Table 5. Avoided Stormwater Runoff by Benchmark Pollutant Measurements

Avoided Pollutant Runoff from Tree Canopy (in pounds)										
Year	Mean Concentration	Total Suspended Solids 2008	Total Suspended Solids 2018	Change in TSS	Total Phosphorus 2008	Total Phosphorus 2018	Change in TP	Total Kjeldahl Nitrogen 2008	Total Kjeldahl Nitrogen 2018	Change in TKN
2005	Median	82,828	77,693	-5,135	394	369	-24	2,234	2,096	-139
	Mean	119,153	111,763	-7,390	479	449	-30	2,629	2,466	-163
2006	Median	56,009	52,526	-3,482	266	250	-17	1,511	1,417	-94
	Mean	80,570	75,562	-5,009	324	304	-20	1,778	1,667	-111
2007	Median	105,959	101,325	-4,635	504	482	-22	2,858	2,733	-125
	Mean	152,426	145,759	-6,667	612	586	-27	3,364	3,216	-147
2008	Median	50,597	47,857	-2,740	240	227	-13	1,365	1,291	-74
	Mean	72,786	68,843	-3,943	292	277	-16	1,606	1,519	-87
2009	Median	86,584	80,029	-6,555	411	380	-31	2,335	2,159	-177
	Mean	124,553	115,126	-9,427	500	463	-38	2,748	2,540	-208
2010	Median	81,773	77,202	-4,571	389	367	-22	2,206	2,082	-123
	Mean	117,633	111,057	-6,576	473	446	-26	2,596	2,451	-145
2011	Median	58,384	55,001	-3,384	277	261	-16	1,575	1,484	-91
	Mean	83,989	79,119	-4,870	337	318	-20	1,853	1,746	-107
2012	Median	50,911	47,524	-3,387	242	226	-16	1,373	1,282	-91
	Mean	73,239	68,365	-4,874	294	275	-20	1,616	1,509	-107
Average	**Median**	**71,631**	**67,395**	**-4,236**	**340**	**320**	**-20**	**1,932**	**1,818**	**-114**
	Mean	**103,044**	**96,949**	**-6,094**	**414**	**390**	**-24**	**2,274**	**2,139**	**-134**

Measuring the levels of pollutants is one method of determining effects of canopy loss, another is measuring the effects of those pollutant concentrations. Table 6 illustrates additional pollutant concerns which can be controlled with attenuation and retention of stormwater via community trees. These measures are known as biological oxygen demand and chemical oxygen demand – an evaluation of the dissolved oxygen available to support aquatic life and oxidizable pollutants. Soluble organic pollutants are those compounds which dissolve in water – some commonly toxic soluble compounds are dichlorodiphenylthrichloroethane (DDT), polychlorinated biphenyls (PCB), and numerous other insecticides, herbicides and plasticizers. These soluble pollutants are not only toxic aquatic life, but also humans when ingested via contaminated water or food.

Table 6. Avoided Pollutant Runoff by Oxygen Demand and Pollutant Loads.

Avoided Pollutant Runoff from Tree Canopy (in pounds)														
Year	Mean Concentration	Soluble Organic Pollutants '08	Soluble Organic Pollutant 2018	Change in SOP	Total Pollutant Load '08	Total Pollutant Load '18	Change Total Pollutant	Biochemical Oxygen Demand 2008	Biochemical Oxygen Demand 2018	Change in BOD	Chemical Oxygen Demand 2008	Chemical Oxygen Demand 2018	Change in COD
2005	Median	157	147	-10	172,125	178,673	6,548	17,478	16,394	-1,084	67,935	63,722	-4,212
	Mean	196	184	-12	225,501	233,370	7,869	21,429	20,100	-1,329	80,245	75,269	-4,976
2006	Median	106	99	-7	116,390	120,818	4,427	11,818	11,084	-734	45,937	43,082	-2,855
	Mean	133	124	-8	152,481	157,802	5,320	14,490	13,590	-901	54,261	50,890	-3,371
2007	Median	200	191	-9	220,193	228,734	8,540	22,358	21,381	-978	86,906	83,105	-3,802
	Mean	251	240	-11	288,474	298,736	10,263	27,414	26,214	-1,199	102,655	98,165	-4,490
2008	Median	96	90	-5	105,145	109,179	4,034	10,677	10,098	-578	41,499	39,252	-2,247
	Mean	120	113	-6	137,751	142,598	4,847	13,090	12,382	-709	49,020	46,364	-2,656
2009	Median	164	151	-12	179,929	186,675	6,745	18,270	16,887	-1,383	71,015	65,638	-5,377
	Mean	205	189	-16	235,721	243,826	8,106	22,401	20,705	-1,696	83,882	77,532	-6,350
2010	Median	155	146	-9	169,933	176,440	6,507	17,255	16,290	-965	67,070	63,320	-3,750
	Mean	194	183	-11	222,626	230,445	7,819	21,156	19,973	-1,183	79,223	74,793	-4,431
2011	Median	110	104	-6	121,328	125,964	4,636	12,320	11,605	-714	47,886	45,110	-2,775
	Mean	138	130	-8	158,952	164,522	5,571	15,105	14,230	-875	56,564	53,285	-3,279
2012	Median	96	90	-6	105,798	109,804	4,006	10,743	10,028	-714	41,757	38,979	-2,778
	Mean	121	112	-8	138,607	143,420	4,814	13,172	12,295	-876	49,324	46,042	-3,282
Average	**Median**	**135**	**127**	**-8**	**148,855**	**154,536**	**5,680**	**15,115**	**14,221**	**-894**	**58,751**	**55,276**	**-3,474**
	Mean	**170**	**160**	**-10**	**195,014**	**201,840**	**6,826**	**18,532**	**17,436**	**-1,096**	**69,397**	**65,292**	**-4,104**

Recommendations and Conclusion

Asheville's urban forest is an important community asset providing numerous environmental, economic and social benefits, however, the loss in tree canopy described in this study should serve as a call to action for the City of Asheville. Canopy loss not only affects the aesthetics of the Asheville, but it also leads to a loss in the ecological, social, and economic benefits that trees provide. With the appropriate planning, management and care, however, Asheville's urban forest can grow and increase in value over time.

The Urban Tree Canopy assessment was designed to help document Asheville's urban forest, quantify the value and benefits that it provides, and develop recommendations for future canopy efforts. Based on the analysis, some key recommendations have emerged:

- Development of an UFMP can provide a road map and shared vision for increasing and improving Asheville's urban forest.
- In the face of 6.4% loss in tree canopy, seek to increase tree protection efforts. This can be done through an ordinance review with a focus on establishing tree protection measures, specifications and mitigation requirements.
- Asheville is encouraged to adhere to the 10-20-30 planting rule and expand its planting palette to include new tree species. The 10-20-30 rule:
    - No more than 30% of any family (e.g. Fagaceae – Beech family (Oak belongs to this family)
    - No more than 20% of any genus (e.g. Quercus – Oak)
    - No more than 10% of any species (e.g. Quercus rubra – Red Oak)
- Intercepting stormwater and mitigating the urban heat island with tree canopy are important priorities for the City of Asheville. To meaningfully expand canopy and address these priorities, Asheville should explore opportunities to improve infrastructure that support trees and engage property and business owners in community forestry efforts within core commercial and industrial areas.
- 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 newly planted trees are growing. Asheville should examine policies to identify any barriers or potential incentives to protecting and expanding tree canopy community wide.

- The i-Tree Landscape planting plan in this report provides a great starting point for urban greening efforts that, if implemented, will have impacts on managing stormwater, reducing the urban heat island and ensuring that planting is prioritized in areas in greatest need. Asheville should use these data to strategically plant trees in a way that provides the greatest community benefits.
- This report represents several ways in which these data can be analyzed. With additional datasets or new questions, the data can further be used to help Asheville manage its urban forest. Therefore, Asheville 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.

The data, analysis and recommendations in this study should be considered as a starting point—a place from which to begin conversations and explore opportunities to enhance the city's tree canopy.

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