Urban Tree Canopy Cover Assessment for the City of Chicopee

from a Climate Change Perspective

Catalyst for Regional Progress
PVPC

Assessing Urban Tree Canopy Cover in the City of Chicopee from a Climate Change Perspective

Prepared for:
The City of Chicopee, Massachusetts

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Prepared in cooperation with the Massachusetts Department of Transportation, and the Federal Highway Administration and the Federal Transit Administration - U.S. Department of Transportation. The views and opinions of the Pioneer Valley Planning Commission expressed herein do not necessarily state or reflect those of the U.S. Department of Transportation.

Contents

Introduction

About the Study

In March 2019, Chicopee completed the second of two Community Resiliency Building Workshops as a major component of the Executive Office of Energy and Environmental Affairs' (EEA) Municipal Vulnerability Preparedness (MVP) certification process. The workshop convened municipal staff, board members and commissioners, residents, business owners, and other local stakeholders to identify the city's assets and vulnerabilities to the impacts of climate change, and established a mandate to develop priority strategies to increase the community's resilience to those impacts. Recognizing the ability of canopy cover to mitigate many of the detrimental effects of climate change, the top priority strategy that workshop participants identified for the City of Chicopee to undertake was to "Improve the resiliency of the City's tree stock by increasing the size of the municipal forestry department and changing the way the City chooses, plants, and maintains trees." The workshop attendees justified their emphasis on supporting and expanding the City's tree planting efforts by acknowledging that "These efforts will improve air quality, diminish the number of power outages."[1]

As a first step toward completing that strategy, this assessment provides the City of Chicopee with a preliminary analysis of aerial imagery of the urban canopy across the city's neighborhoods and an economic valuation of the air quality, stormwater management, and carbon sequestration and storage benefits that that canopy provides.

The data provided in this report will assist the City in:

- identifying and quantifying the benefits provided by existing canopy cover;
- identifying and prioritizing areas in need of increased canopy cover; and
- providing material for authoring compelling grant narratives to fund future urban forestry projects that expand/improve canopy coverage.

While this report details existing conditions in order to assist the City in the creation of canopy cover goals, it does not set canopy cover goals in and of itself. It is up to the City to identify and tailor specific canopy goals to specific neighborhoods based on the ecosystem services canopy cover can provide.

WHAT IS URBAN TREE CANOPY (UTC)?

Tree canopy, defined as the layer of leaves, branches, and stems of trees that cover the ground when viewed from above (as in from aerial photography), provides many environmental and public health benefits and services to both rural and urban communities. The urban tree canopy (UTC) is a component of the urban forest—all of a community's vegetative material on both public and private land. The urban forest forms landscape-scale green infrastructure which complements a community's grey infrastructure (such as water and sewer lines) and can be managed with equal importance to support municipal resilience.

Report Contents

This report overlays city and neighborhood demographic data with canopy cover analysis to provide a nuanced characterization of which populations have access to the public health benefits of existing canopy cover.

By characterizing general city demographics, the report then details the populations specific to individual neighborhoods in order to provide context for public health benefits provided by canopy cover.

The report then quantifies canopy cover in the city as a whole and in individual neighborhoods, and discusses the ecosystem services and benefits that canopy provides.

Finally, the report provides basic guidance in setting canopy cover goals/targets and visualizing prioritization scenarios.

City Geographic Context and Forestry Program

Geographic Context

The City of Chicopee is located at the confluence of the Connecticut and Chicopee Rivers, with the Connecticut River forming its western boundary. To

THE VALUE OF UTC

While this report primarily focuses on valuating the air quality benefits provided by UTC, healthy tree canopy has other public health benefits, such as producing positive changes in energy, stress, anger, and overall mental health in urban dwellers.[14] UTC also has myriad benefits beyond the health sector. With existing i-Tree software, the study was unable to quantify these benefits for neighborhoods in Chicopee; however, previous studies have calculated average savings per tree in temperate climates such as that of New England. UTC:

- improves stormwater management. Based solely on rainfaill interception by tree canopy, annual savings per individual trees can range from $0.28 to $54.61
- can reduce energy consumption for heating and cooling adjacent buildings. Calculated net energy savings per tree saw values ranging from 12 kWh to 919 kWh. Annual economic benefits ranged from $4 to $166 per tree.
- enhances property value. Trees have been show to effect property sales between $7 to $165 per tree.[15]

While tree canopy provides these same benefits in rural communities, the effect of the canopy is felt especially strongly in urban areas otherwise characterized by large amounts of impervious surfaces. Impervious surfaces, such as buildings, roadways, and sidewalks, absorb heat from the sun, and radiate it back out over the course of the day and night, causing urban heat islands (UHI), urban regions experiencing warmer temperatures than their rural surroundings. Heat islands affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and deteriorating water quality.[16]

the south, Chicopee is bordered by Springfield, Massachusett's third-largest city; Chicopee is bounded by the Towns of Ludlow to the east, Granby to the northeast, and South Hadley to the north.

With a total land area of 22.9 square miles, Chicopee has a population of over 55,500 people and comprises 43 census block groups. Census block groups are geographical units used by the United States Census Bureau to sample demographic data. As the smallest geographical unit for which the Bureau publishes sample data, for the purposes of this report it is more useful to use census block groups as the basis of study than the city's popularly recognized nine neighborhoods, which have indistinct boundaries and do not neatly conform with the geography of the census block groups. Typically, census block groups have a population of 600 to 3,000 people.

These census block groups each support variations in their demographic make-up and distinct land uses and qualities of their built environments. This report will provide demographic context for the city as a whole and the census block groups specifically in order to develop a holistic understanding of the intersection between existing canopy cover and current demographic trends.

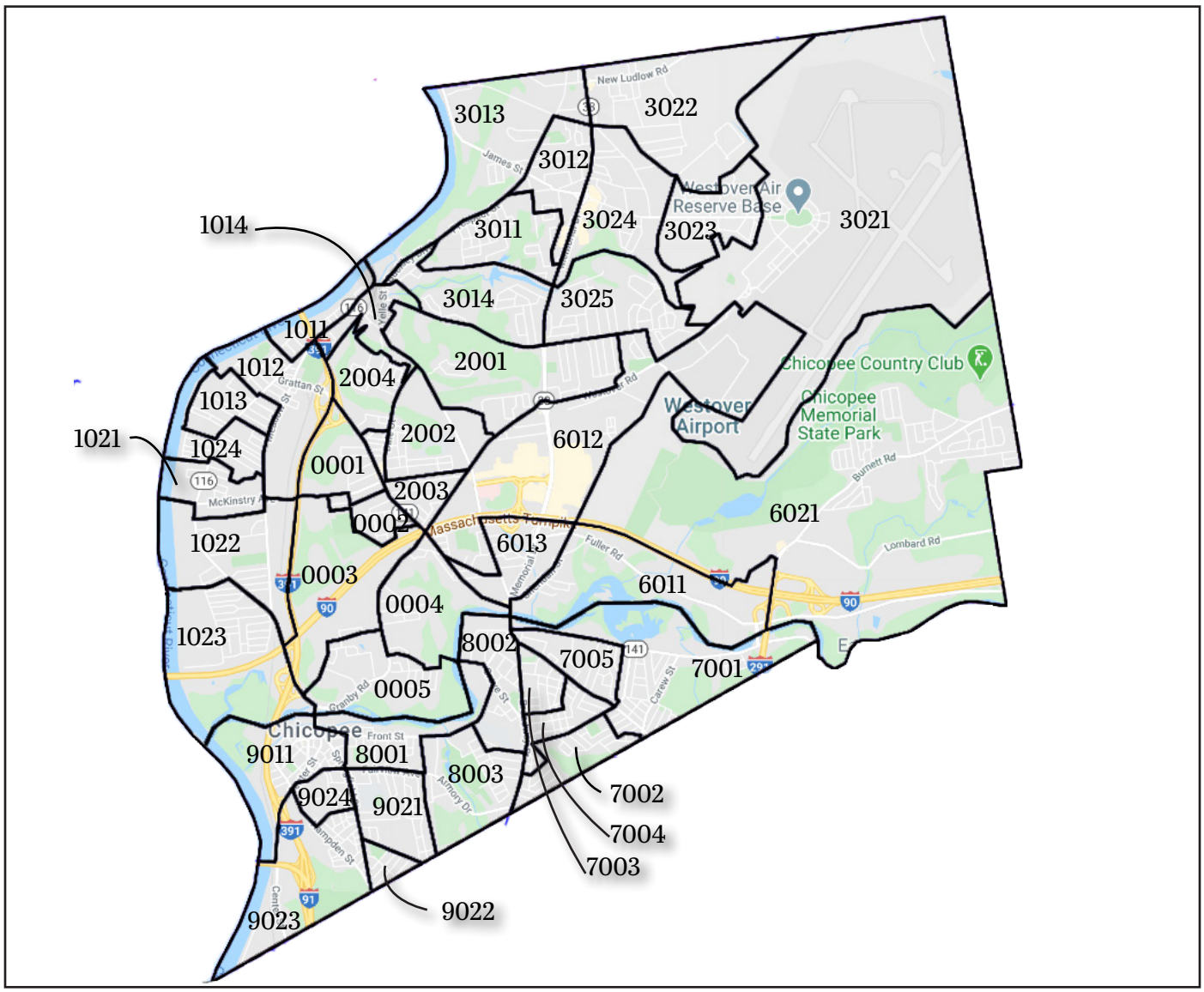
Forestry Program

Despite the challenges its urban setting poses, Chicopee has demonstrated commitment to increasing and maintaining its community tree stock. Funding for the City's Urban Forestry Program (nested within the Department of Public Works [DPW]) comes from a dedicated forestry fund, which is part of the City's annual budget. Chicopee conducted an inventory of public trees in 2013. The City has a tree ordinance, maintains a budget of more than $2 per capita for tree related expenses, celebrates Arbor Day, and has been a National Arbor Day Foundation Tree City USA partner for 20 years. In 2020, the Massachusetts Tree Wardens and Foresters Association honored Christopher Scott, the City of Chicopee's Tree Warden, as Tree Warden of the Year.

In 2014, the Office of Community Development, Planning Department, DPW, Forestry Department, and the Engineering Department collaborated with Davey Resource Group to generate a Public Tree Management Plan (Davey Resource Group, 2014). This document, which plans for 2014 through 2020, identifies a target of 116 new street trees planted annually.

Chicopee's Director of Planning and Development served as the City's liaison in developing this report, with the idea that this document can serve as a tool to show where the city may need more trees to mitigate the effects of climate change and excessive stormwater runoff, and to illustrate importance of

FIGURE 1. CENSUS BLOCK GROUPS IN CHICOPEE



canopy cover when communicating with elected officials and applying for grants.

Key Findings

Via an i-Tree Canopy assessment, Chicopee was found to have a citywide canopy cover of approximately 34%, which is high compared to the nearby urban communties of Holyoke, with 26.5% coverage (2013) and Springfield, with approximately 25% coverage (2014), but low compared to the more suburban and rural neighbors of South Hadley (63%, 2006), Granby (78%, 2006), and Ludlow (64%, 2006).[2] As discussed in the "Canopy Cover Assessment" section on page 8, there is no one-size-fits-all target for canopy cover in developed areas; however, communities located within temperate climates such as that of the northeast United States of America can reasonably obtain 40-60% canopy cover.[3]

Chicopee's canopy cover provides the community with approximately $2,496,513 in combined annual hydrological, air pollution, and carbon sequestration benefits. Chicopee's land cover is about 27% impervious surfaces. For more information on the effects of canopy cover and impervious surfaces on public health, stormwater management, and energy usage, see the callout box **The Value of UTC** on the opposite page.

While it is helpful to have an understanding of the citywide canopy coverage, it is important to understand that distribution of tree canopy cover is not uniform across any municipality. It is more informative to look at canopy coverage on a finer scale, such as by neighborhood, census block group, sub-watershed, or land use or zoning designations. As previously noted, this report uses census block groups as the geographical unit by which to measure tree canopy cover. The following census block groups

ABOUT I-TREE

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service (USFS) that provides urban and rural forestry analysis and benefits assessment tools. The i-Tree tools help communities of all sizes strengthen forest management and advocacy efforts by quantifying forest structure and the environmental benefits that trees provide.

For the purposes of this report, PVPC used the i-Tree Canopy and i-Tree Landscape softwares to generate the enclosed data and analysis. i-Tree Canopy produces statistically valid estimates of land cover types using aerial images available in Google Maps. i-Tree Landscape combines geospatial data for an area of interest with demographic data to allow users to overlay environmental data with socio-economic and public health data. It makes use of datasets, such as land cover and U.S. Census data, to provide local information, tree benefits, and planting prioritization by designated management boundaries. This assessment involved an aerial assessment of canopy cover based on available Bing and Google satellite imagery. A next step the City may want to consider is to "ground-truth" the report findings by verifying the location and health of individual trees.

represent the lowest and highest canopy cover, respectively.

Census block group 3023, immediately adjacent to the Westover Air Reserve Base (WARB), has the lowest canopy cover at 4.77%, or about 84% less than the citywide average. Approximately 43% of its land cover is impevious surface. Census block group 3023's existing canopy provides approximately $5,813 in combined annual stormwater, carbon sequestration, and public health benefits. This census block group is consistently identified as among the top priority census block groups for increasing tree canopy in the **Sample Prioritization Scenarios**.

Census block group 6021, which encompasses Chicopee State Park, has appromixately 43.44% canopy cover, roughly 25% more than the citywide average. It also has the least impervious cover of all census block groups in Chicopee (about 17.26%) impervious cover, is about half of the citywide average. Census block group 6021's existing canopy provides approximately $590,196 in combined annual stormwater, carbon sequestration, and public health benefits. This census block group is consistently indentified as very low priority for increasing tree canopy when compared to all other census block groups in Chicopee.

Demographic Considerations

Because canopy cover assessments are used to prioritize new areas of plantings and form the basis of future urban forestry goal setting and strategic planning, it is important to understand the demographic makeup of the community or neighborhood under study. Historically, in any community, certain populations have enjoyed greater political representation, and therefore have had access to more community resources. Historically disenfranchised communities, such as those inhabiting Environmental Justice (EJ) neighborhoods, have faced public health risks and increased vulnerability to environmental hazards that their better-situated neighbors have not.[4] Regardless of race or wealth, age can also be a predictor of vulnerability, and some age groups are considered generally more sensitive and prone to specific health risks.

Chicopee's 43 census block groups each have their own demographic make-up and land cover. While this section details citywide considerations and highlights those census block groups with notable data trends, no one data point will point to a need for increased canopy cover in any one section of the city. It is the overlaying of the following data points with land cover data that will reveal areas of most need.

Targeted canopy campaigns can help alleviate some health burdens, as described in **Next Steps and Sample Prioritization Scenarios**.

Age

Understanding the age of the local resident population provides important insights when considering the impact and value of a neighborhood's canopy cover. Young children and the elderly are considered vulnerable populations in the event of hazardous environmental events, such

FIGURE 2. AGE-RELATED DEMOGRAPHICS BY CENSUS BLOCK GROUP IN CHICOPEE

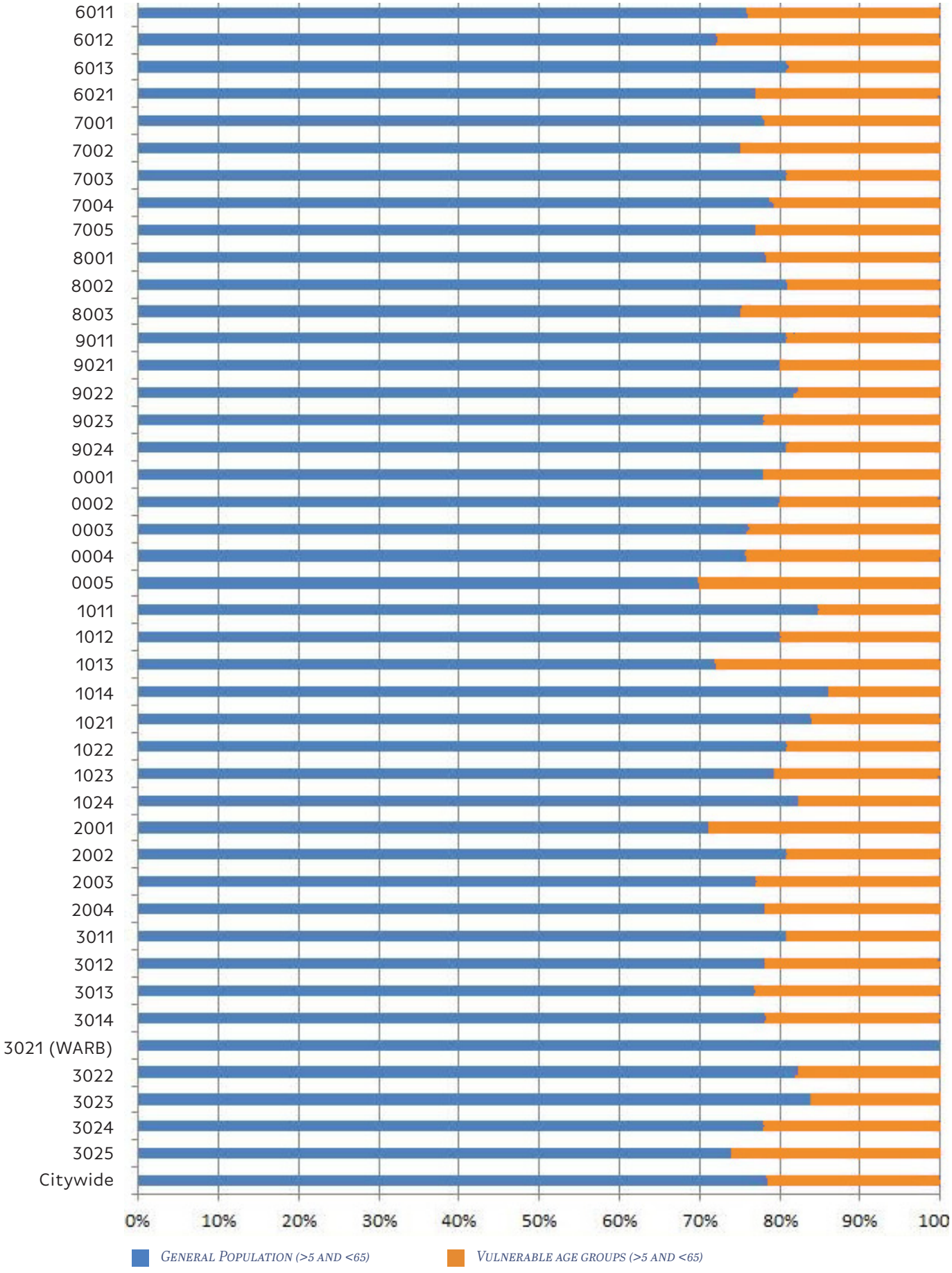
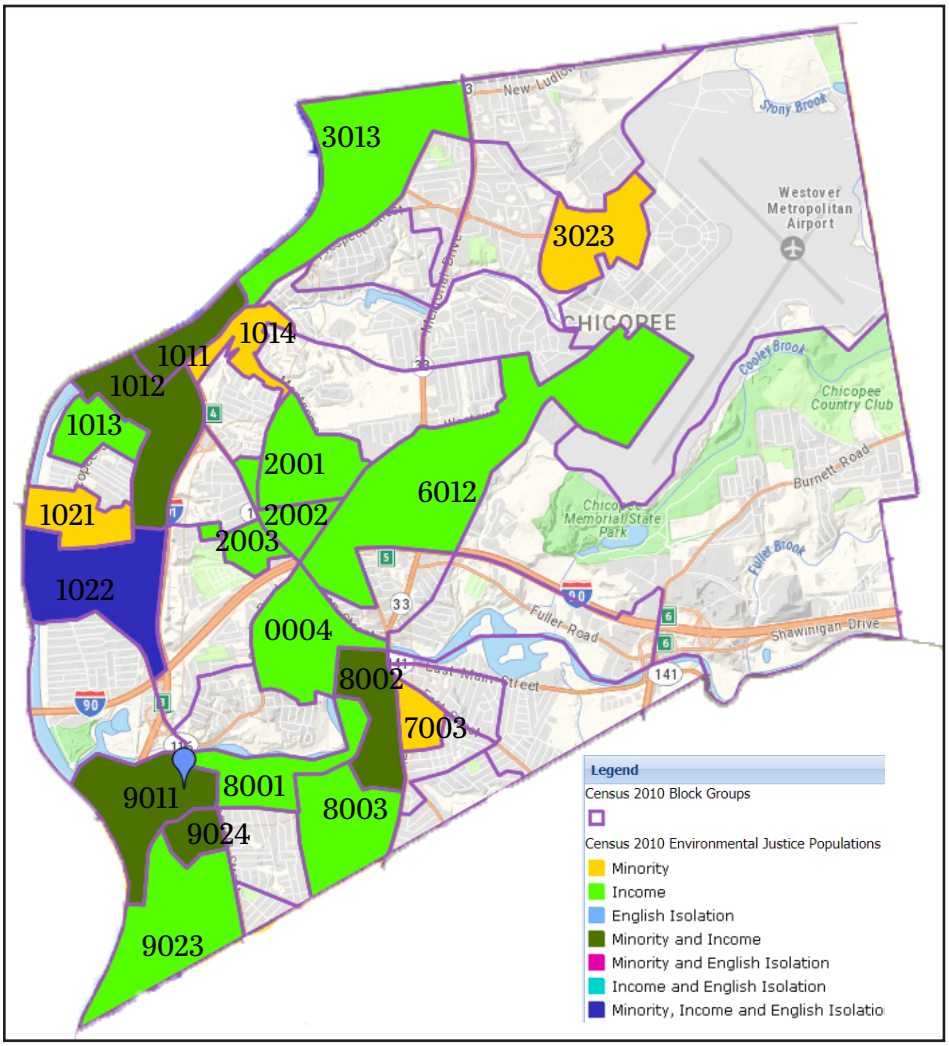


FIGURE 3. CENSUS 2010 ENVIRONMENTAL JUSTICE POPULATIONS IN CHICOPEE

MAP CLIPPED FROM MASSGIS OLIVER: HTTP://MAPS.MASSGIS.STATE.MA.US/MAP_OL/OLIVER.PHP



as flooding and extreme heat, in part because both groups are generally less mobile during disasters. The elderly are more likely than the general population to experience chronic health conditions, such as diabetes. Children and some older adults, especially those with disabilities, may also need assistance with activities for daily living. In 2010, nearly half of US residents over age 65 were reported to have a disability, compared to about 17% of people aged 21–64.[5] Young children and seniors may also be more likely than other age groups to stay at home during the day, and are therefore more exposed to the local environment around their homes. A recent study found a correlation between higher percentage of tree canopy and more positive mental health among populations age 55 and older.[6]

In Chicopee, children under the age of 5 account for about 5.6% of the population while seniors 65 and older account for 16%,[7] meaning that, combined, nearly 22% of the population is of an age where they are likely to be more vulnerable to heat and weather related hazards and be more sensitive to poor environmental conditions such as air pollution.

All of the city's census block groups compare within ±8% to the community's general age-related demographic make-up, with the census block group with the least concentration of vulnerable ages (1014) registering at 14%, and the census block group with the highest concentration of vulnerable age groups (0005) registering at 30%.

Disadvantaged Populations

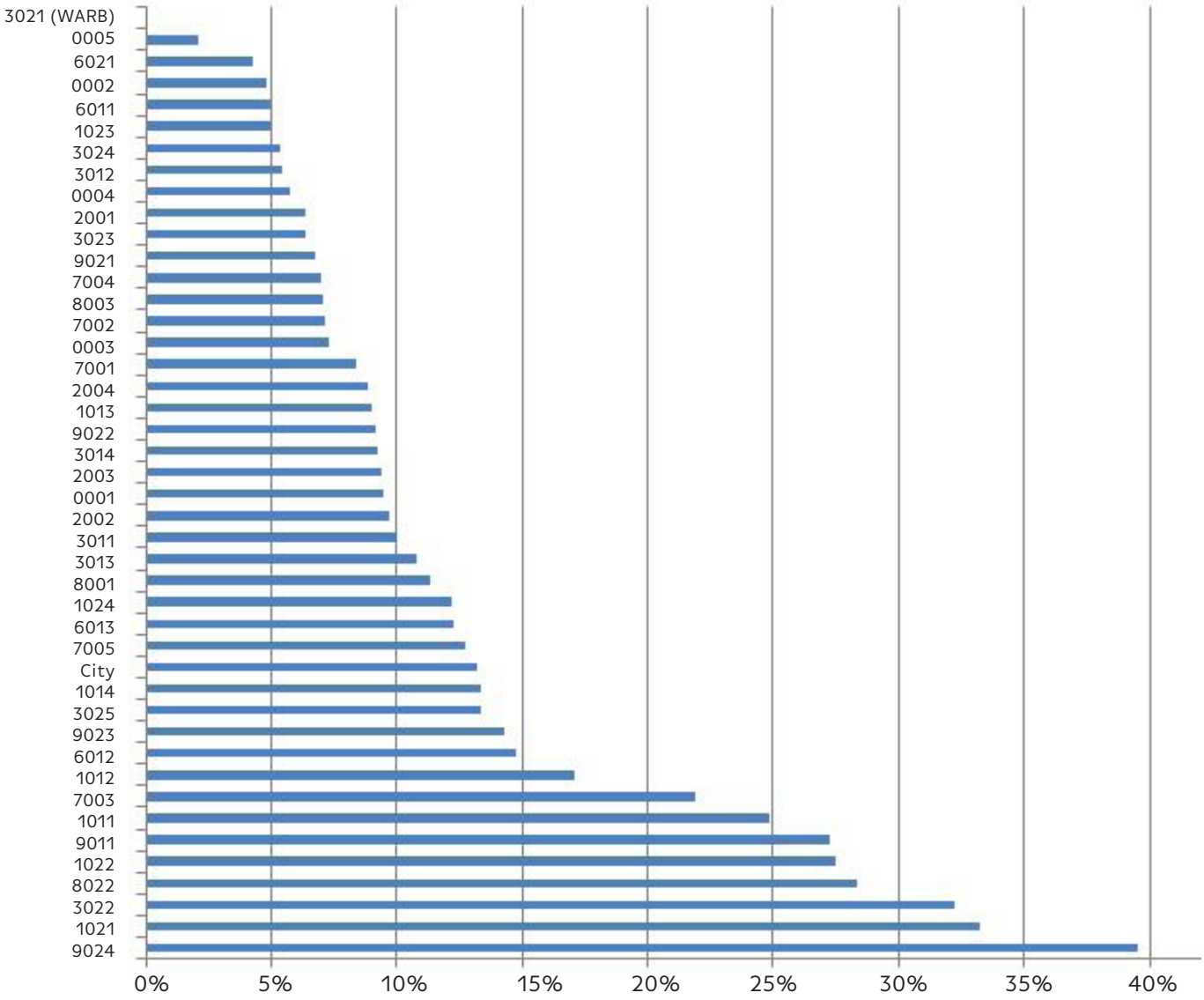
Race and Ethnicity

Historically, there has been a disproportionate burden of environmental and industrial pollution and lack of regulatory enforcement in communities of color and low-income communities when compared to wealthier, white communities in the same region.[8] That "zip code is a better determinant of health than genetic code" has been widely documented.[9] This legacy continues to affect public health across the nation, and the US Environmental Protection Agency has designated at-risk communities as EJ populations. Chicopee, which is just over 13% minority as a whole, does have minority populations concentrated in some census block groups and under-represented in others. Census block group 9024 has the highest density of minority residents at almost 40%, and is a designated EJ neighborhood by race and income. This census block group ranks in the middle for canopy density in the city, at approximately 23%. Census block group 0005 has the lowest percentage of minority residents at just over 2% of its population, while it enjoys amongst the highest rates of canopy cover at 40% canopy cover.

Household Median Income and Median Home Value

Similarly to communities of color, low-income communities are more likely to face environmental pollution and health risks than wealthier

FIGURE 4. PERCENT MINORITY RESIDENTS BY CENSUS BLOCK GROUP IN CHICOPEE



communities. When assessing the value and services provided by urban tree canopy, it is essential to understand local socio-economic conditions.

The median household income in Chicopee is $49,434 and the median home value in the city in 2020 is approximately $198,124.[10] Median home value is an indicator of socioeconomic status that focuses on wealth rather than income.[11]

Homeownership status also affects household wealth as renters, as a rule, have little to no equity built up in their homes, indicating less household wealth overall. Renters are also less likely to be able to modify the landscapes on which they live, and may rely more on City-provided tree canopy than home owners who can often plant their own trees. Approximately 43% percent of households rent in Chicopee.

Residents of census block group 1011 have the lowest income and have lower overall wealth in the form of homeownership than residents of Chicopee as a whole. The estimated median household income in this census block is $17,212, about one-third of the city-wide median household income. Over 26% of the census block group's population lives below the poverty line. The median home value in the census block is estimated at $182,200, or about 10% less than that of the city-wide median home value.[11] Nearly twice as many households in census block 1011 are renters than in the city as a whole, at 75%.

In contrast, census block group 6021 has the city's second-highest median houshold income at $68,750 or nearly 1.5 times the city's average. This block group has the lowest poverty rate (3%), more than eight-times lower than poverty rate of 1011. With 6% of total households renting, this census block group is almost entirely populated by homeowners. Census

block group 6021's median home value is $226,500, about 15% higher than the city median home value. At over 43%, this census block group has the highest rate of canopy cover in Chicopee.

While census block groups 1011 and 6021 represent the city's extreme examples, they also illustrate general trends in Chicopee. As demonstrated in the graph below, neighborhoods with lower rates of

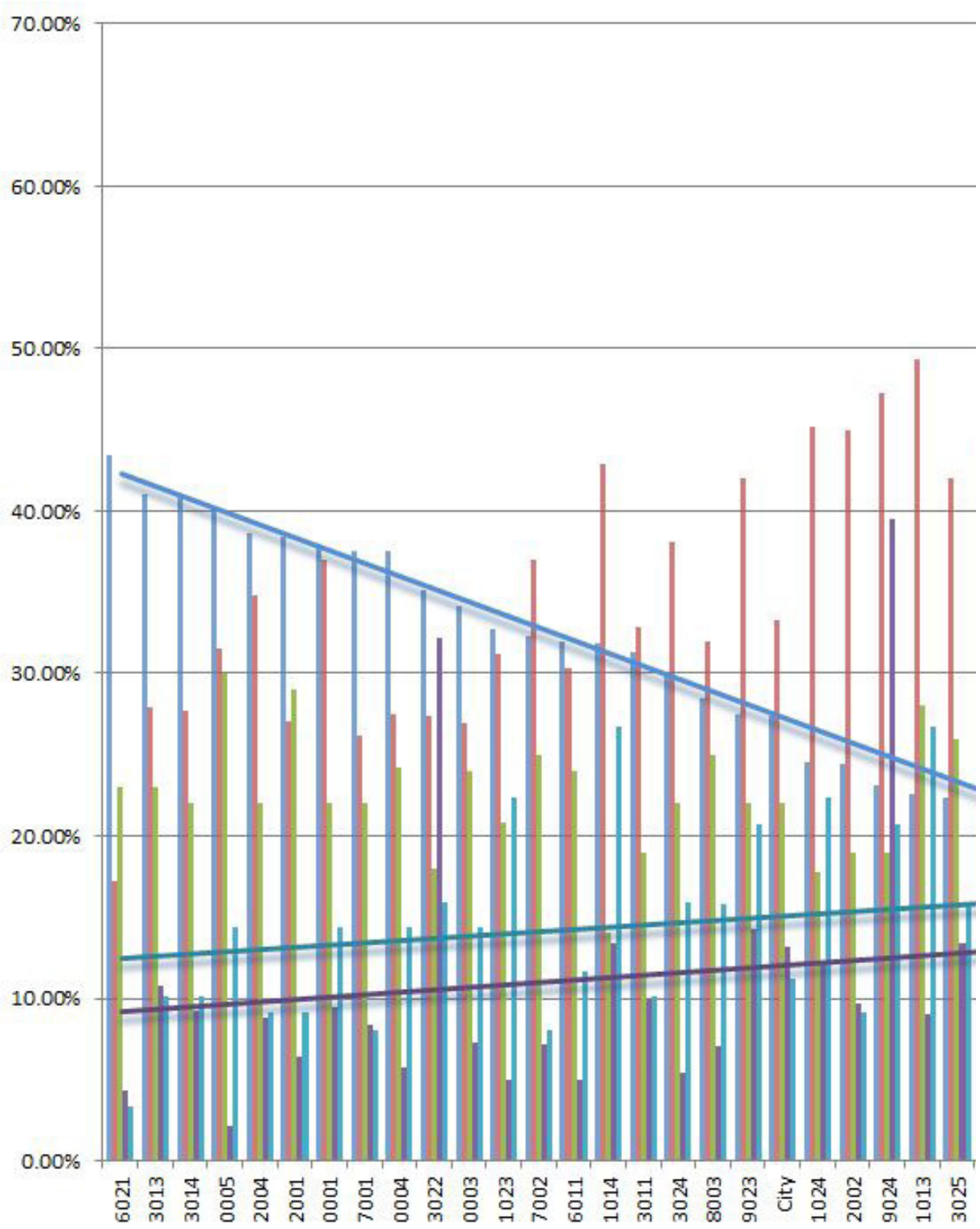
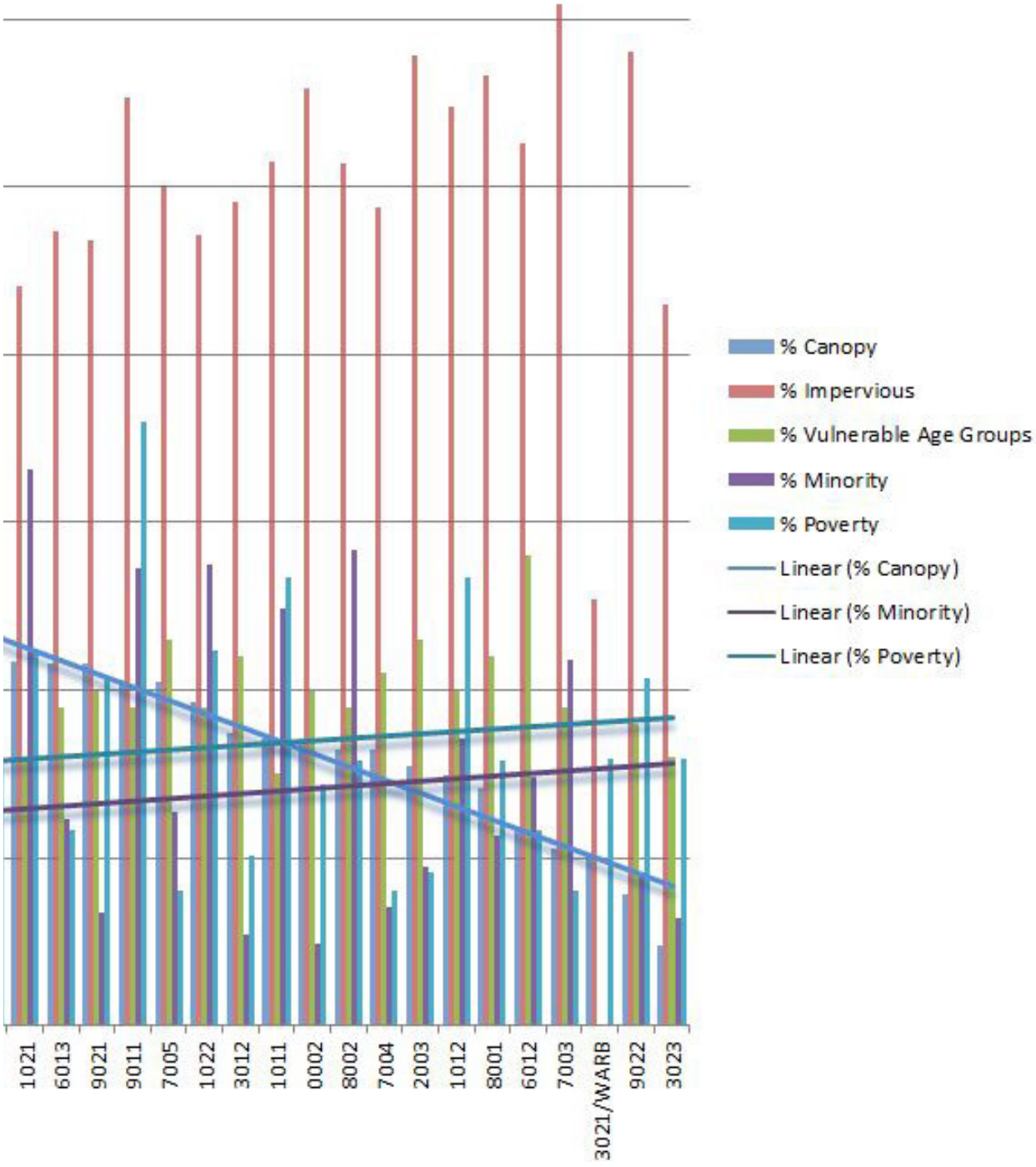


Figure 5. Land Cover and Demographic Trends in Chicopee

poverty and fewer minority residents generally have higher canopy coverage, while more disadvantaged neighborhoods with higher rates of poverty and more minority residents tend to have less canopy cover.



Canopy Cover Assessments

Canopy and Impervious Cover Analysis

The City of Chicopee covers 22.9 square miles of land, of which approximately 6.21 square miles is impervious cover (~27%) and 8.12 square miles is canopy cover (~34%). The city's densest canopy is located within Chicopee's several large-scale natural areas, including the heavily forested Chicopee Memorial State Park (census block group 6021), Atwater Park (census block group 9023), and the preserved flood plain forested buffers located along the confluence of the Connecticut and Chicopee rivers (census block groups 9011 and 1023).

As depicted in "Figure 6. Chicopee Canopy and Impervious Cover Analysis" on page 11, much of the city experiences moderate to dense canopy cover while impervious cover tends to be clustered in the city's commercial areas and the census block groups adjacent to or comprising the Westover Air Reserve Base (WARB). For the full i-Tree Canopy analysis of land cover in Chicopee as a whole, see **Appendix A**.

Economic Valuation of Existing Canopy Cover

This 8.12 square miles of canopy cover provides Chicopee with approximately $2,496,513 in combined annual air quality, carbon sequestration, and stormwater management benefits. As enumerated in **Appendix A**, this number does not include the total value of carbon dioxide stored in the neighborhood's trees. Trees' ability to store carbon dioxide is not only useful from a public health perspective (represented in the value of carbon dioxide sequestered annually in trees) but it also highly valuable in the effort to mitigate the effects of climate change.

As previously noted, census block group 3023, immediately adjacent to the WARB, has the lowest percentage of its land area in canopy cover at 4.77%, or about seven times less than the citywide average. Approximately 43% of its land cover is impevious surface. Census block group 3023's existing canopy provides approximately $5,813 in combined annual stormwater, carbon sequestration, and air quality benefits.

Census block group 6021, which encompasses Chicopee State Park, has appromixately 43.44% canopy cover, roughly 25% more than the citywide average. It also has the least impervious cover of all census block groups in Chicopee (17.26%), or about half of the citywide average. Census block group 6021's existing canopy provides approximately $590,196 in combined annual stormwater, carbon sequestration, and air quality benefits.

Key Considerations for Public Health

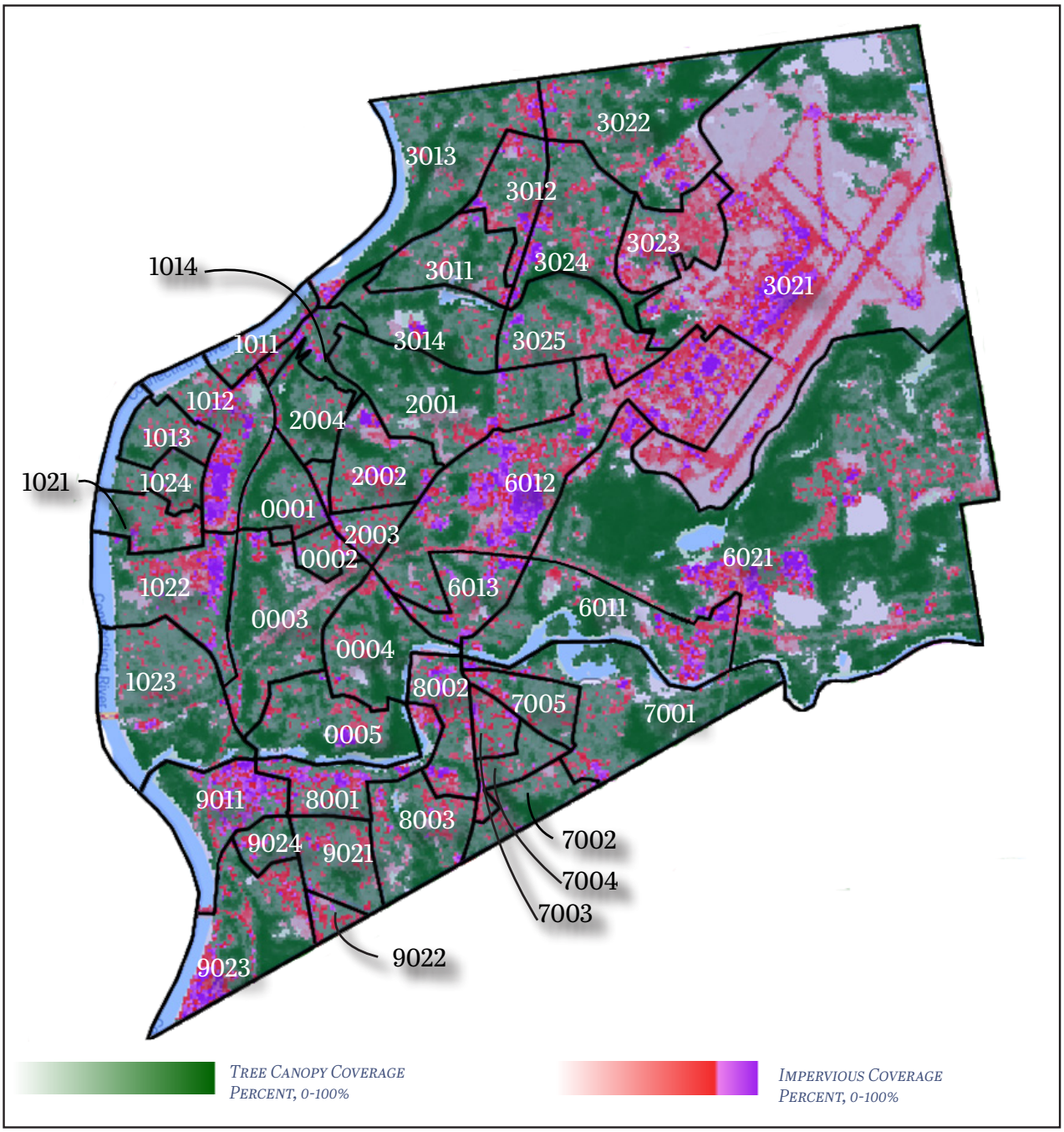
As shown in the table on page 12, i-Tree Canopy estimates tree benefits for several air quality pollutants. Carbon monoxide, nitrogen dioxide, and sulfur dioxide are air pollutants formed via the combustion of fossil fuels, such as petroleum gas in cars and trucks. These gases can cause inflammation and irritation of the respiratory system, and are of special concern for residents with asthma or other chronic respiratory conditions. In a region with generally poor air quality,[12] protecting and enhancing associated benefits from tree canopy is of high importance.

Likewise, particulate matter (both smaller than 2.5 microns [PM2.5] and smaller than 10 microns but larger than 2.5 microns [PM10]) is a respiratory irritant. Most particulate matter forms in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides. Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.[13]

Ground level ozone (O_3) is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and volatile organic compounds. Breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

i-Tree Landscape uses downscaled EPA data from 2008 to display PM2.5 averages and maximums, O_3 maximums, the Ultraviolet (UV) Index averages and maximums, and Land Surface Temperature (LST) Differences throughout Chicopee's census block groups. These visualizations can be found on pages 12 and 13.

FIGURE 6. CHICOPEE CANOPY AND IMPERVIOUS COVER ANALYSIS

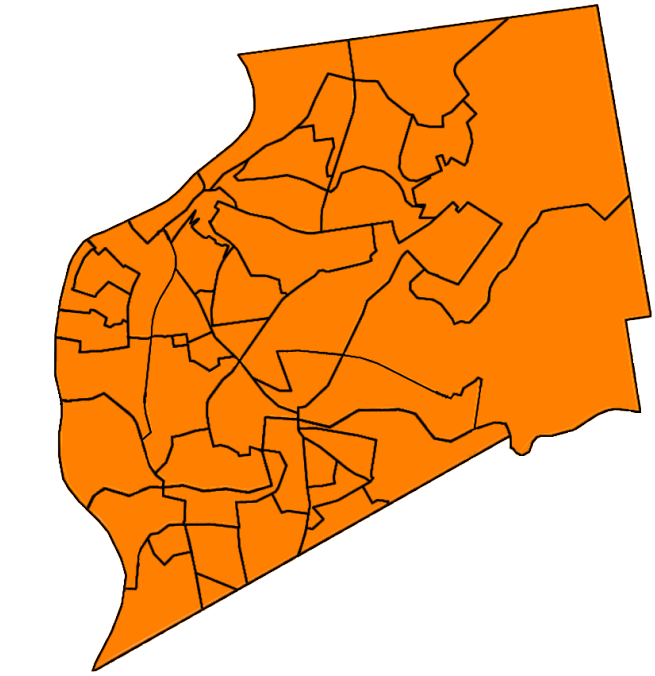


The UV Index visualization provides average and maximum intensity of UV radiation from the sun. Overexposure to the sun's ultraviolet radiation can cause immediate damage, such as sunburn, and long-term problems, such as skin cancer and cataracts. Shade from tree canopy can protect those spending time outdoors from higher levels of exposure.

The visualization of LST differences demonstrates how some areas of the city achieve higher temperatures than others. Shade from canopy cover and air cooling via evapotransporation from trees can mitigate and reduce local surface and air temperatures, thus providing relief from extreme heat.

From these visualizations it is clear that, like much of the rest of the region, Chicopee suffers from unhealthy air quality throughout the year.

Figure 7. Annual Average Particulate Matter in Chicopee

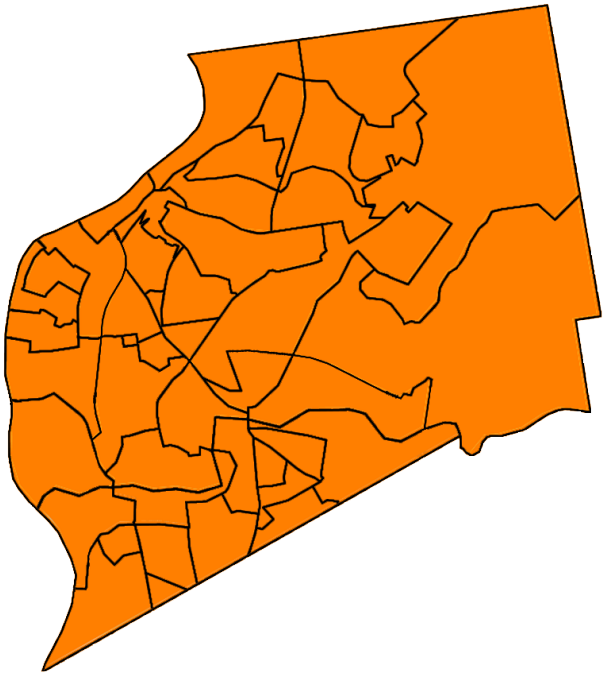


Particulate Matter (PM2.5) Average

- Good [4 thru 6 (µg/m³)]
- Moderate [7 thru 9 (µg/m³)]
- Unhealthy for Sensitive Groups [10 thru 12 (µg/m³)]
- Unhealthy [13 thru 15 (µg/m³)]
- Very Unhealthy [16+ (µg/m³)]

The average PM2.5 (µg/m3) value for all days in 2008 from U.S. EPA Downscaler Modal- epa.gov.

Figure 8. Annual Maximum Particulate Matter in Chicopee



Particulate Matter (PM2.5) Maximum

- Good [10 thru 12 (µg/m³)]
- Moderate [13 thru 35 (µg/m³)]
- Unhealthy for Sensitive Groups [36 thru 55 (µg/m³)]
- Unhealthy [56 thru 150 (µg/m³)]
- Very Unhealthy [151+ (µg/m³)]

The maximum PM2.5 (µg/m3) value for all days in 2008 from U.S. EPA Downscaler Modal- epa.gov.

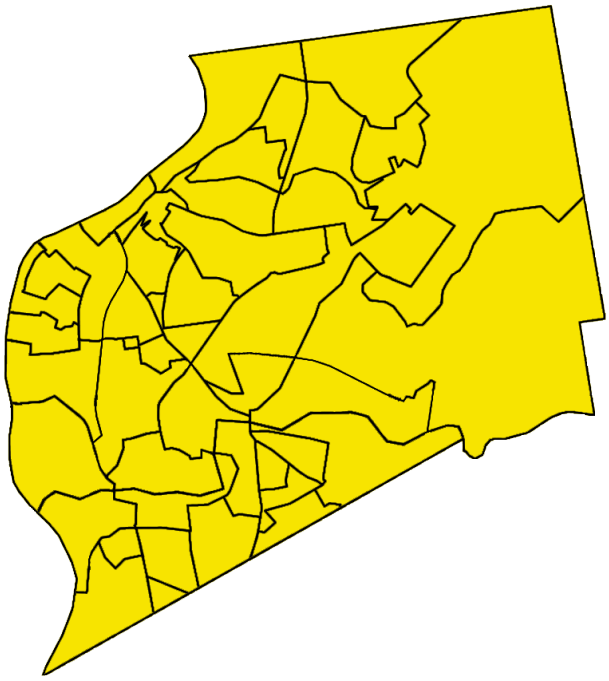
Figure 9. i-Tree Canopy Valuation of Tree Benefits for Air Pollution Reduction in Chicopee

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	1,674.55	±104.34	$1,117	±70
NO2	Nitrogen Dioxide removed annually	35,418.21	±2,206.86	$7,494	±467
O3	Ozone removed annually	218,430.86	±13,610.11	$332,903	±20,743
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	41,409.08	±2,580.14	$129,785	±8,087
PM2.5	Particulate Matter less than 2.5 microns removed annually	11,763.53	±732.97	$819,621	±51,069
SO2	Sulfur Dioxide removed annually	11,486.63	±715.72	$774	±48
Total		**320,182.87**	**±19,950.12**	**$1,291,693**	**±80,484**

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/mi²/yr @ $/lb/yr:
CO 206.171 @ $0.67 | NO2 4,360.682 @ $0.21 | O3 26,893.155 @ $1.52 | PM10* 5,098.276 @ $3.13 | PM2.5 1,448.323 @ $69.67 | SO2 1,414.231 @ $0.07 (English units: lb = pounds, mi² = square miles)

Figure 10. Annual Average UV Index in Chicopee

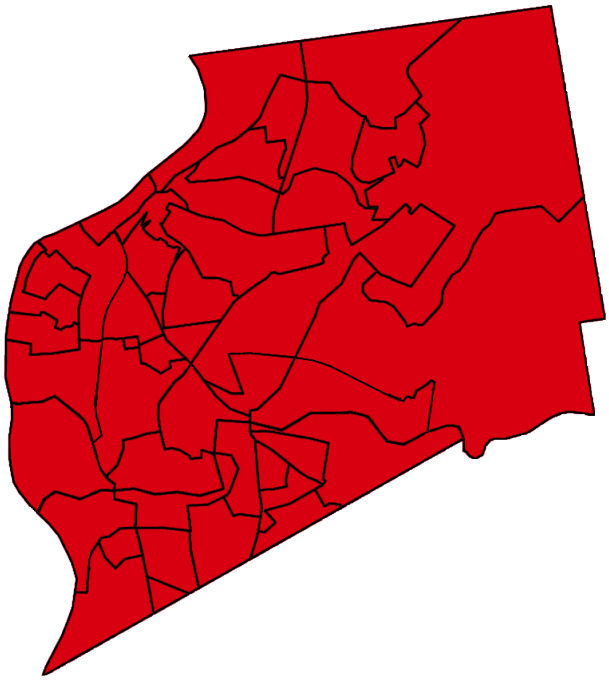


Ultraviolet Index (Average and Maximum)

clear (no data)
Low (0, 1, 2)
Moderate (3, 4, 5)
High (6, 7)
Very High (8, 9, 10)
Extreme (11+)

The UV index at local solar noon for all days between 2008-2013 from Tropospheric Emission Monitoring Internet Service- temis.nl.

Figure 11. Annual Maximum UV Index in Chicopee

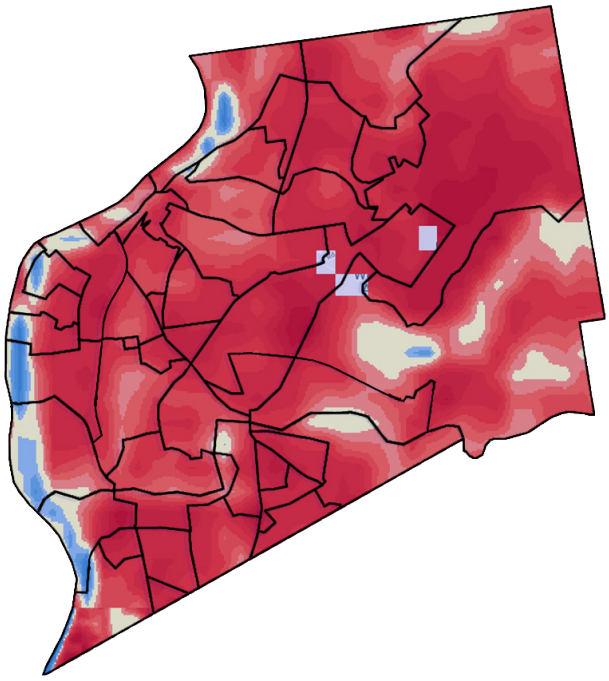


Ultraviolet Index (Average and Maximum)

clear (no data)
Low (0, 1, 2)
Moderate (3, 4, 5)
High (6, 7)
Very High (8, 9, 10)
Extreme (11+)

The UV index at local solar noon for all days between 2008-2013 from Tropospheric Emission Monitoring Internet Service- temis.nl.

Figure 12. Land Surface Temperature Difference in Chicopee



Land Surface Temperature Difference

Δ -20 °C : (-36.0 °F)
Δ -16 °C : (-28.8 °F)
Δ -8 °C : (-14.4 °F)
Δ -4 °C : (-7.2 °F)
Δ -2 °C : (-3.6 °F)
Δ < 0 °C : (< 0.0 °F)
Δ 0 °C : (0.0 °F)
Δ > 0 °C : (> 0.0 °F)
Δ 2 °C : (3.6 °F)
Δ 4 °C : (7.2 °F)
Δ 8 °C : (14.4 °F)
Δ 16 °C : (28.8 °F)
Δ 20 °C : (36.0 °F)

Land Surface Temperature Difference data derived from Landsat-8 Thermal Infrared Sensor Data. Temperature values are the difference from the median surface temperature for each Landsat scene - landsat.usgs.gov.

Next Steps and Sample Prioritization Scenarios

How to Set Canopy Cover Goals

The purpose of this report is to detail existing conditions so that the City might have additional information from which to work when setting canopy goals or targets for neighborhoods or census block groups. It is up to the City to prioritize the specific canopy cover benefits it would like to maintain, protect, or enhance in specific areas.

It is important that canopy cover goals are both attainable and sustainable. Canopy cover goals for specific areas must be compatible with existing and/or future land uses, and must be developed in conjunction with a program to sustain new trees over their lifetime.

American Forests, a recognized leader in conservation and urban forest management, states "Targets ...should consider constraints to creating canopy such as:

- Development densities (i.e., dense development patterns with more impervious surfaces have less opportunity for cover);
- Land use patterns (i.e., residential areas may have more opportunity for canopy than commercial areas, but canopy cover tends to be less in residential areas of disadvantaged communities versus wealthy ones);
- Ordinances (i.e., parking lot shade ordinances promote cover over some impervious areas); and
- Climate (i.e., canopy cover in desert cities is often less than tropical cities)."[17]

Informed by those constraints, canopy targets should be shaped to achieve specific objectives, such as reaching the canopy percentage necessary to reduce urban heat island temperatures to a specific range, or to reduce stormwater runoff by a projected amount. According to a national analysis by U.S. Forest Service researchers David and Eric Greenfield, a 40-60 percent urban tree canopy is obtainable under ideal conditions in [temperate] forested states.[18]

Canopy cover targets or goals should be shaped by robust stakeholder engagement with municipal boards, commissions, and professionals (Department of Public Works, Planning, Conservation Commission, Tree Warden, Tree Committee, Parks and Recreation, etc.), as well as with neighborhood committees and local businesses and residents.

Various powerful and free tools exist to aid a community in setting canopy cover targets. Vibrant Cities Lab provides the Urban Forestry Toolkit (http://www.vibrantcitieslab.com/toolkit), which provides guidance on canopy cover assessment, prioritization, organization and outreach, creating urban tree plans, and building and maintenance plans.

i-Tree Landscape (https://landscape.itreetools.org/) is a powerful visualization tool that allows the user to establish prioritization scenarios based on census data and existing canopy and impervious cover. The web-based software is available to use by professional and laypeople alike, and while it doesn't project an ideal canopy cover target for specific goals, it will allow the user to compare two or more locations to visualize which area will benefit more from increase canopy cover for any default or custom scenario. Below are examples of several default scenarios as provided by the website.

Sample Prioritization Scenarios

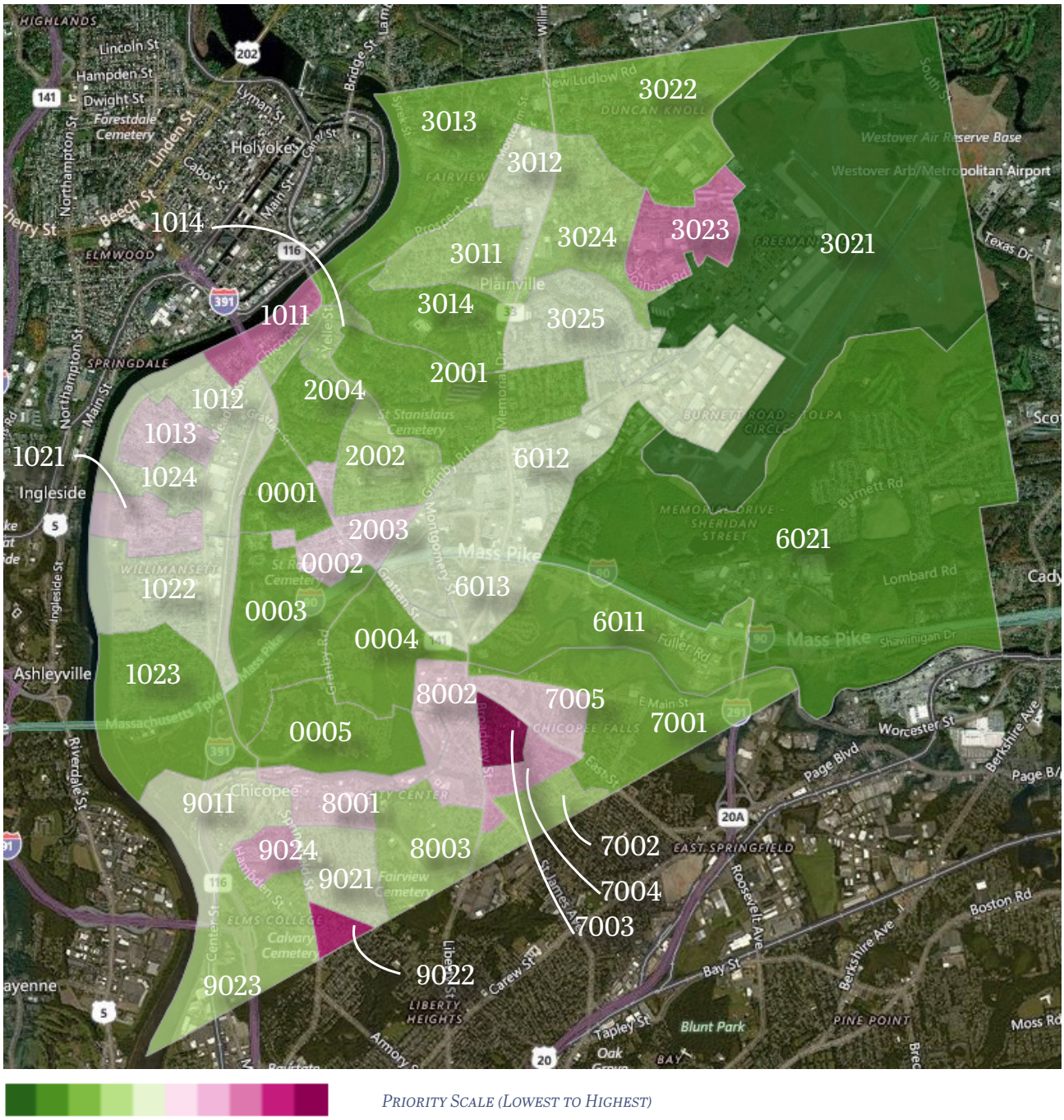
The following canopy cover prioritization scenarios were generated via i-Tree Landscape's Common (default) Scenarios component. Using the city's boundaries as the area limit, each Common Scenario is weighted to prioritize specific census block groups within the city based on enhancing specific canopy benefits.

Sample Prioritization Scenario 1: Population Density

Scenario 1: Population Density is an index weighted toward areas of relatively high population density, low tree cover per capita, and high available planting space. Specifically, the scenario is weighted toward areas affected by the following factors: Low Tree Stocking Level (30%), Low Tree Cover Per Capita (30%), and High Population Density (40%).

This scenario identifies census block group 7003 as having the strongest need for increased canopy cover, followed by 9022 and then 1011 and 3023. As census block group 3021 (the WARB) has no residential land use, it is ranked as least priority. Of the census block groups with residential land use, 6021, home to Chicopee State Forest, is least priority due to population density and relatively high canopy cover per capita.

FIGURE 13. SAMPLE PRIORITIZATION SCENARIO 1: POPULATION DENSITY



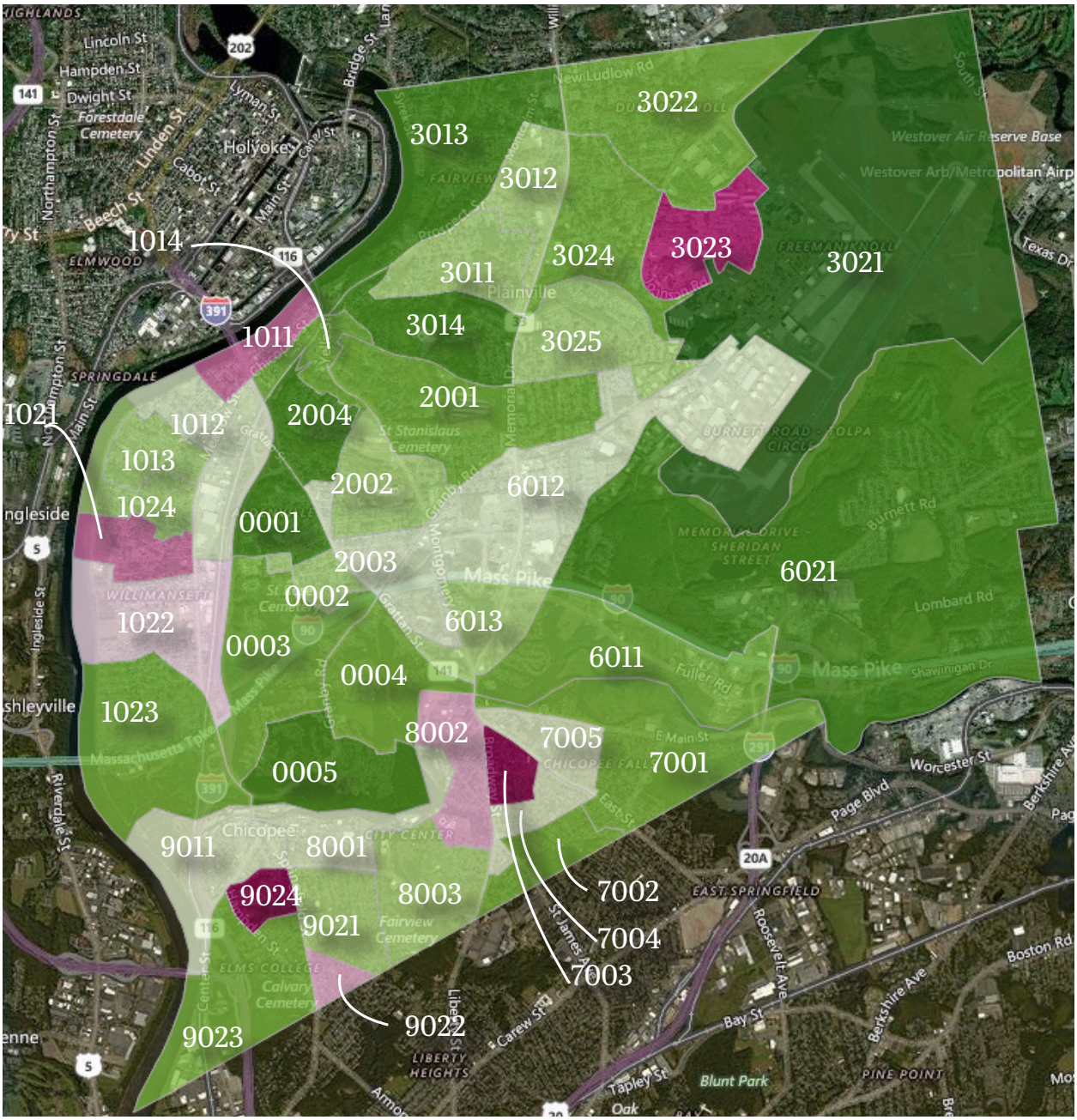
PRIORITY SCALE (LOWEST TO HIGHEST)

Sample Prioritization Scenario 2: Minority Population

Scenario 2: Minority Population is an index weighted toward areas of relatively high minority population density, low tree cover per capita, and high available planting space. Specifically, the scenario is weighted toward areas affected by the following factors: Low Tree Stocking Level (30%), Low Tree Cover Per Capita (30%), and High Minority Population Density (40%).

In this second scenario, census block group 7003 is again identified as the highest priority area for increasing canopy cover, along with 9024. Census block group 3023 ranks as second highest priority. Ignoring census block group 3021 (WARB), 6021, home of Chicopee State Park, is again ranked amongst the lowest priority tier, along with census block groups 0005, 0001, 2004, 3014, and 3013.

FIGURE 14. SAMPLE PRIORITIZATION SCENARIO 2: MINORITY POPULATION



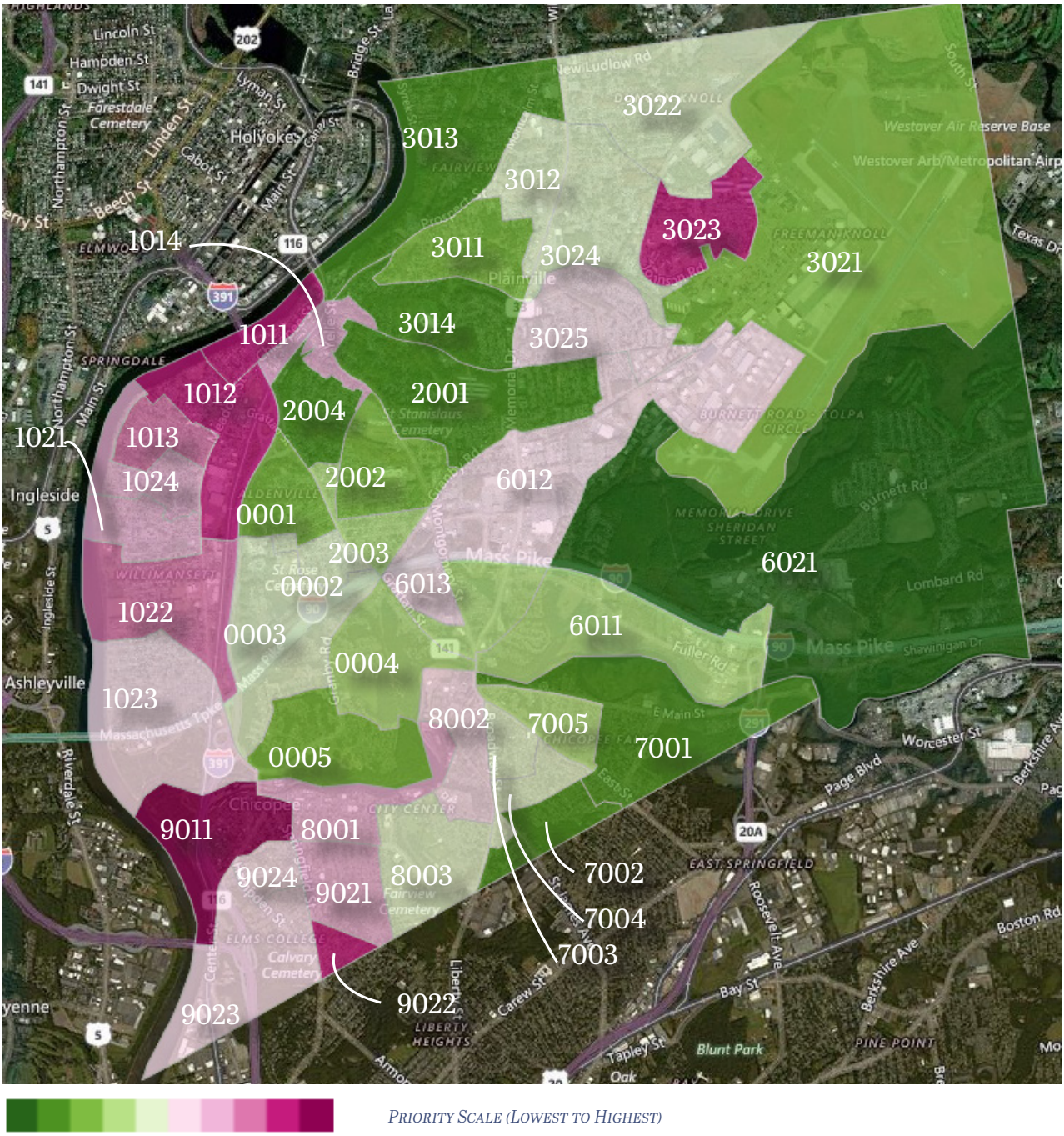
PRIORITY SCALE (LOWEST TO HIGHEST)

Sample Prioritization Scenario 3: Population Below Poverty Line

Scenario #3: Population Below Poverty Line is an index weighted toward areas of relatively high density of population below the poverty line, low tree cover per capita, and high available planting space. Specifically, the scenario is weighted toward areas affected by the following factors: Low Tree Stocking Level (30%), Low Tree Cover Per Capita (30%), and High Population Below Poverty Line Density (40%).

In this scenario, and confirming a theme from the previous two scenarios, the census block group 3023 is among the highest priority. All of the census block groups along the Connecticut River, south of the MA Route 116 bridge, rank as mid-to-high priority as well, with 9011 ranking as the highest priority of all. Here, census block group 6021 once again ranks as least priority for increasing canopy cover, while 7001, 2001, 3014, 3013, and 2004 are also low priority.

FIGURE 15. SAMPLE PRIORITIZATION SCENARIO 3: POPULATION BELOW POVERTY LINE



PRIORITY SCALE (LOWEST TO HIGHEST)

Endnotes

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https://www.americanforests.org/blog/no-longer-recommend-40-percent-urban-tree-canopy-goal/

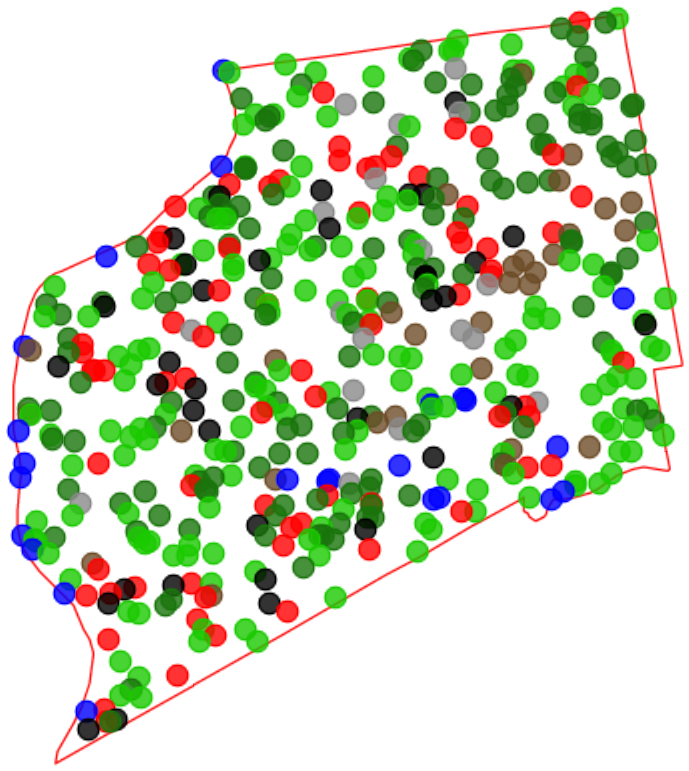
18 Ibid.

Appendix A: i-Tree Canopy Assessment

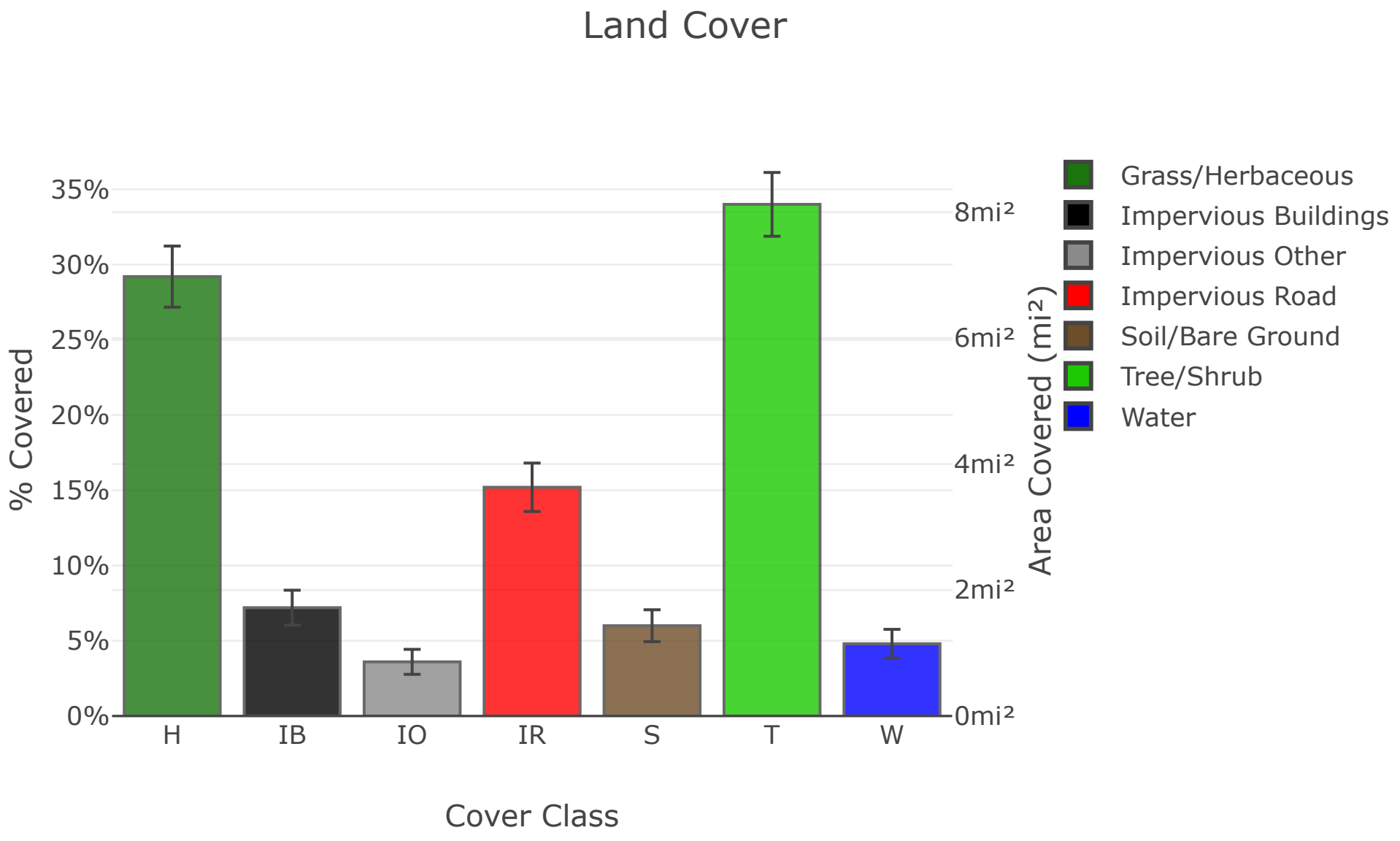
i-Tree Canopy v7.0

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 7/7/2020



Land Cover



Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (mi^2) ± SE
H	Grass/Herbaceous		146	29.20 ± 2.03	6.98 ± 0.49
IB	Impervious Buildings		36	7.20 ± 1.16	1.72 ± 0.28
IO	Impervious Other		18	3.60 ± 0.83	0.86 ± 0.20
IR	Impervious Road		76	15.20 ± 1.61	3.63 ± 0.38
S	Soil/Bare Ground		30	6.00 ± 1.06	1.43 ± 0.25
T	Tree/Shrub		170	34.00 ± 2.12	8.12 ± 0.51
W	Water		24	4.80 ± 0.96	1.15 ± 0.23
Total			**500**	**100.00**	**23.89**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (kT)	±SE	CO_2 Equiv. (kT)	±SE	Value (USD)	±SE
Sequestered annually in trees	7.10	±0.44	26.02	±1.62	$605,089	±37,702
Stored in trees (Note: this benefit is not an annual rate)	178.20	±11.10	653.40	±40.71	$15,196,057	±946,844

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Carbon sequestered is based on 0.874 kT/mi^2/yr. Carbon stored is based on 21.940 kT/mi^2. Carbon is valued at $23,256.92/kT. (English units: kT = kilotons (1,000 tons), mi^2 = square miles)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	1,674.55	±104.34	$1,117	±70
NO2	Nitrogen Dioxide removed annually	35,418.21	±2,206.86	$7,494	±467
O3	Ozone removed annually	218,430.86	±13,610.11	$332,903	±20,743
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	41,409.08	±2,580.14	$129,785	±8,087
PM2.5	Particulate Matter less than 2.5 microns removed annually	11,763.53	±732.97	$819,621	±51,069
SO2	Sulfur Dioxide removed annually	11,486.63	±715.72	$774	±48
Total		**320,182.87**	**±19,950.12**	**$1,291,693**	**±80,484**

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/mi^2/yr @ $/lb/yr:
CO 206.171 @ $0.67 | NO2 4,360.682 @ $0.21 | O3 26,893.155 @ $1.52 | PM10* 5,098.276 @ $3.13 | PM2.5 1,448.323 @ $69.67 | SO2 1,414.231 @ $0.07 (English units: lb = pounds, mi^2 = square miles)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	67.11	±4.18	$599,731	±37,368
E	Evaporation	370.99	±23.12	N/A	N/A
I	Interception	371.70	±23.16	N/A	N/A
T	Transpiration	568.34	±35.41	N/A	N/A
PE	Potential Evaporation	3,024.60	±188.46	N/A	N/A
PET	Potential Evapotranspiration	2,212.25	±137.84	N/A	N/A

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/mi^2/yr @ $/Mgal/yr:
AVRO 8.263 @ $8,936.00 | E 45.676 @ N/A | I 45.764 @ N/A | T 69.973 @ N/A | PE 372.388 @ N/A | PET 272.372 @ N/A (English units: Mgal = millions of gallons, mi^2 = square miles)

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton, and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company)

Limitations of i-Tree Canopy

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.