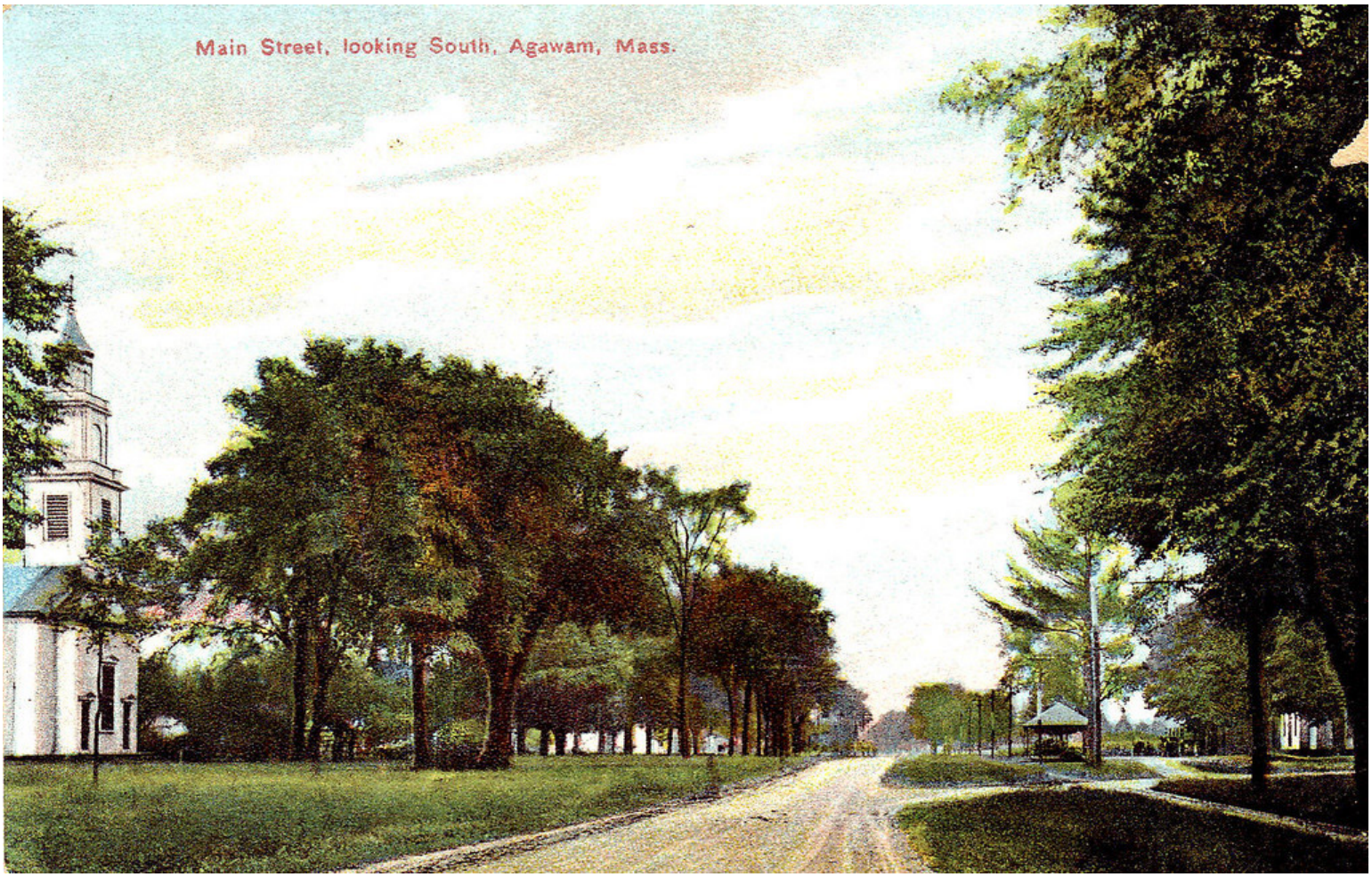

Urban Tree Canopy Cover Assessment for the Town of Agawam

from a Climate Change Perspective

TOWN OF AGAWAM
INCORPORATED MAY 17, 1855

Catalyst for Regional Progress
PVPC

ASSESSING URBAN TREE CANOPY COVER IN THE TOWN OF AGAWAM FROM A CLIMATE CHANGE PERSPECTIVE

Prepared for:
The Town of Agawam, Massachusetts

Prepared by:
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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.

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INTRODUCTION

Purpose of the Study

In January 2020, Agawam completed its Community Resilience Building Workshop 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 town's assets and vulnerabilities to the impacts of climate change, and 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, one of the strategies Agawam stakeholders identified was to "Increase tree canopy in neighborhoods."[1]

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

The data provided in this report will assist the Town 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 Town in the creation of canopy cover goals, it does not set canopy cover goals in and of itself. It is up to the Town to identify and tailor specific canopy goals to specific neighborhoods.

Report Contents

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

The report first characterizing general town demographics, then details the populations specific to individual neighborhoods.

The report then quantifies canopy cover in the town as a whole and in individual neighborhoods, and valuates the public health benefits that canopy provides.

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

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 roadways and grey infrastructure (such as water and sewer lines) and can be managed with equal importance to support municipal resilience.

Town Geographic Context and Forestry Program

Geographic Context

The Town of Agawam lies at the confluence of the Connecticut and Westfield Rivers. The Connecticut River forms the eastern boundary of the town, separating Agawam from the City of Springfield and and the Town of Longmeadow, and the Westfield River forms the northern boundary between the Town of West Springfield and Agawam. To the west, Provin Moutain demarks the boundary with the Town of Southwick, and the State of Connecticut borders Agawam to the south.

Primarily a suburban residential community, Agawam has several large-scale natural areas, such as Robinson State Park and the preserved flood plains located along the Connecticut and Westfield Rivers. Despite governance by a City Council,

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.[10] 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 Agawam; 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.[11]

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). 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.[12]

residents characterize their community as that of a small town and in 1989 voted to be called the "Town of Agawam" instead of the "City of Agawam."

With a total land area of 23.2 square miles, Agawam has a population of over 28,700 residents in 17 census block groups. Census block groups are geographical units used by the United States Census Bureau to sample demographic 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.

This report will provide demographic context for the town as a whole and the census block groups within it in order to develop a holistic understanding of the intersection between existing canopy cover and current demographic trends.

Forestry Program

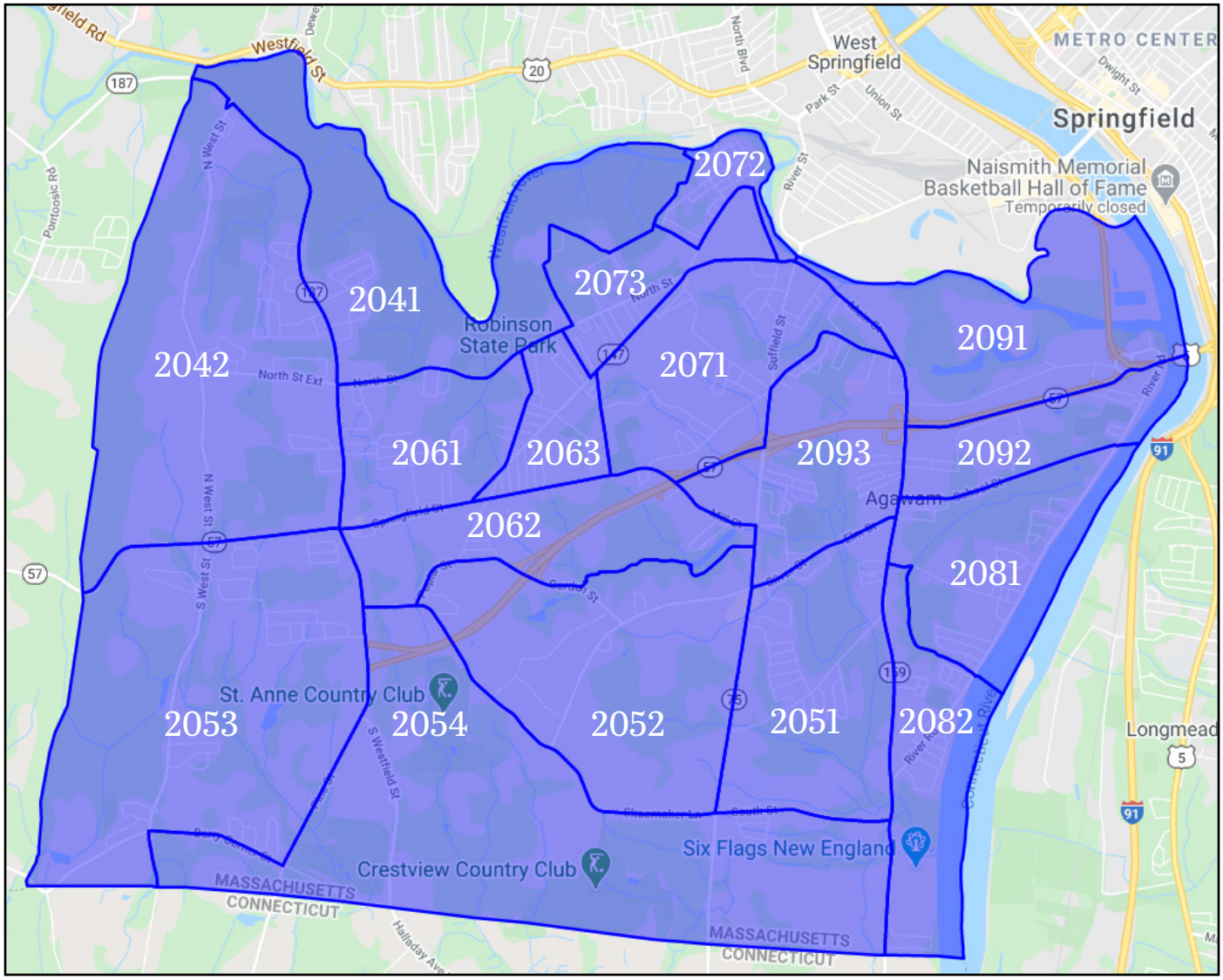
In Agawam, the Department of Public Works (DPW) Superintendent also holds the role of Tree Warden. The Town currently does not have an active shade or street tree planting program and does not have a community forestry plan in place to identify planting targets for street trees or strategies for protecting or enhancing public tree canopy. The DPW staff are actively involved with the trimming and take-downs of hazard public trees, while the staff of the Parks and Recreation Department are responsible for the landscaping of town parks.

Agawam's Director of Planning and Community Development served as the Town's liaison in developing this report, with the idea that this document can serve as a tool to show where the town may need more trees to mitigate the effects of climate change and excessive stormwater runoff, and to illustrate importance of canopy cover when communicating with elected officials and applying for grants.

Key Findings

Via an i-Tree Canopy assessment, Agawam was found to have a townwide canopy cover of approximately 41%, which is lower than the neighboring rural and suburban communities such as Southwick, with a 72% canopy cover (2008), and West Springfield, with 50% canopy cover (2019). However, Agawam's canopy cover is high compared to the nearby urban communties of Holyoke, with 26.5% coverage (2013) and Springfield, with approximately 25% coverage (2014). 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;

FIGURE 1. CENSUS BLOCK GROUPS IN AGAWAM



however, communities located within temperate climates, such as that of the northeast United States, can reasonably obtain 40-60% canopy cover.

Agawam's canopy cover provides the community with approximately $1,485,114 of value in combined annual carbon sequestration ($816,957), air quality ($449,353), and stormwater management ($218,804) benefits.

While it is helpful to have an understanding of the townwide canopy coverage, it is important to know 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. The following census block groups represent the lowest and highest canopy cover, respectively.

At nearly 20.5% canopy cover, census block group 2063 in the Central Agawam census tract/ neighborhood has the lowest percentage of its land area in canopy cover, and the highest percentage in impervious cover at 42.8%. Census block group 2063's existing canopy provides approximately $29,804 in combined annual stormwater, carbon sequestration, and air quality benefits.

Home to Robinson State Park, census block group 2041 in the Northwestern Agawam neighborhood was found to have the highest percentage of canopy cover at 67.4% with only 6.1% impervious cover. Census block group 2041's canopy cover provides approximately $274,503 in value combined annual stormwater, carbon sequestration, and air quality benefits.

This analysis found that neighborhoods with lower rates of 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.

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 Town may want to consider is to "ground-truth" the report findings by verifying the location and health of individual trees.

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.[2] 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.

Agawam has 17 census block groups, each with their own demographic make-up and land cover. While this section details townwide 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 town. 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**.

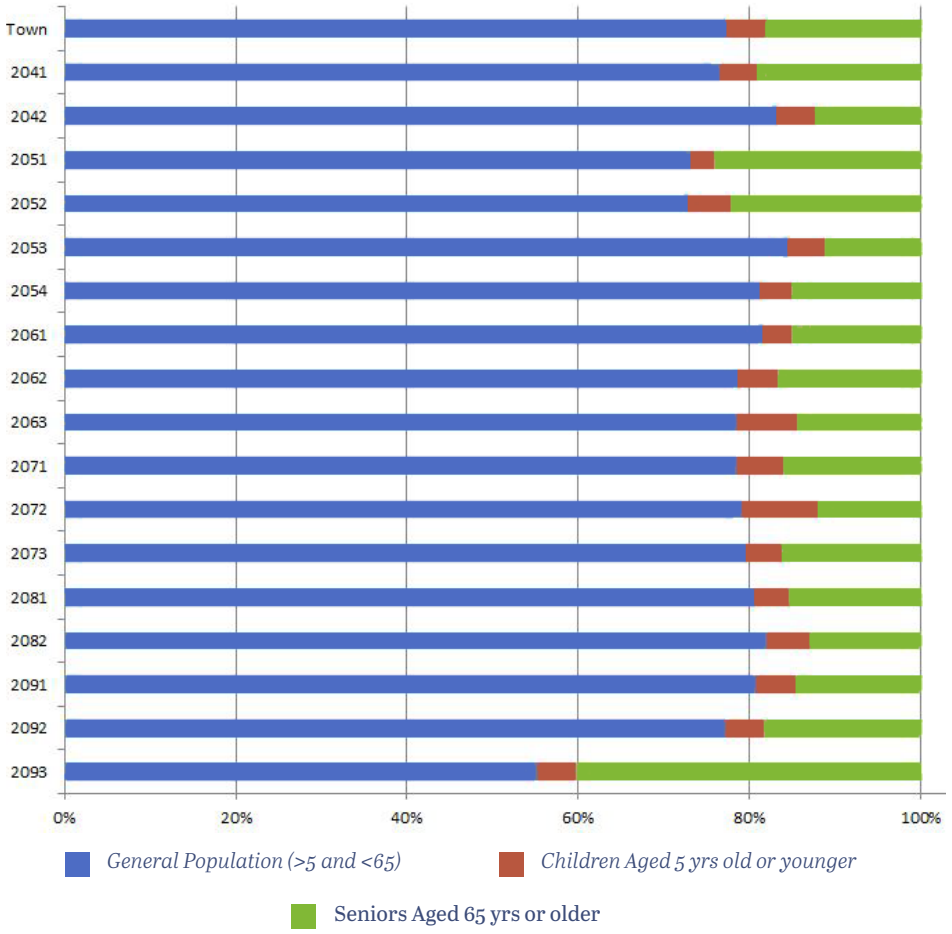
Age

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 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 of 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.[3] 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.[4]

In Agawam, children under the age of 5 account for nearly 5% of the population while seniors 65 and older account for 18%,[5] meaning that, combined, nearly 23% 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.

Most of the town's census block groups compare similarly to the community's general age-related demographic make-up, with 16 to 23% of their respective populations comprising children younger than five years old or seniors aged 65 or older.

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



Census block group 2093 is an exception, with approximately 45% of its population deemed of vulnerable age.

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.[6] That "zip code is a better determinant of health than genetic code" has been widely documented.[7] This legacy continues to affect public health across the nation, and the US Environmental Protection Agency has designated at-risk communities as EJ populations. Agawam, which is just over 5% minority as a whole, does have minority populations concentrated in some census block groups and under-represented in others. Census block group 2041, with the highest percentage of canopy cover, also has the lowest minority representation among its residents at just over 1.5%. Census block groups 2091 and 2082 each have some of the lowest canopy cover of the census block groups in town, and have the highest percentage of minority residents at just over and just under 10% respectively. With the highest percentage of minority residens, census block group 2091 is also a designated EJ neighborhood by income.

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 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 Agawam is $62,664 and the median household value in town in 2020 is approximately $241,550.[8] Median home value is an indicator of socioeconomic status that focuses on wealth rather than income.[9]

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 Town-provided tree canopy than home owners who can often plant their own trees. Approximately 26% percent of households rent in Agawam.

Residents of census block group 2091 have the lowest income and have lower overall wealth in the form of homeownership than residents of Agawam as a whole. The estimated median household income in this census block is $36,023, about 57% of the city-wide median household income. The median home value in the census block is estimated at $142,100, or about 58% that of the city-wide median home value.[11] Twice as many households in census block 2091 are renters than in the town as a whole, at 54%.

In contrast, census block 2041 has the town's highest median houshold income at $94,922, or 1.5 times the town's average. With under 3% of total households renting, this census block is almost

entirely populated by homeowners. The median home value for 2041 is $269,500, more than 10% higher than the town median home value and nearly 190% higher than that of census block 2091.

While census block groups 2091 and 2041 are the town's extreme examples, they illustrate general trends in Agawam. As demonstrated in "Figure 5. Land Cover and Demographic Trends in Chicopee" on page 8, neighborhoods with lower rates of 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.

FIGURE 3. CENSUS 2010 ENVIRONMENTAL JUSTICE POPULATIONS IN AGAWAM

Map clipped from MassGIS Oliver: http://maps.massgis.state.ma.us/map_ol/oliver.php

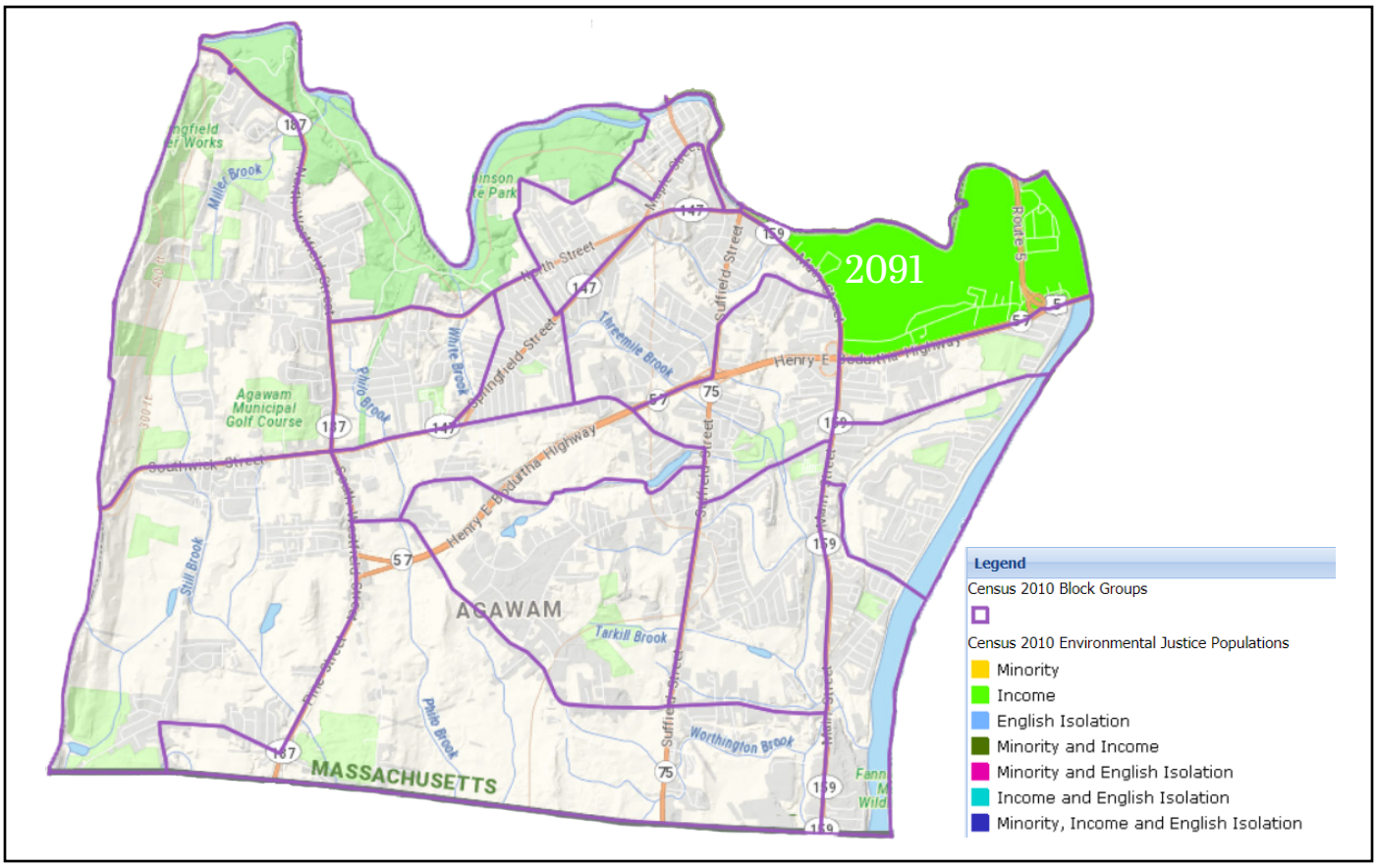


FIGURE 4. PERCENT MINORITY RESIDENTS BY CENSUS BLOCK IN AGAWAM

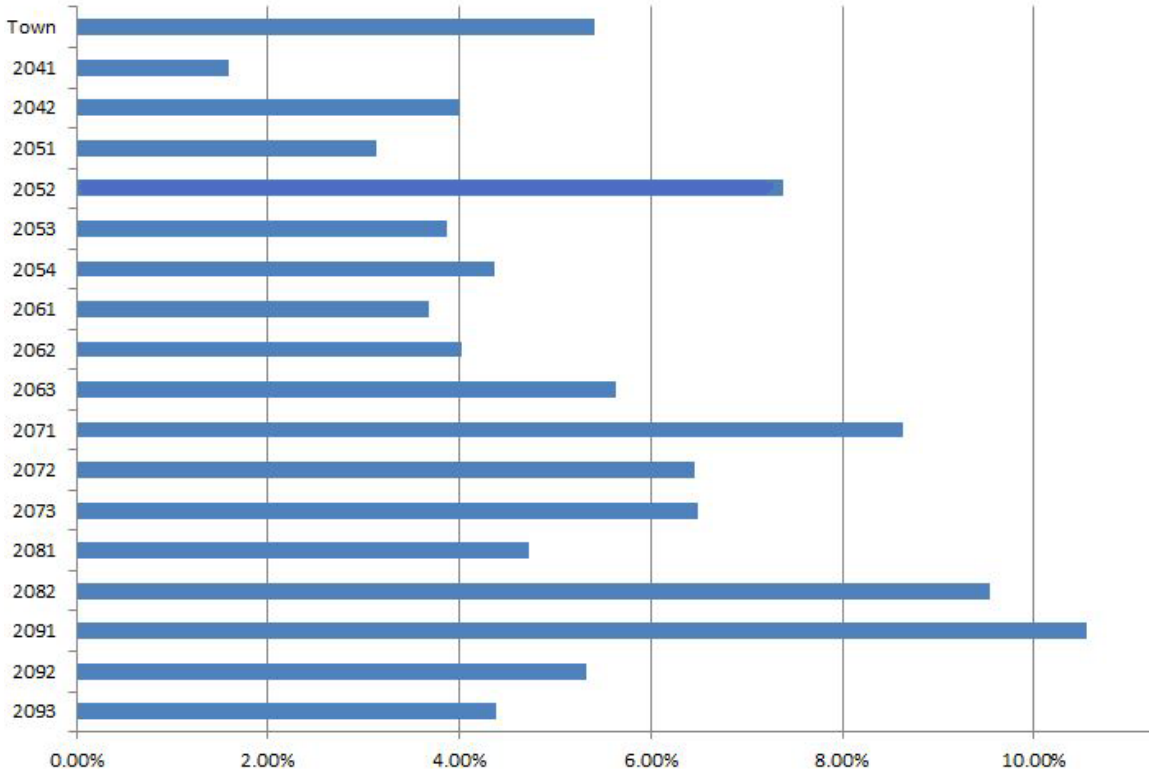
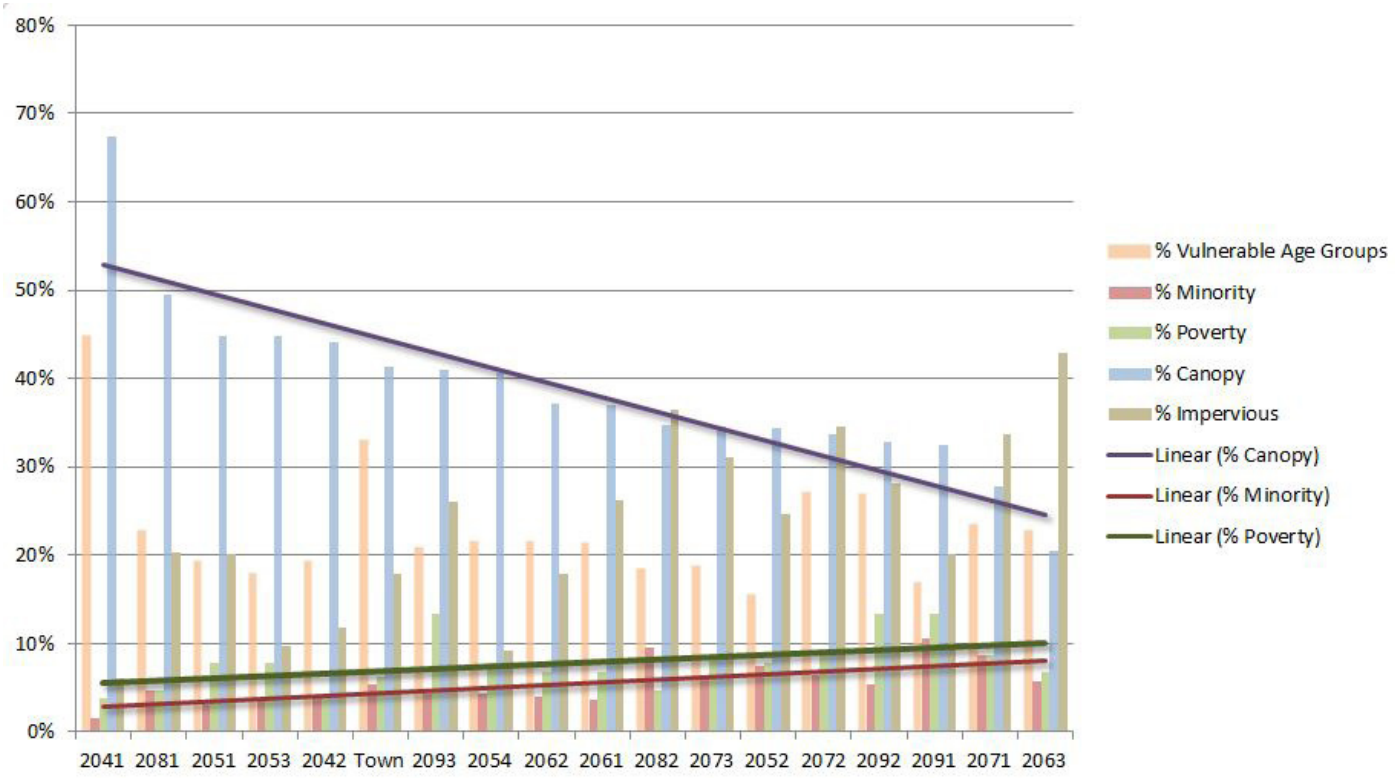


FIGURE 5. LAND COVER AND DEMOGRAPHIC TRENDS IN AGAWAM



CANOPY COVER ASSESSMENTS

Canopy and Impervious Cover Analysis

The Town of Agawam covers 23.2 square miles of land, of which approximately 4.15 square miles is impervious cover (~17.9%) and 9.6 square miles is canopy cover (~41.4%). Much of the canopy cover is concentrated in Agawam's several large-scale natural areas, including the heavily forested Provin Mountain area (the western boundaries of census block groups 2042 and 2053), Robinson State Park (census block group 2041), and other preserved flood plain forested buffers located along the Connecticut and Westfield Rivers.

As depicted in the visualization on page 9, much of the town experiences moderate to dense canopy cover while intensive impervious cover tends to be clustered in the town's decentralized commercial areas. For the full i-Tree Canopy analysis of land cover in Agawam as a whole, see **Appendix A**.

Economic Valuation of Existing Canopy Cover

The 9.6 square miles of canopy cover in Agawam provides approximately $449,353 in combined annual public health benefits. As enumerated in Figure 6, 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.

At nearly 20.5% canopy cover, census block group 2063 in the Central Agawam census tract/ neighborhood has the lowest percentage of its land area in canopy cover, and the highest percentage in impervious cover at 42.8%. Census block group 2063's existing canopy provides approximately $29,804 in combined annual stormwater, carbon sequestration, and public health benefits.

While census block group 2063 has the lowest percentage of canopy cover in town, census block group 2091 also stands out for having the third-lowest canopy cover (32.4%) and for the previously identified demographic trends that identify it as housing some of the most vulnerable populations in town. Census block group 2091's canopy cover provide an estimated $106,543 in combined annual public health benefits.

Home to Robinson State Park, census block group 2041 in the Northwestern Agawam neighborhood was found to have the highest percentage of canopy cover at 67.4% with only 6.1% impervious cover. Census block group 2041's canopy cover provides approximately $274,503 in combined annual public health benefits.

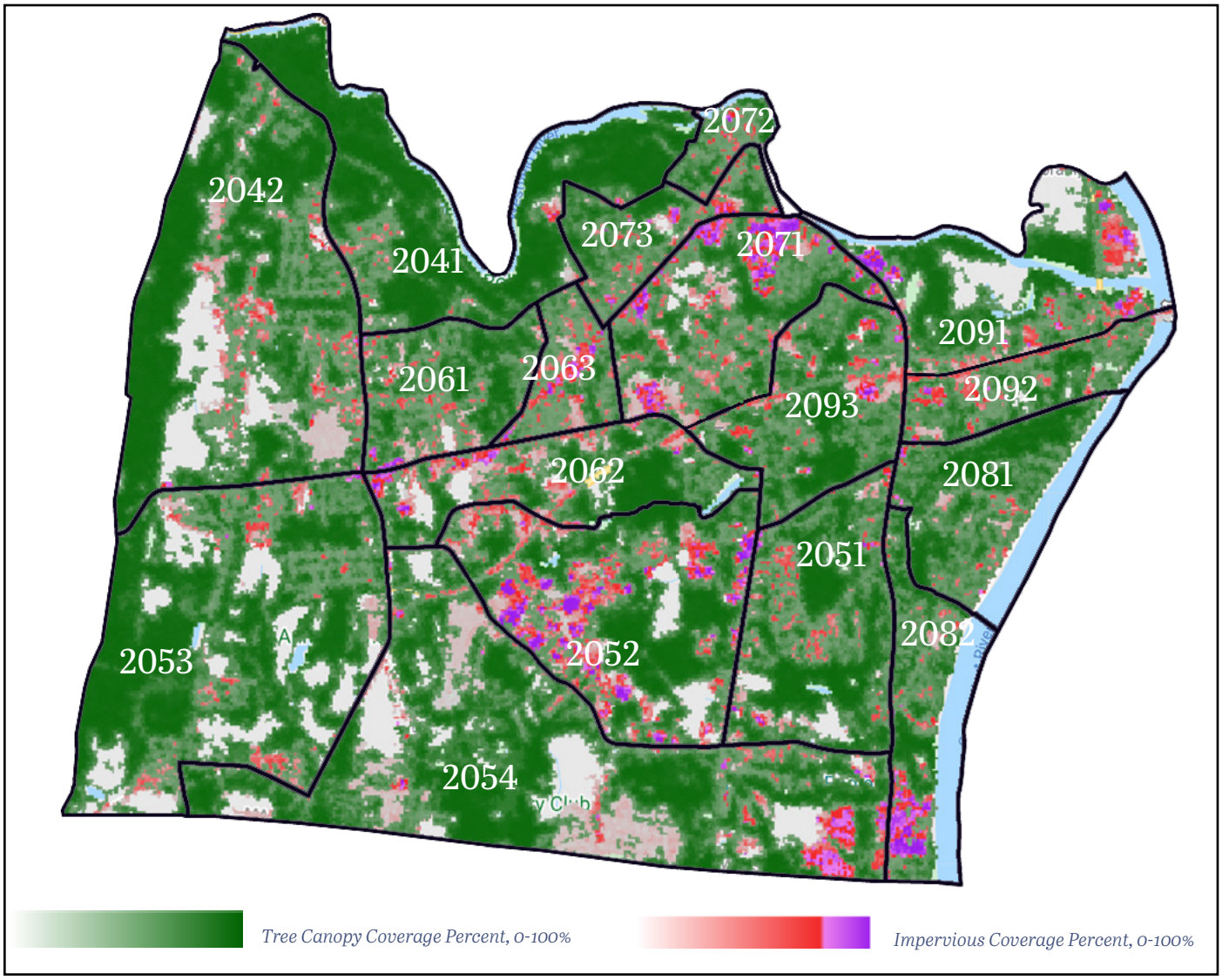
Figure 6. i-Tree Canopy Valuation of Tree Benefits for Air Pollution Reduction in Agawam

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	1,720.50	±85.06	$357	±18
NO2	Nitrogen Dioxide removed annually	62,328.03	±3,081.58	$2,767	±137
O3	Ozone removed annually	282,463.29	±13,965.36	$117,720	±5,820
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	56,177.92	±2,777.51	$42,261	±2,089
PM2.5	Particulate Matter less than 2.5 microns removed annually	13,974.28	±690.91	$285,975	±14,139
SO2	Sulfur Dioxide removed annually	14,958.21	±739.55	$274	±14
Total		**431,622.23**	**±21,339.97**	**$449,353**	**±22,217**

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 156.892 @ $0.21 | NO2 5,683.703 @ $0.04 | O3 25,757.872 @ $0.42 | PM10* 5,122.874 @ $0.75 | PM2.5 1,274.317 @ $20.46 | SO2 1,364.042 @ $0.02 (English units: lb = pounds, mi² = square miles)

FIGURE 7. AGAWAM CANOPY AND IMPERVIOUS COVER ANALYSIS



Key Considerations for Public Health

In a region with generally poor air quality,[13] protecting and enhancing associated benefits from tree canopy is of high importance.

As shown in Figures 8 through 11 on pages 10-11, 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.

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.[14]

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 Agawam's census block

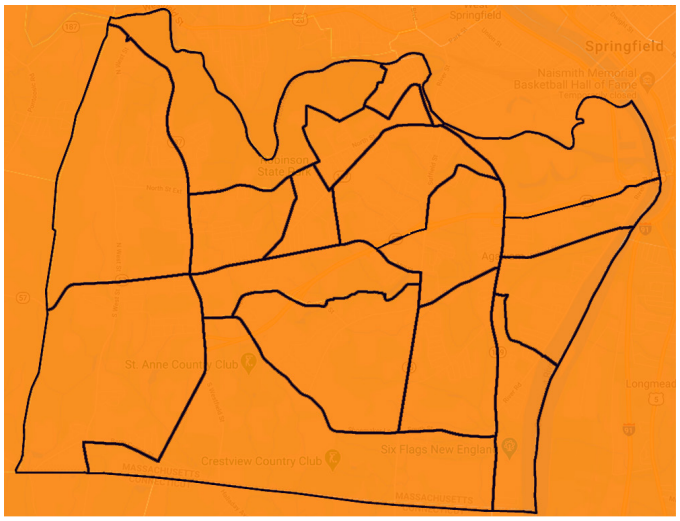
groups. These visualizations can be found in Figures 8 through 11.

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 town 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, Agawam suffers from unhealthy air quality throughout the year.

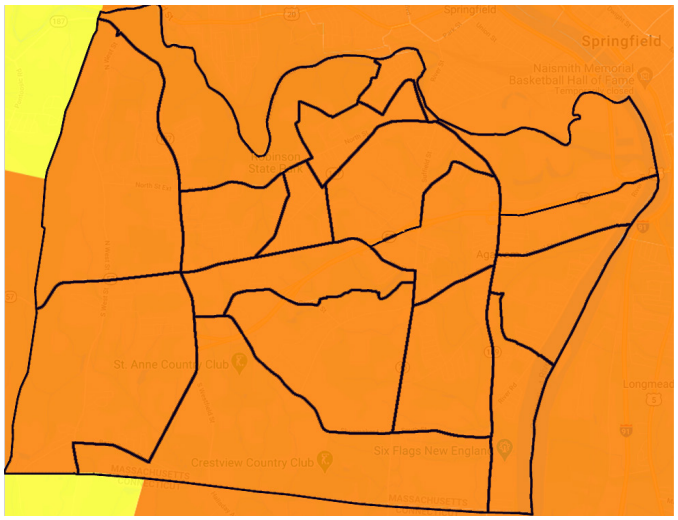
Figure 8. Annual Average and Maximum Particulate Matter in Agawam



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.

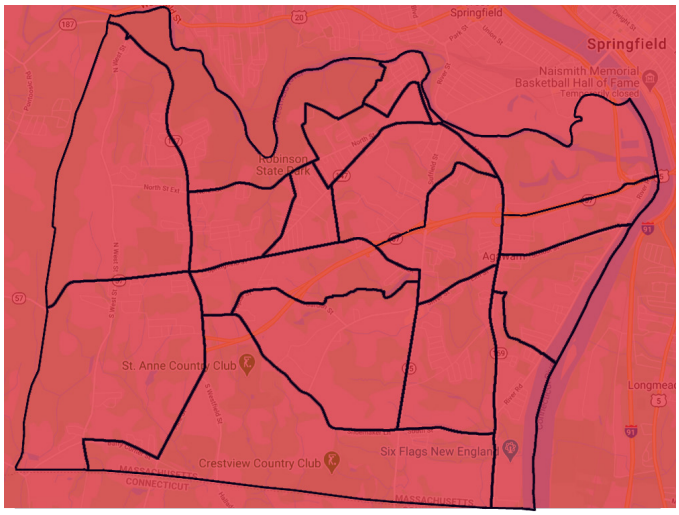


Particulate Matter (PM2.5) Maximum

- 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. Annual and Maximum UV Index in Agawam

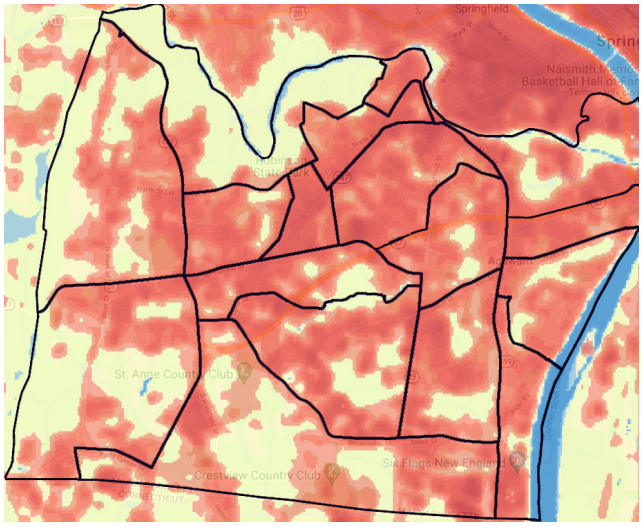


Ultraviolet Index (Average and Maximum)

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 10. Land Surface Temperature Difference in Agawam

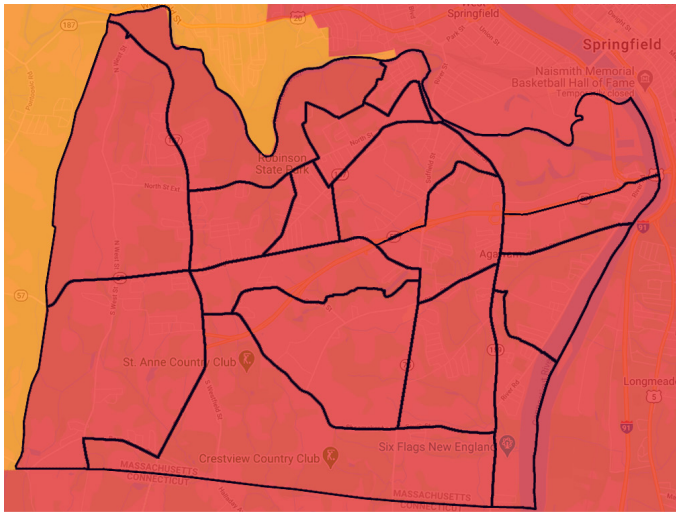


Land Surface Temperature Difference

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 Sens Data. Temperature values are the difference from the median surface temperature for eac Landsat scene - landsat.usgs.gov.

Figure 11. Annual Ozone Maximum in Agawam



Ozone (O3) Maximum

Good [50 thru 54 (ppb)]
Moderate [55 thru 70 (ppb)]
Unhealthy for Sensitive Groups [71 thru 85 (ppb)]
Unhealthy [86 thru 105 (ppb)]
Very Unhealthy [106+ (ppb)]

The maximum O3 (ppb) value for all days in 2008 from U.S. EPA Downscaler Modal - epa.gov.

NEXT STEPS AND SAMPLE PRIORITIZATION SCENARIOS

How to Set Canopy Cover Goals

The purpose of this report is to detail existing conditions; the report does not set canopy goals or targets for the Town of Agawam's neighborhoods or census block groups. It is up to the Town 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
- Regional climate (i.e., canopy cover in desert cities is often less than tropical cities)."[15]

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 forested states.[16]

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, Board of Health, 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 increased canopy cover for any default or custom scenario. Below are examples of several default scenarios as provided by the website.

Sample Prioritization Scenarios

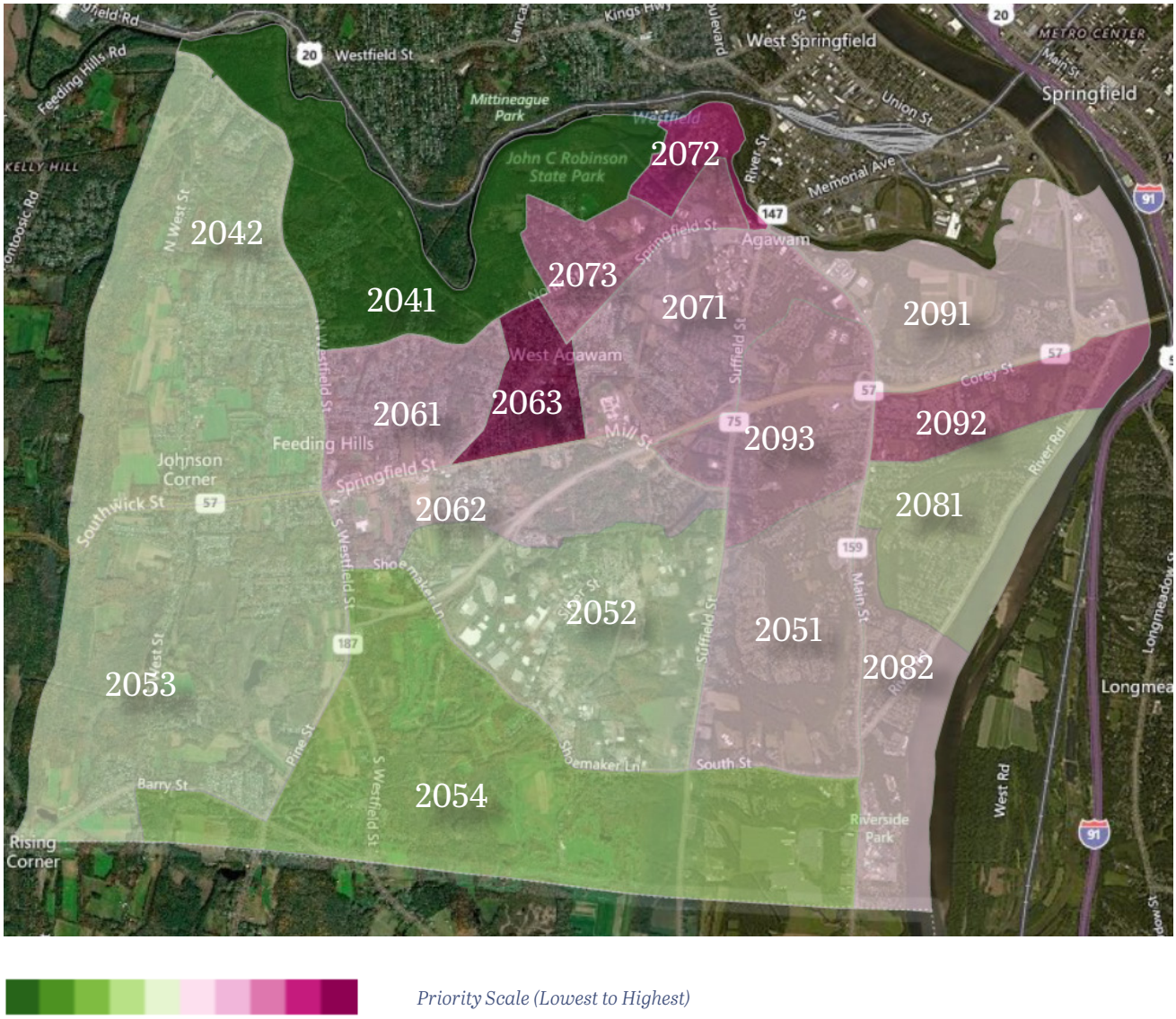
The following canopy cover prioritization scenarios were generated via i-Tree Landscape's Common (default) Scenarios component. Using the town's boundaries as the area limit, each Common Scenario is weighted to prioritize specific census block groups within the town based on enhancing specific canopy 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 generally identifies census block groups within Central Agawam, North Central Agawam, and Northeastern Agawam as having the strongest need for increased canopy cover. Specifically, census block groups 2063 and 2072 as the highest priority to increase canopy cover by population density, followed by census block groups 2073 and 2092. Census block groups 2041 and 2054 are lowest priority, due to lower population densities and relatively high canopy cover per capita.

Figure 12. Sample Prioritization Scenario 1: Population Density

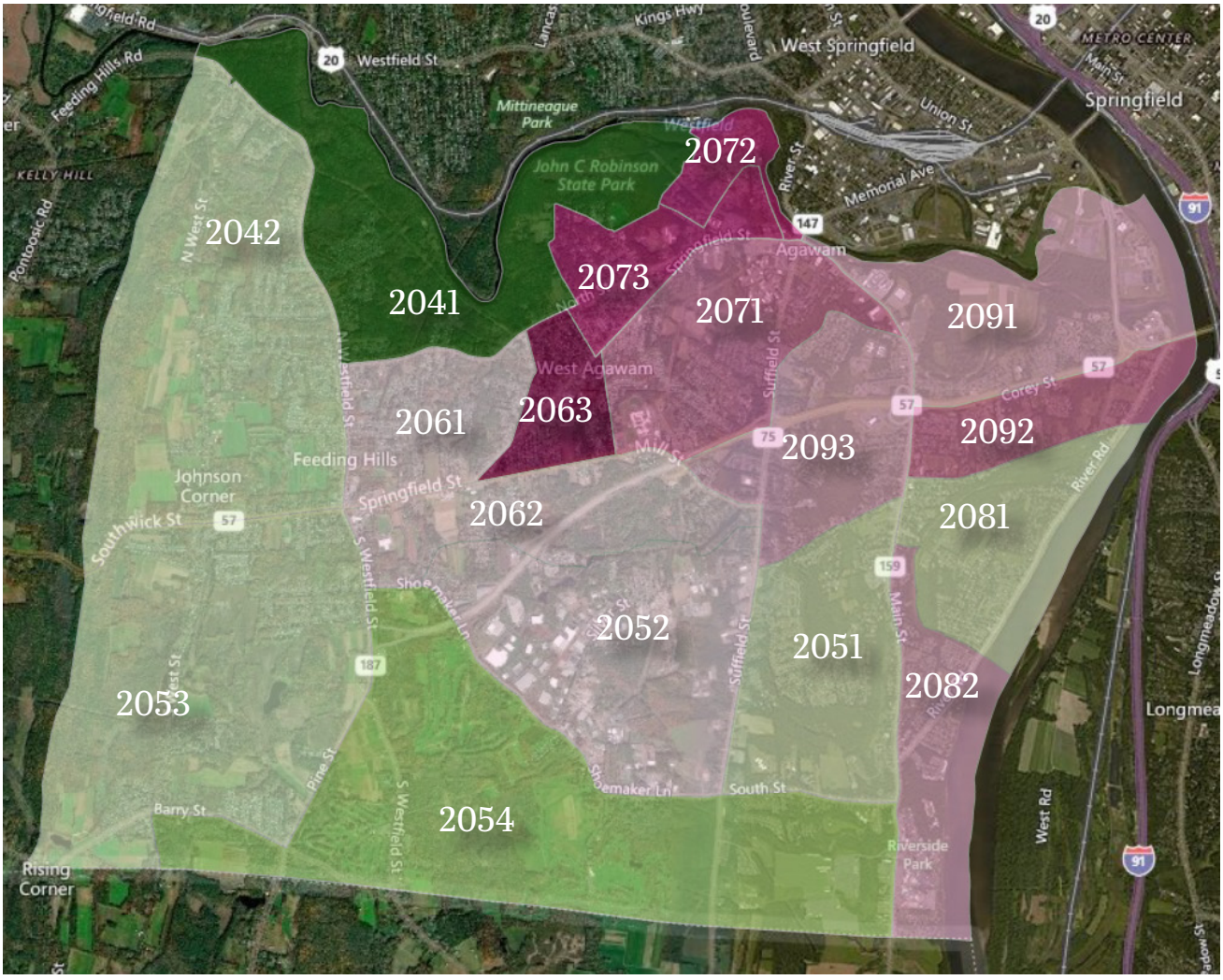


Sample Prioritization Scenario 2: Minority Population

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, North Central and Northeastern Agawam are again identified as the highest priority area for increasing canopy cover. Census block group 2063, located in the Central Agawam census tract, has the highest need for inceased canopy cover, while the remaining census block groups within the tract are ranked more neutrally. Again, census block groups 2041 and 2054 are ranked as the the lowest priority.

Figure 13. Sample Prioritization Scenario 2: Minority Population



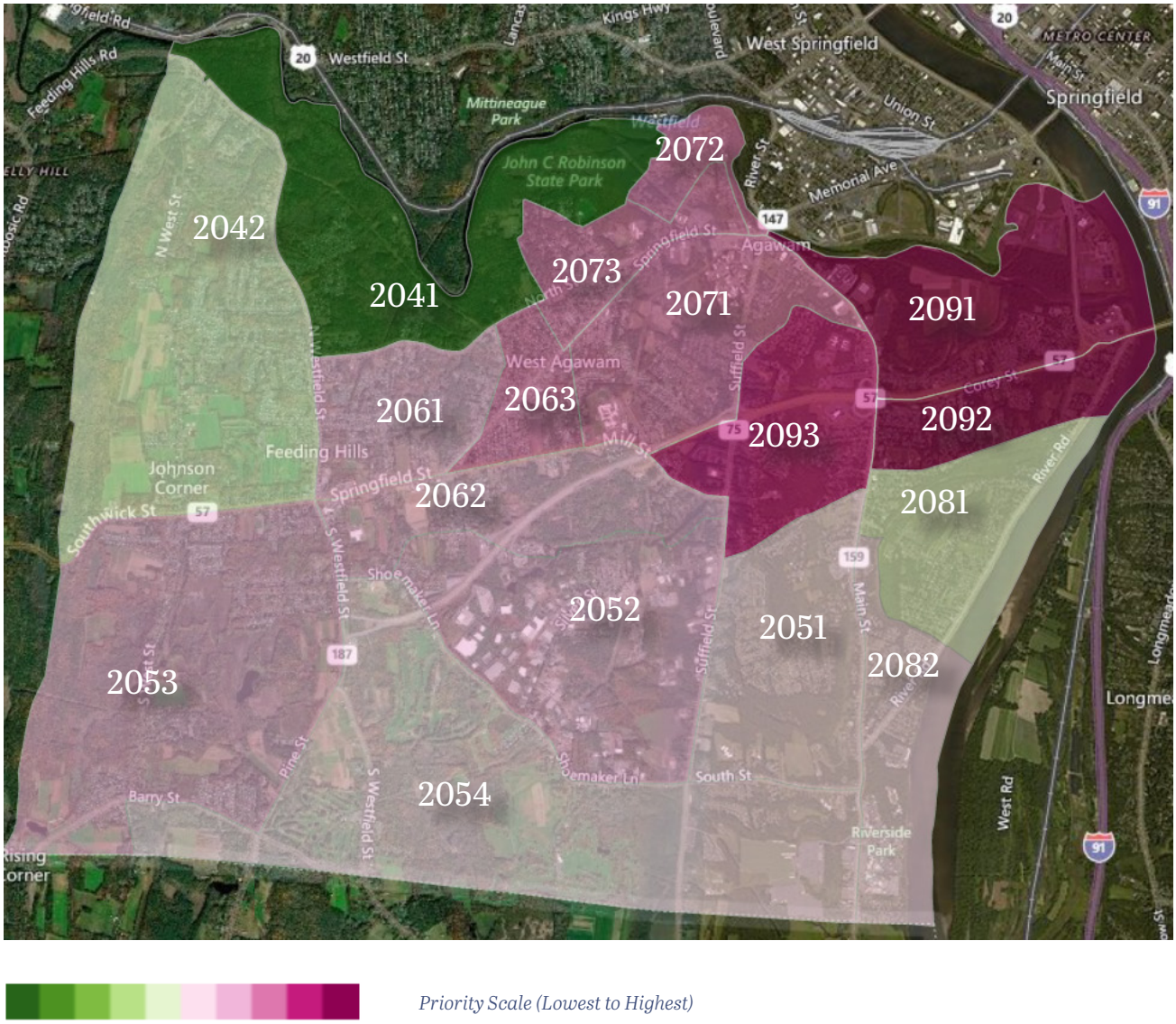
Priority Scale (Lowest to Highest)

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 groups in Northeastern Agawam and North Central Agawam have second priority. Much of Feeding Hills is ranked neutrally, while census block groups 2041 is again in least need.

Figure 14. Sample Prioritization Scenario 3: Population Below Poverty Line



Priority Scale (Lowest to Highest)

ENDNOTES

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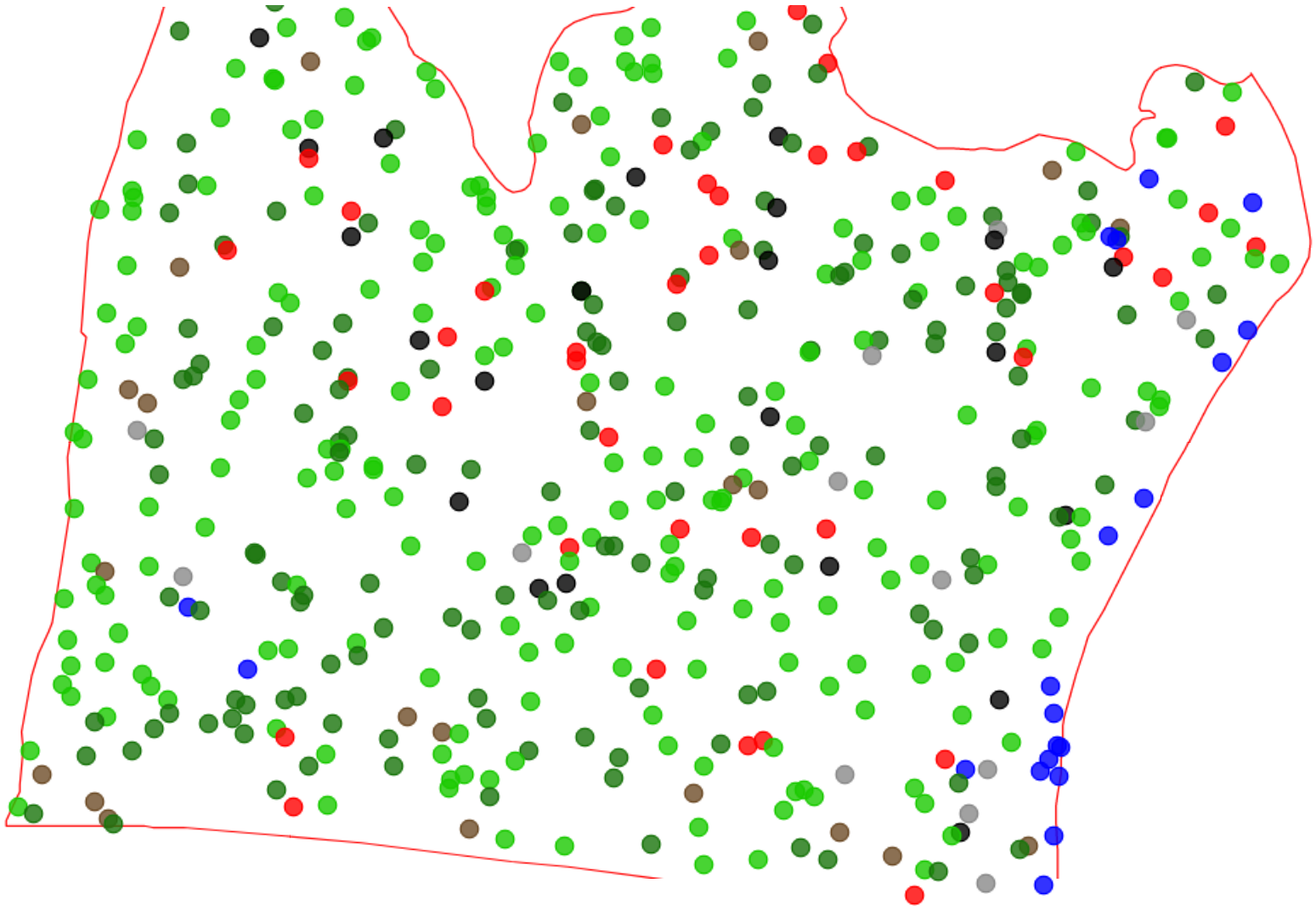
APPENDIX A: I-TREE CANOPY ASSESSMENT

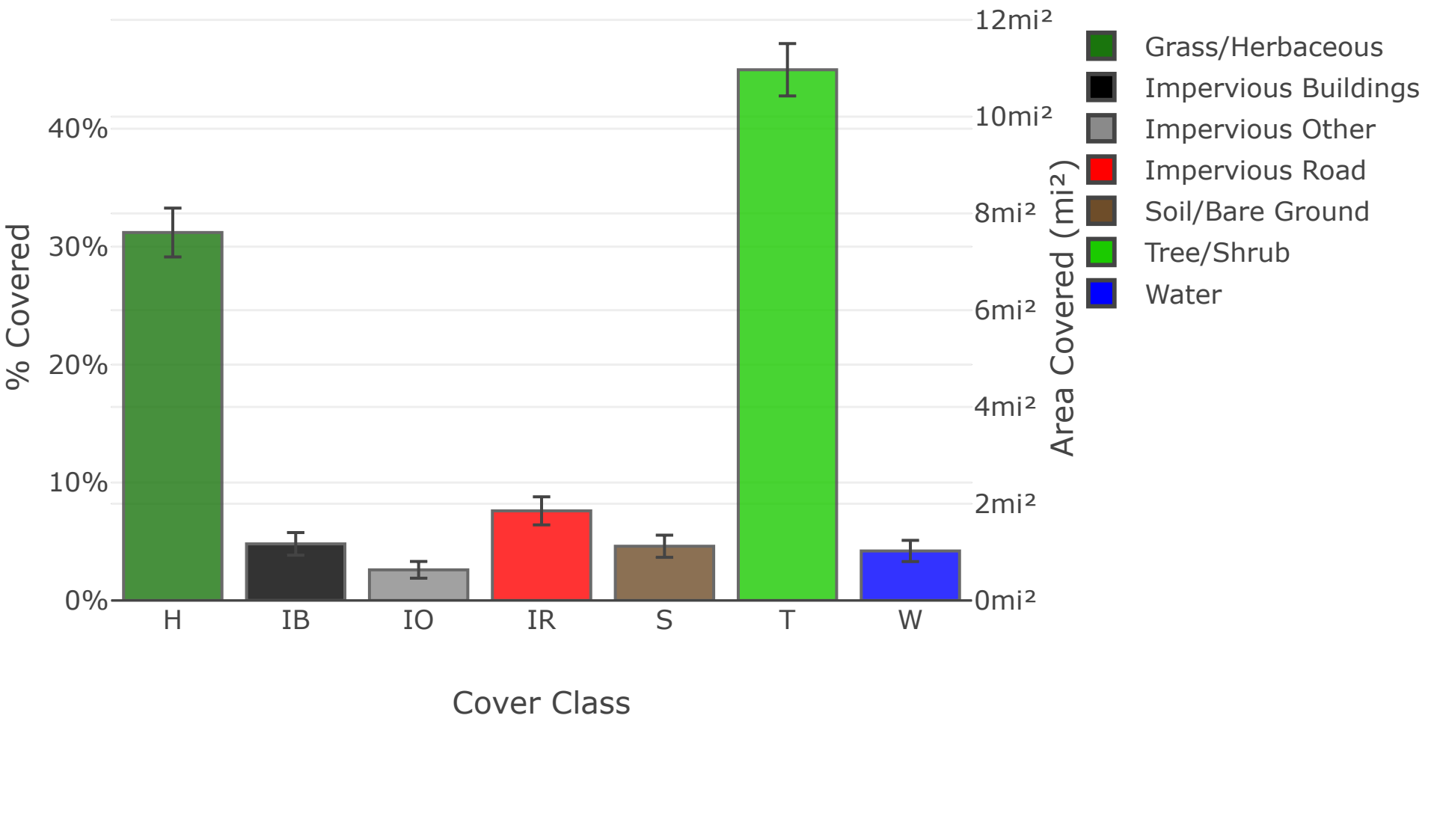
i-Tree Canopy v7.0

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 6/12/2020



Land Cover



Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (mi²) ± SE
H	Grass/Herbaceous		156	31.20 ± 2.07	7.60 ± 0.50
IB	Impervious Buildings		24	4.80 ± 0.96	1.17 ± 0.23
IO	Impervious Other		13	2.60 ± 0.71	0.63 ± 0.17
IR	Impervious Road		38	7.60 ± 1.19	1.85 ± 0.29
S	Soil/Bare Ground		23	4.60 ± 0.94	1.12 ± 0.23
T	Tree/Shrub		225	45.00 ± 2.22	10.97 ± 0.54
W	Water		21	4.20 ± 0.90	1.02 ± 0.22
Total			**500**	**100.00**	**24.37**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (kT)	±SE	CO_2 Equiv. (kT)	±SE	Value (USD)	±SE
Sequestered annually in trees	9.58	±0.47	35.13	±1.74	$816,957	±40,391
Stored in trees (Note: this benefit is not an annual rate)	240.60	±11.90	882.18	±43.62	$20,516,850	±1,014,380

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/mi²/yr. Carbon stored is based on 21.940 kT/mi². Carbon is valued at $23,256.92/kT. (English units: kT = kilotons (1,000 tons), mi² = square miles)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	1,720.50	±85.06	$357	±18
NO2	Nitrogen Dioxide removed annually	62,328.03	±3,081.58	$2,767	±137
O3	Ozone removed annually	282,463.29	±13,965.36	$117,720	±5,820
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	56,177.92	±2,777.51	$42,261	±2,089
PM2.5	Particulate Matter less than 2.5 microns removed annually	13,974.28	±690.91	$285,975	±14,139
SO2	Sulfur Dioxide removed annually	14,958.21	±739.55	$274	±14
Total		**431,622.23**	**±21,339.97**	**$449,353**	**±22,217**

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 156.892 @ $0.21 | NO2 5,683.703 @ $0.04 | O3 25,757.872 @ $0.42 | PM10* 5,122.874 @ $0.75 | PM2.5 1,274.317 @ $20.46 | SO2 1,364.042 @ $0.02 (English units: lb = pounds, mi² = square miles)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	24.49	±1.21	$218,804	±10,818
E	Evaporation	539.72	±26.68	N/A	N/A
I	Interception	540.87	±26.74	N/A	N/A
T	Transpiration	794.94	±39.30	N/A	N/A
PE	Potential Evaporation	4,176.04	±206.47	N/A	N/A
PET	Potential Evapotranspiration	3,049.99	±150.80	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/mi²/yr @ $/Mgal/yr:
AVRO 2.233 @ $8,936.00 | E 49.217 @ N/A | I 49.322 @ N/A | T 72.491 @ N/A | PE 380.814 @ N/A | PET 278.129 @ N/A (English units: Mgal = millions of gallons, mi² = 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.