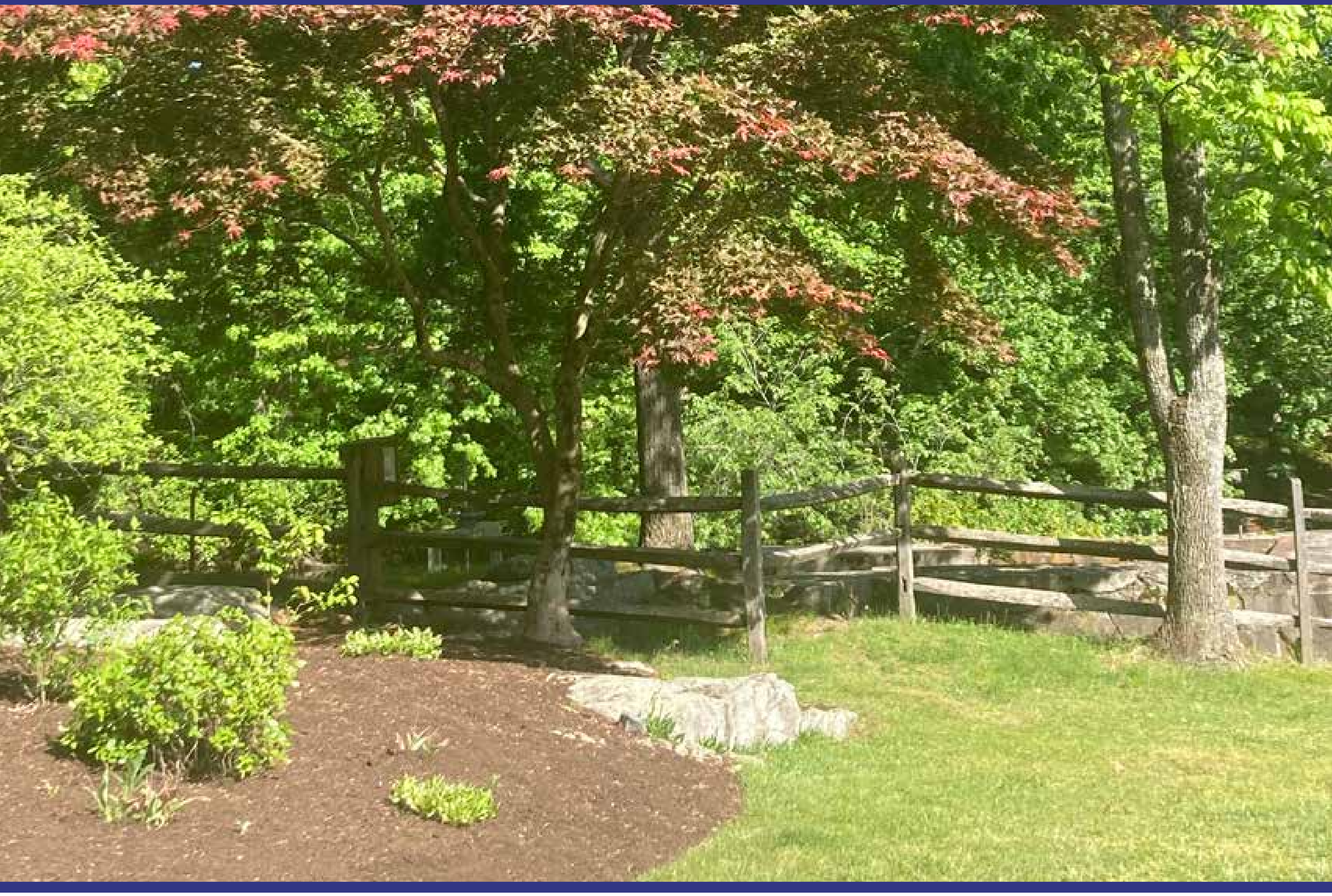
East Providence
RHODE ISLAND

Strategic Tree Canopy Plan



MARCH 2024

Prepared by the Green Infrastructure Center Inc.

Green Infrastructure Center

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Publication Date: March 2024

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Executive Summary

This plan and the accompanying assessments were completed by the Green Infrastructure Center, Inc. through a grant from the Rhode Island Department of Environmental Management's Division of Forest Environment (DFE). This plan describes the findings of the tree canopy assessment, ecosystem services analysis, and codes and ordinances assessment for East Providence, Rhode Island. Building upon these data the city, DFE, GIC and stakeholders participated in goal setting sessions and developed proposed strategies for meeting the goal to maintain tree canopy at 34% over the next 10 years. Data and strategies were presented to the public at an open house where they were given an opportunity to vote on proposed strategies and add additional comments. Finally, Force of Nature Solutions (FoNS), a consultant company, was brought in to connect trees as green infrastructure and provide guidance on how these data and proposed strategies could be used for disaster planning and hazard mitigation.

East Providence Canopy Goal: Maintain Tree Canopy at 34% over the next 10 years

Top Five Strategies to Achieve This Goal:

- Revise landscaping requirements for parking lots in Commercial and Office zones.
- Retrofit impervious commercial properties with new trees.
- Educate the public on the importance of trees to public health and the environment.
- Build and train a youth workforce to help manage the urban forest.
- Revitalize street corridors with tree plantings.

(Above) Some of the best areas for planting trees are on residential private property. The city's Tree Setback Planting Program is one way to increase canopy in right-of-ways and neighborhoods.

(Left) Rhode Island's Division of Forest Environment received federal funding sources to plant more trees in communities. This highlights the importance of using high quality data in deciding how to allocate these resources equitably across the city.

East Providence Fast Facts

County: Providence County
Population: 46,691 people*
Total City Area: 16.5 sq. miles
Land Area: 13.3 sq. miles
Lakes/ponds: 295 acres
Swamp & Marsh: 509 acres
Tidal shoreline: 14.4 miles
Streams: 16.6 miles
Tree canopy: 2,927 acres
Impervious surfaces: 3,188 acres

**(U.S. Census 2022 estimate)*

Moving Forward, East Providence Can Use the Results of This Report to:

- Support the city's implementation of a federal award from the U.S. Forest Service through the Inflation Reduction Act (IRA) to plant more trees and increase tree canopy at schools and in underserved neighborhoods.
- Build capacity for the City's Street Tree and Tree Setback Planting programs.
- Identify areas to plant trees, slowdown and soak up stormwater and improve water quality and reduce nonpoint source nutrients flowing into Narragansett Bay.
- Document the many environmental and social benefits provided by city trees.
- Determine the strategic locations for retaining or planting trees to realize environmental and social equity benefits.
- Inform management of the city's urban forest and support investments in tree care and planting.
- Prioritize policy and code updates to support more tree plantings and tree retention.

Trees play an important role in mitigating stormwater runoff and preventing nonpoint source pollution from entering into local waterbodies such as the Narragansett Bay.

Summary Outcomes

Canopy

East Providence has a tree canopy of 34%. The city has room to add more tree cover that would provide many benefits to the city for shade, air quality, urban cooling and habitat and natural beauty. These benefits provided by trees are called ecosystem services. East Providence could achieve a maximum tree canopy of 41%, with any increase in tree canopy increasing the benefits provided.

Air quality

Trees play a critical role in not only providing oxygen, but also cleaning the air of particulate matter and ground level ozone (O3), which can harm human health. Trees also sequester greenhouse gases such as sulfur dioxide and carbon dioxide, and as these gasses are trapped by trees, the severity of climate change is reduced. Trees also store carbon and prevent its release, mitigating climate change impacts. Each year, the tree canopy of East Providence removes 12,732 metric tons of carbon, 58,294 lbs. of ground-level ozone (O3) and 12,700 lbs. of airborne particulate matter that can cause respiratory distress.

Heat Island

Similar to most cities, East Providence suffers from the urban heating and stormwater runoff impacts from too much impervious surface coupled with a lack of vegetative cover. Excessive pavement and lack of shade lead to increased temperatures known as urban heat islands. The lower the tree canopy cover, the higher the surface temperatures and the hotter the city.

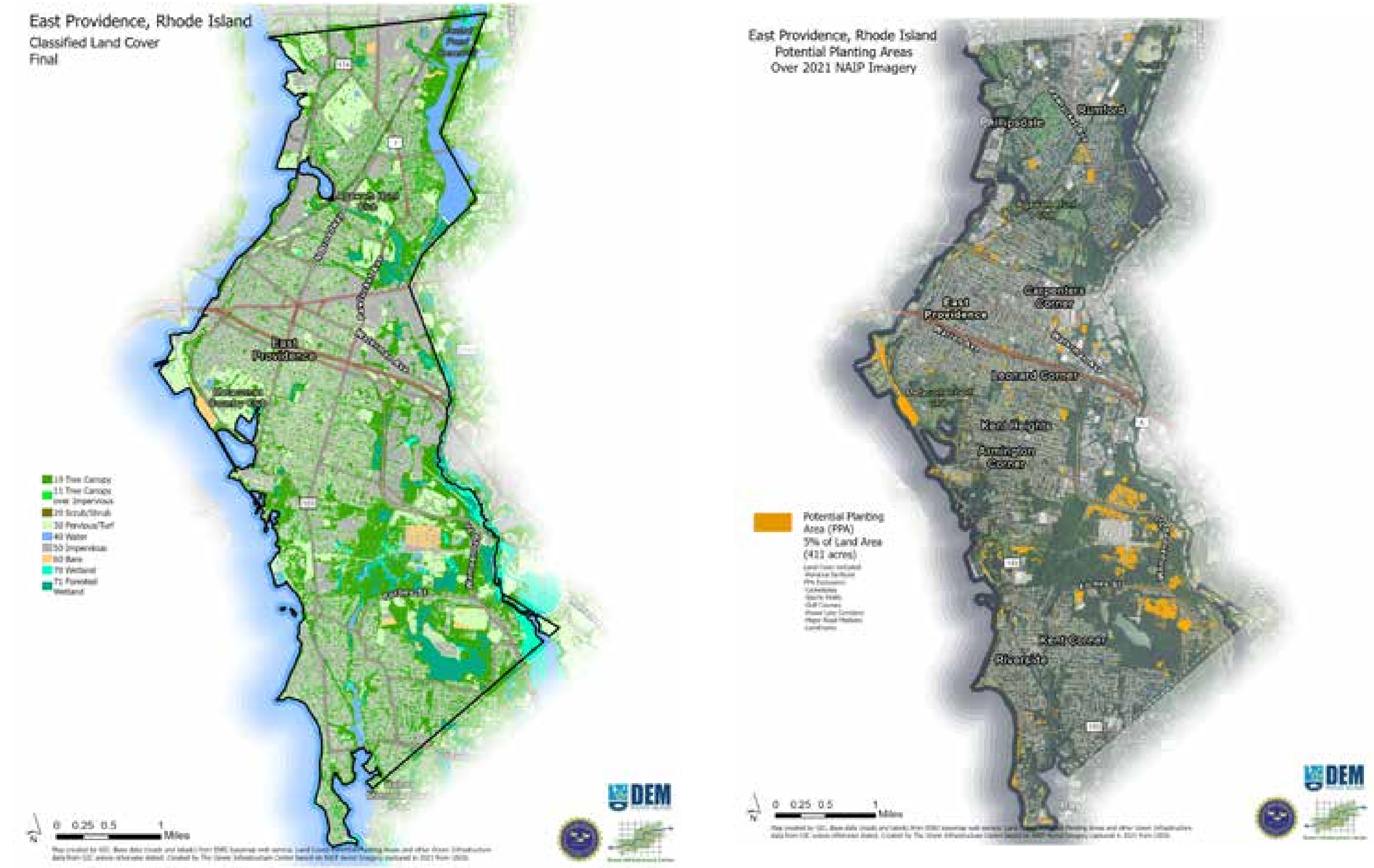
Stormwater Uptake

The city's trees also help mitigate stormwater as they capture rainfall in their canopy, trunk and roots and surrounding soils and then release some of that water back to the atmosphere through evapotranspiration. One mature large tree can absorb thousands of gallons of water per year. During a one-year/24-hour rainfall event (2.82 inches), the city's trees soak up 8.8 million gallons of water! This means less flooding of streets. During that same rainfall, the city's trees reduce runoff pollution loads for nitrogen by 16%, phosphorus by 23%, and sediment by 14%, thereby reducing water pollution.

Canopy Trends and Goals

Maintaining canopy while keeping up with losses as older trees age and die, are lost to storms, or are cleared for development, requires the city to continually plant trees. As the city recovers from past storms and continues to grow and develop, it will be important to maintain existing coverage and to plant replacement trees to overcome losses. In order to achieve its proposed goal, the community needs to increase the rate of planting to prepare for and to recover from natural disasters and the impacts of new development.

East Providence has proposed a citywide goal of maintaining at least 34% canopy with the aim of increasing by 1-2% over the next ten years. This requires planting more than 12,105 trees in total or 1,200 trees annually across the city to achieve a goal of 36%. The city can reassess progress and adapt its canopy goal over time to achieve a higher overall canopy coverage.



The City of East Providence now has baseline data on its tree canopy and potential planting areas to identify opportunities to plant new trees. More trees equate to better air quality, shade and energy savings, more stormwater uptake and improved water quality too!

Introduction

East Providence is a 16.6 square-mile community in Providence County in Eastern Rhode Island and is the fifth largest city in the state, with an estimated 2022 population of 46,691 persons. The city is 78.9% non-Hispanic Whites, 5.4% Black/African Americans, 2.5% Asian, and 7.6% Latino residents[1].

The Narragansett Bay (Algonquian: Naiaganset) is a brackish water body covering 120.5 square miles of Rhode Island and it is an important ecological, economic and cultural resource for Rhode Islanders. The bay's border adjoins 14 miles of East Providence's shoreline along with the Seekonk and Providence Rivers to the north and the Ten Mile River which feeds into the Runnins River to the east of the city, all of which flow into the bay. The Runnins River is a designated "Special Resource Protection Waters" (SRPW) by the Rhode Island Department of Environmental Management (RIDEM) for its high-quality surface waters, and its ecological and recreational values. With 825 acres of municipal parks, beach and conservation lands, the city is rich in natural amenities that contribute to its high-quality lifestyle.

Gray vs Green. The Image on the left shows an example city's gray infrastructure including buildings and roads. Classified high-resolution satellite imagery (at right) adds city green infrastructure data layer (trees and other vegetation). The green infrastructure provides cleaner air, water, energy savings and natural beauty.

Why Map the Urban Canopy?

Trees are declining throughout the United States. The causes of decline include land conversion for development, storm damage, pests and disease, and lack of tree replacement as older trees die. Many communities in Rhode Island are looking for ways to protect or expand their tree canopy and community forests. Data about the East Providence's trees will allow the city to track trends, assess losses or set goals to retain or restore canopy. Through this planning process the city now has baseline data to set canopy goals, monitor canopy protection progress, measure environmental benefits of city trees and prioritize strategic tree planting locations.

Trees are part of the city's green infrastructure. Just as we manage our grey infrastructure (roads, sidewalks, bridges and pipes), we also need to manage our 'green infrastructure' (trees and other vegetation). East Providence's green infrastructure provides many values that support a vibrant, safe and healthful city. Trees add to the city's historic coastal character, and they enhance its livability by filtering storm water and reducing runoff, cleaning the air, providing oxygen, shading, and natural beauty and enhanced property values. As the city continues to grow and adapt to climate change and more frequent and severe storm events, it should also manage and expand the urban forest. This will meet the city's vision as it "embraces a positive community understanding of the value that natural resources have on the quality of life in a community" (Natural Resources Element, East Providence Comprehensive Plan 2010-2015).

One of the City's beautiful trees

[1]https://www.census.gov/quickfacts/fact/table/eastprovidencecityrhodeisland/PST045222

The Canopy Assessment

This report describes the state of the city's urban forest based on current canopy coverage, an analysis of the canopy's environmental benefits and a review of the relevant codes and ordinances. With these data, the city and community devised strategies to sustain and expand the urban forest. Products created include:

- Analysis of the current extent of the urban forest through high resolution tree canopy mapping
- Possible Planting Area analysis to determine where additional trees could be planted
- Calculation of the environmental benefits and pollution removal by city trees
- Analysis of city's codes, ordinances and practices for effective conservation, protection, and management of the urban forest
- A public open house addressing priority tree planting efforts and the top strategies for increasing tree canopy
- Tree canopy community outreach and educational materials

The city can utilize the tree canopy to maximize environmental and social benefits including:

- Community health and vibrancy
- Aesthetic values and natural beauty,
- Decreased urban heat island and reduced heating and cooling costs,
- Abundant bird and wildlife habitat.
- Expanded walkability and multimodal transit support; and,
- Revenue from tourism and retail sales.

How the Urban Forest Benefits East Providence, RI

Reducing Stormwater Runoff and Filtering Pollutants

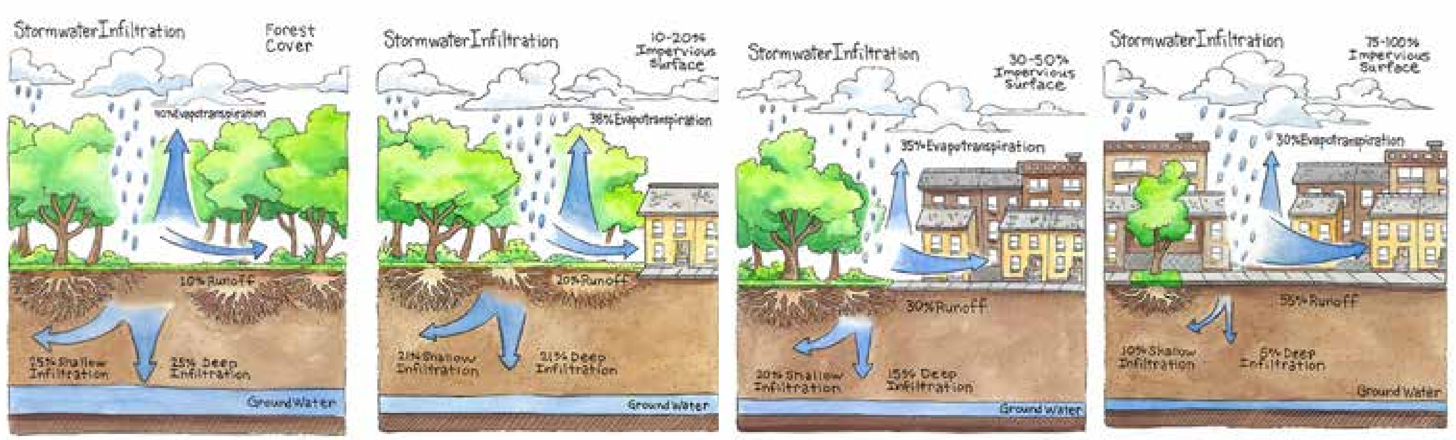
Trees protect cities from problems associated with stormwater runoff. However, as forested land is converted to impervious surfaces, runoff increases. Excess stormwater runoff can cause temperature spikes in receiving waters, increased pollution of surface and ground waters, and greater potential for flooding.

Trees also reduce nitrogen, phosphorus, and sediment runoff by cleaning rainfall and stormwater of these pollutants. Increased loads of nutrients can reduce oxygen in surface water causing harm to fish and other aquatic life. The presence of trees means less pollutants reach drainage ditches, the river, and the bay.

The average annual precipitation in East Providence is 45 inches (114 cm), some of which runs off carrying surface pollutants. Large, paved areas contribute significant volumes of this runoff. During a one-inch rainfall event, a one-acre paved area such as a mall parking lot, will release 27,000 gallons of runoff compared to an acre of forest, where only 750 gallons of water runoff. While stormwater ponds and other best management practices are designed to mimic rainfall release by detaining and filtering runoff, they do not

Forests and tree canopy reduce nonpoint source pollution from entering into the local waterways such as the Ten Mile River and ultimately the Narragansett Bay.

Water Infiltration Rates with Development



Stormwater runoff increases as land is developed. Data Source: U.S. EPA

fully replicate pre-development hydrology. In addition, older parts of the city may lack stormwater management practices that are required for new developments, so not all runoff is captured or treated before it flows to open waterways.

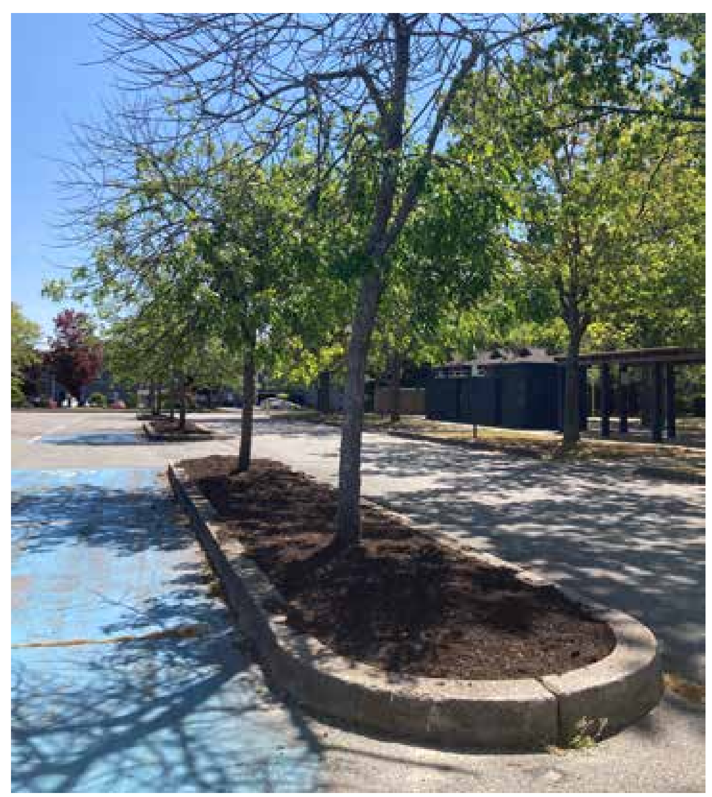
Since trees filter stormwater and reduce overall flows, planting or conserving trees is a natural way to mitigate stormwater. Each tree plays an important role in stormwater management. Based on the GIC's review of multiple studies of canopy rainfall interception, a typical street tree's crown can intercept between 760 gallons to 4000 gallons of water per tree per year, depending on the species and age. During a 1-year/24-hour rainfall event (2.82 inches) in East Providence, the trees take up 8.8 million gallons of runoff, or about 18 Olympic swimming pools of water. In a larger rainfall event similar to the Rhode Island floods in 2010 (up to 5 inches of rain in 24 hours) the trees take up 25 million gallons.

As tree cover is lost and impervious areas expand, excessive urban runoff results in pollutants such as oil, metals, lawn chemicals (e.g., fertilizer and herbicides), pet waste, trash, and other contaminants flowing into surface waters. Trees help capture and filter that urban runoff. According to GIC's stormwater model, during a 1-year/24hour rainfall event (2.82 inches) in East Providence the trees capture:

- 20,650 lbs. nitrogen,
- 1,673 lbs. of phosphorus and
- 1,257 tons of sediment.

Nitrogen and phosphorus are plant nutrients that can cause harmful algal blooms while sediment can clog fish gills, smother aquatic life, and necessitate additional dredging of canals and waterways. Algal blooms can reduce oxygen levels further harming fish and other aquatic life.

Excess impervious areas cause hot temperatures and runoff. This parking lot can be retrofitted to add more trees.



There are many spaces in existing parking lots where tree islands can be improved to support healthier tree growth.

Trees help mitigate stormwater runoff from both residential and institutional properties.

Buffering Storms and Flooding

Another benefit of conserving trees and forests is buffering against storms and losses from flooding. According to the U.S. Environmental Protection Agency (EPA), excessive stormwater runoff accounts for more than half of the pollution in the nation's surface waters and causes increased flooding and property damages, as well as public safety hazards. The EPA recommends a number of ways to use trees to manage stormwater in the book Stormwater to Street Trees.

Retaining trees and forests along coasts also provides a wind break and helps to evaporate and reduce standing water. In addition, utilizing trees as 'green infrastructure' can provide a basis for reimbursement from FEMA if trees are damaged during storms. To qualify, trees must be inventoried and specifically utilized for stormwater management, erosion and sediment control, buffers or other green infrastructure functions.

East Providence participates in the National Flood Insurance Program's Community Rating System (CRS). The CRS is a voluntary incentive system that allows local governments to earn flood insurance premium discounts for policyholders in the community. Local governments receive points for actions or policies that reduce flooding and flood damage; these points earn premium discounts as high as 45%. East Providence is currently rated as Class 8 in the CRS program, saving residents and businesses within its special flood hazard areas a 10% discount on standard-rate policies.

Additionally, communities can earn credit for adopted management plans that protect the critical natural functions of floodplains and native species, while implementing habitat restoration projects. CRS requirements include an inventory of all species in the plan's geographic purview, action items for protecting one or more of the identified species of interest, restoring natural floodplain functions, and the review and update of the plan every 10 years. If a green infrastructure plan is created using the canopy data, this can also be tied to the city's effort to earn additional points in the CRS to further reduce flood insurance premiums. Multiple objectives can be achieved by combining canopy data with the planning efforts to identify green infrastructure networks.

Air Quality and Surface Temperature

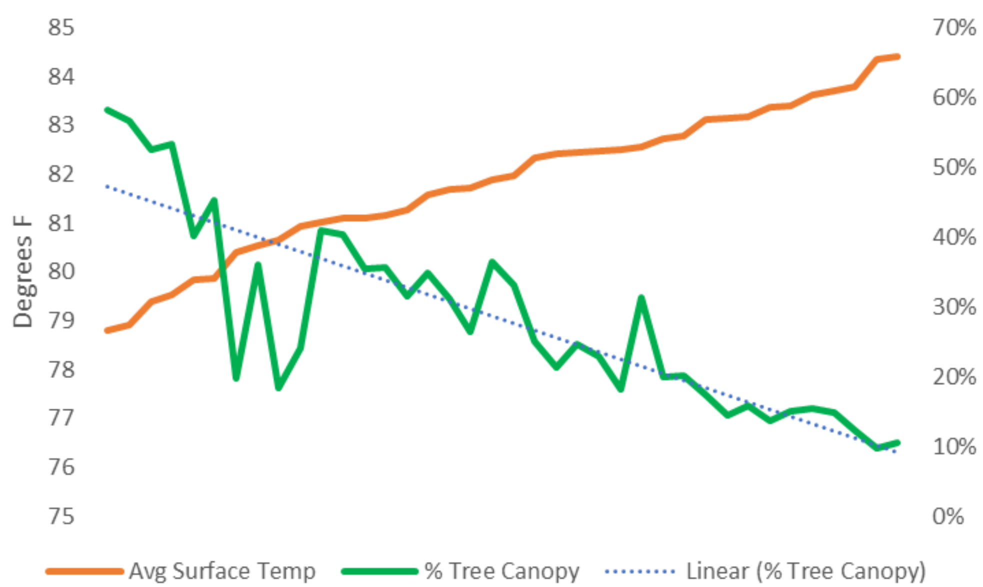
Trees Cool the City

As summer temperatures in Rhode Island climb, the importance of shade cast by trees increases. Excessive heat can lead to heat stress which especially affects infants and children up to four years of age, those 65+ years of age and older, those with underlying medical issues, and those on some medications (Centers for Disease Control 2020).

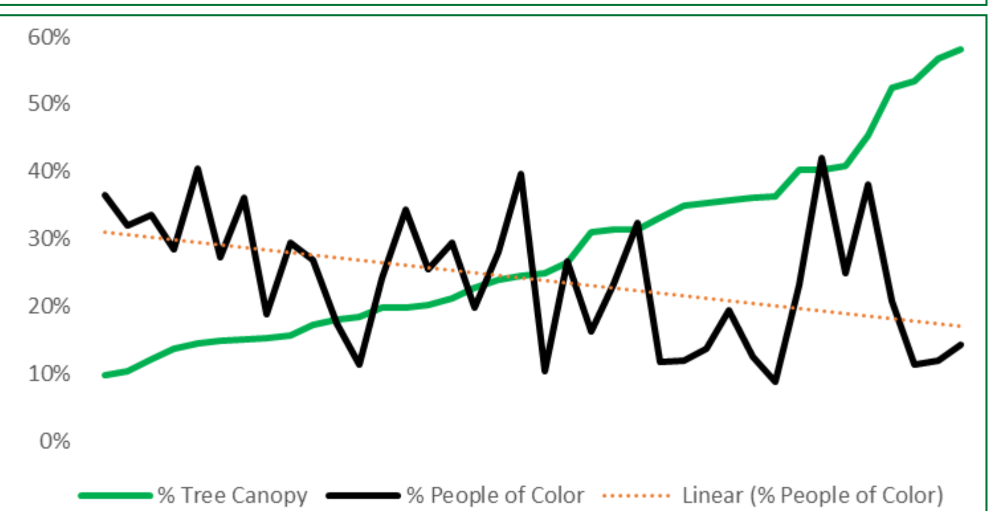
Tree cover shades streets, sidewalks, parking lots, and homes, making urban locations cooler, and more pleasant for walking or biking. Multiple studies have found significant cooling (2-7 degrees Fahrenheit) and energy savings from having shade trees in cities (McPherson et al 1997, Hashed et al 2001). Shaded pavement also has a longer lifespan, so maintenance costs associated with roadways and sidewalks are less (McPherson and Muchnick, 2005).

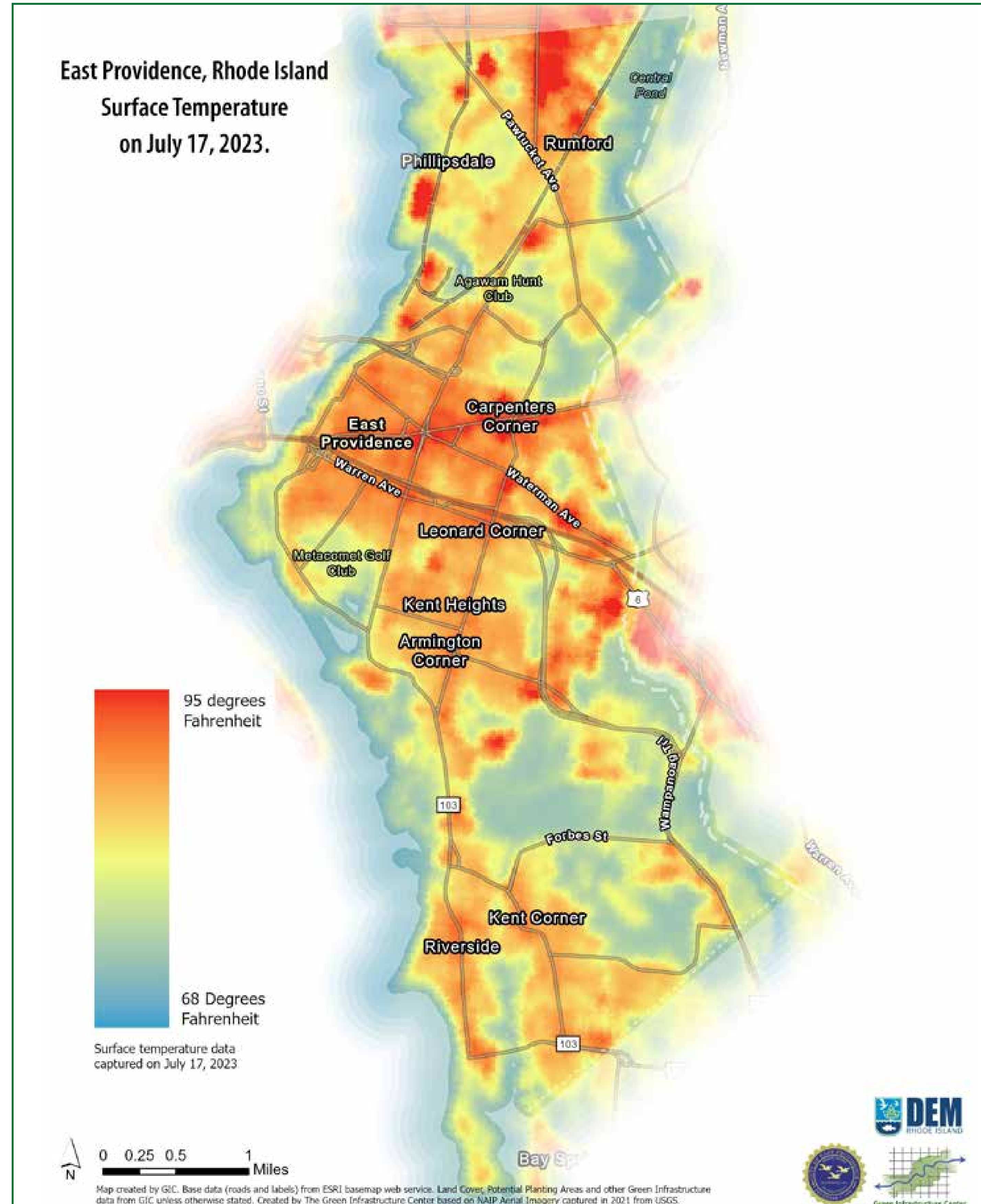
Using the tree canopy data, surface temperature data and U.S. Census data at the Block Group level, analyses can be done to identify inequities in the distribution of tree canopy and discover opportunities to correct those inequities through strategic tree planting efforts. The following map illustrates one way to prioritize tree planting efforts in the city through an urban heat island and tree equity lens. Using the Potential Planting Areas (PPA) data, surface temperature and the U.S. Census's Median Household Incomes (MHHI) data at the Block Group level, GIC prioritized areas of the city for tree planting that lack canopy, are the hottest and have low-income populations that are vulnerable to heat (see map on page 16). The city can use this data to do further analysis and inform how they implement tree planting efforts in the city that are equitable and help to restore canopy in neighborhoods where trees are lacking.

Higher surface temperatures are positively correlated with reductions in tree canopy coverage.

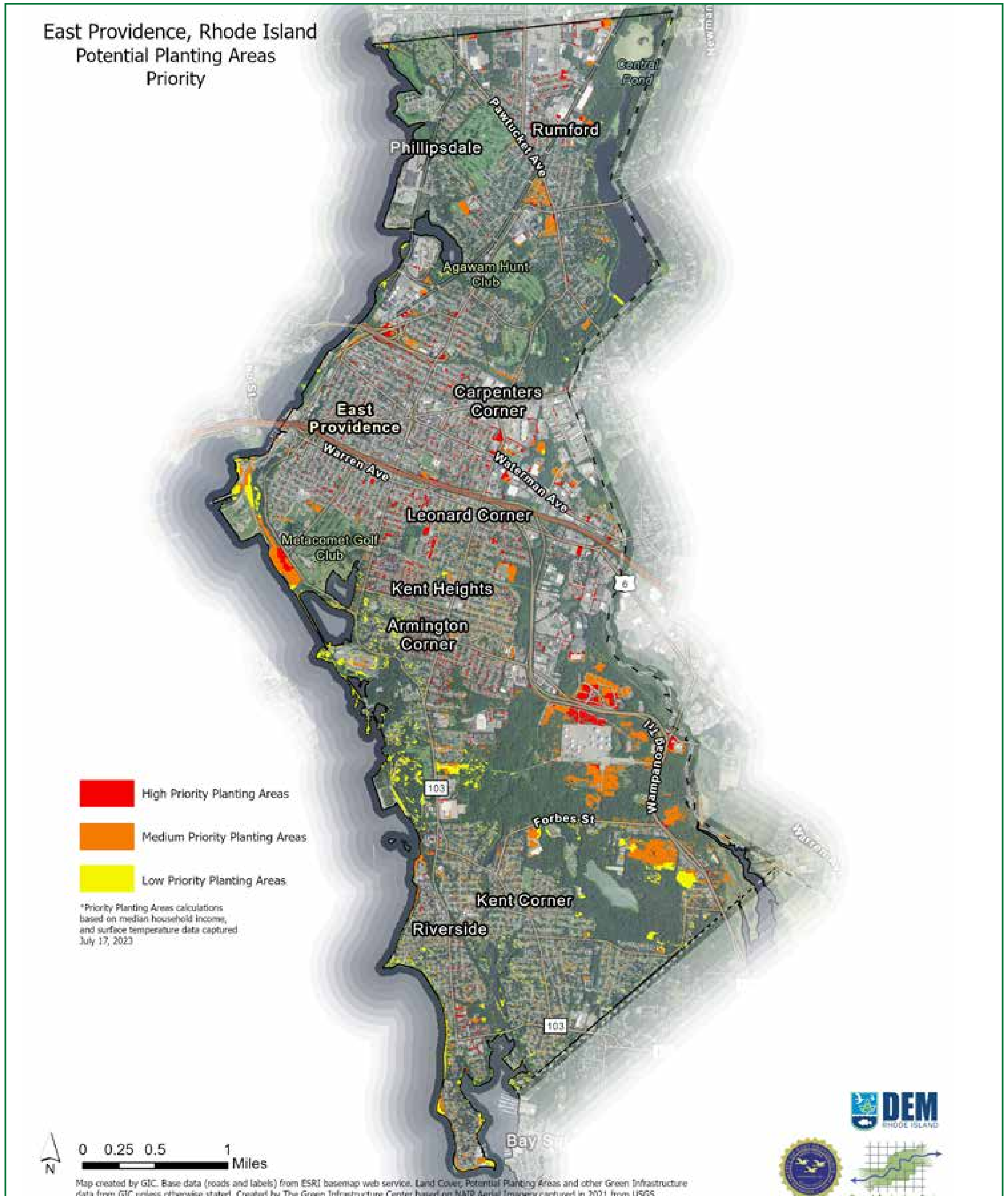


Combining U.S. Census data with tree canopy coverage we can see that Census Block Groups with higher percentages of People of Color (POC) tend to have lower canopy cover.





This map shows the hottest surface temperature areas (in degrees Fahrenheit) of East Providence on July 17, 2023.



This map shows one way to prioritize tree planting efforts in the city through a tree equity lens by focusing tree planting in the hottest and lowest income neighborhoods of the city.

Trees Clean the Air

In addition to cooling surfaces, trees absorb volatile organic compounds and particulate matter from the air, improving air quality, and thereby reducing asthma rates. Trees play a critical role in not only providing oxygen but also cleaning the air of particulate matter and ground level ozone (O3), which can harm human health. Trees also sequester greenhouse gases such as sulfur dioxide and carbon dioxide. As these gasses are trapped by trees, the severity of climate change is reduced. Trees also store carbon and prevent its release, further helping to alleviate possible climate change impacts. Even at the neighborhood level, trees reduce pollutants. Trees clean the air and well treed neighborhoods suffer less respiratory illnesses, such as asthma. (Rao et al, 2014),

Social Values

Trees Improve Cognitive Function

Children who suffer from Attention Deficit Hyperactivity Disorder (ADHD) benefit from living near forests and other natural areas. One study showed that children who moved closer to green areas have the highest level of improved cognitive function after the move, regardless of level of affluence (Wells 2000). Thus, communities with greener landscapes benefit children and reduce ADHD symptoms. Exposure to green spaces for 20 minutes a day can also improve cognitive function. Providing more natural areas on or near school grounds as well as greening routes to school can better prepare children to learn.

Edward R. Martin Middle School has room for many more trees on school grounds.

Exposure to green spaces for 20 minutes a day can improve cognitive function.

Well treed areas encourage people to walk and bike.

Trees Improve Walkability

The presence of trees leads people to walk more and walk farther. This is because when trees are not present, distances are perceived to be longer and destinations farther away, making people less inclined to walk than if streets are well treed (Tilt, Unfried and Roca 2007).

Nature Sells—

Market prices for treed lots *versus* untreed lots:

18% more	22% more	35% more	37% more
Building lots with substantial mature tree cover	Tree-covered undeveloped acreage	Lots bordering suburban wooded preserves	Open land that is two-thirds wooded

Source: Kathleen Wolf, 2007, *City Trees and Property Values*.

Home buyers are willing to pay more for homes located near a park or other natural area.

Trees Increase Property Values and Sales

Developments that include green space or natural areas in their plans sell homes faster and for higher profits than those that take the more traditional approach of building over an entire area without providing for community green space (Benedict and McMahon 2006).

A study by the National Association of Realtors found that 57% of those surveyed were more likely to purchase a home near green space and 50% were more willing to pay 10% more for a home located near a park or other protected area.

Urban Tree Loss – Reversing the Trend

East Providence now has baseline data to monitor canopy increases from plantings, measure the stormwater and water quality benefits of its urban forest, and prioritize restoration of canopy where it is most needed. Currently the city's canopy coverage is 34%, but it could be expanded.

To increase the canopy, the city needs to actively plant trees to replace those lost to natural mortality (old age), storms, development, pests, and neglect or poor care. As older trees die (or before they die), younger trees need to be planted to restore the older canopy. While the city has been planting trees, more trees need to be planted by both the public and private sectors at greater numbers to achieve the goal of a 2% citywide canopy increase. The data from this report can inform the city's tree canopy planting plan and can be shared with the public to encourage them to plant trees. This strategy can also be used to secure grants and donations to help fund the effort.

Newly Planted Tree

Why Are Urban Trees Declining?

Tree loss is not a problem that is unique to East Providence. Trees are declining throughout the United States. Cities are also losing older, established trees from the cumulative impacts of land development, storms, diseases, old age and other factors (Nowak and Greenfield 2012).

It is not just development and storms that contribute to tree loss. Millions of trees are also lost as they reach the end of their life cycle through natural causes. Choosing the wrong tree for a site or climate, planting it incorrectly, or caring for it poorly can all lead to tree canopy loss. For every 100 street trees planted, only 50 will survive 13-20 years largely due to poor planting conditions and care (Roman et al 2014). Even in older developed areas with a well-established tree canopy, redevelopment projects may remove trees. It is important to realize that an older, well-treed neighborhood of today may not have good coverage in the future unless young trees – the next generation – are planted.

Current and Potential Canopy and Ecosystem Services Modeling

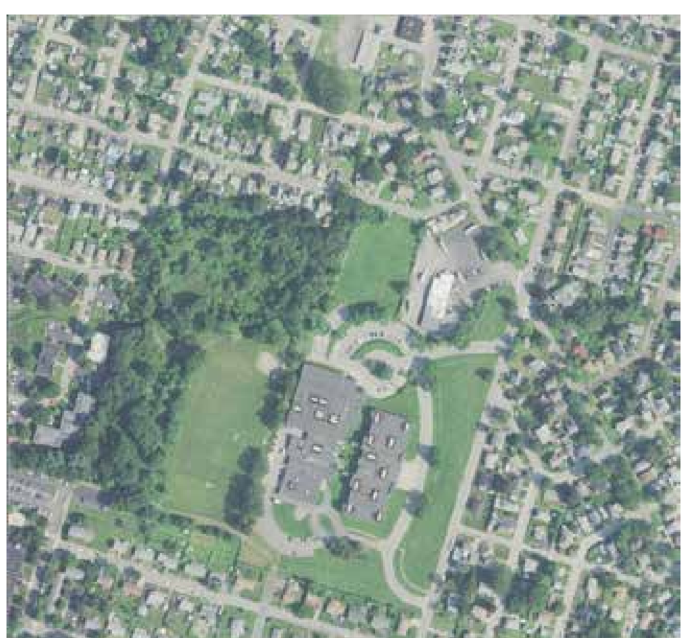
In order to determine the current tree canopy, model scenarios for future tree coverage, and quantify their ecosystem services, a highly detailed land cover analysis and an estimation of potential future planting areas were developed (see Appendix A for details). In addition to urban forest planning, the new land cover data can be used for other purposes such as analyzing urban cooling, walkability, street tree plantings, inform area plans, or the city's comprehensive plan.

Method

Satellite imagery from the National Agricultural Imagery Program (NAIP) distributed by the USDA Farm Service Agency was classified based on 4 infrared bands to determine the types and extent of different land covers in East Providence. Canopy maps were created using NAIP imagery data from 2021. Additional data from the City of East Providence. the National Wetlands Inventory, and National Hydrography Dataset were also used to determine:

1) Tree canopy (including trees and wooded wetlands).
2) Wetlands not distinguishable using spectral/feature-based image classification tools.
3) Forested open space (compact, continuous tree canopy greater than one acre) not intersected by buildings or paved surfaces.

The final classification for land cover consists of nine classes; tree canopy, tree canopy over impervious, scrub/shrub, pervious/turf, water, impervious, bare earth, wetland, forested wetland.



NAIP Image 2021

Potential Planting Area (PPA)
with exclusions in red hatching

Potential Planting Areas (PPA)

In urban areas, realistic goals for expanding urban canopy depend on an accurate assessment of plantable open acreage. A Potential Planting Area (PPA) map estimates areas that may be feasible to plant trees. The PPA is created by selecting the land cover features that have space available for planting trees and accounts for the overlap of canopy (e.g., canopy that is intermingled or a large canopy tree that partially covers an understory tree). Of the eight land cover classes, only pervious/turf were considered for PPA. However, some paved areas could be removed or reduced, soils conditioned, and then used to plant new canopy.

Eligible planting areas are limited based on their proximity to features that might either interfere with a tree's natural growth (such as buildings) or places a tree might affect the feature itself, such as power lines, sidewalks or roads. Playing fields, cemeteries and other known land uses that would not be appropriate for tree cover, such as golf courses and airports were also avoided in calculating plantable areas. The resulting PPA represent the maximum potential places trees can be planted and grow to full size. The GIC recommends no more than half the available PPA is realistic to plant, since many uses such as tomato gardens or sunbathing by the pool require full sun.

Potential Planting Spots (PPS)

Potential Canopy Area (PCA)

Potential Planting Spots (PPS)

Potential Planting Spots (PPS) are created from the PPA. A GIS modeling process is applied to select spots where a tree can be planted depending on the desired size. For this analysis, expected sizes of 20 ft. and 40 ft. diameter for individual mature tree canopy were used with priority given to 40 ft. diameter trees (larger trees have more benefits).

Potential Canopy Area (PCA)

The Potential Canopy Area (PCA) is created from the PPS. Once possible planting spots are selected, a buffer around each point that represents a tree's mature canopy is created. For this analysis, that buffer radius is either 10 ft. or 20 ft., which represents a 20 ft. or 40 ft. diameter canopy. These individual tree canopies are then dissolved together to form the potential overall canopy area. For East Providence 7% more canopy could be added to the city.

For East Providence 7% more tree canopy could be added to the city.

Maps and Findings

The tree canopy map should be used to plan for tree conservation and as a benchmark to gauge future progress in tree preservation and planting. An ArcGIS geodatabase with all GIS shape files produced during the study was provided to the city.

Tree Canopy Goal for the City of East Providence

Using tree canopy and land cover data, this plan's consultants mapped the maximum potential tree canopy for planting 100% of the available planting areas which equates to a potential canopy cover of 41%. However, planting 100% of the PPA is not a realistic goal because property owners have other uses for their land such as vegetable and ornamental gardens, or lawns. A more realistic goal for the maximum potential tree canopy is to plant only 50% of the PPA, resulting in a maximum desired goal of 38% tree canopy.

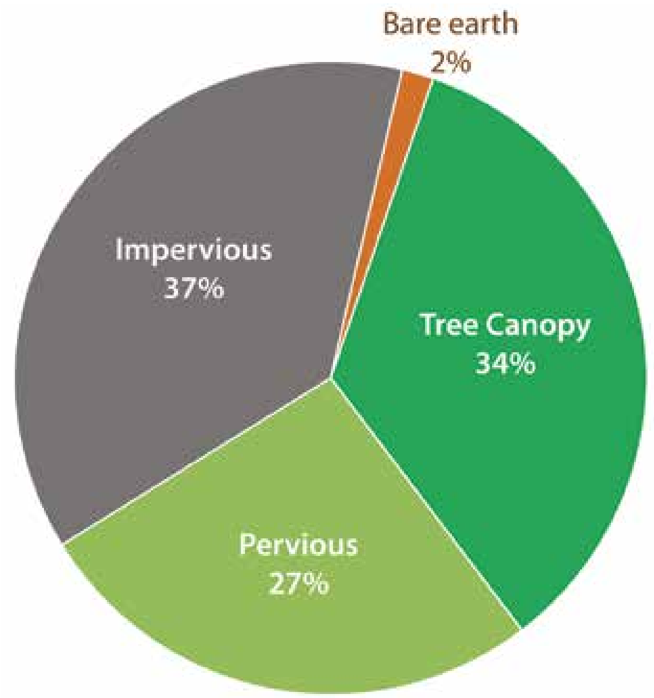
Using this information and other tools, such as GIC's Canopy Budget Calculator Tool which estimates the financial cost of increasing canopy to a certain percentage, the city decided to set a goal of at least maintaining its current canopy at 34% with the aim of increasing the canopy by an additional 1-2% over the next 10 years. If the East Providence community wants to increase the canopy from the current 34% to 36% over the next 10 years assuming around 200 trees are lost per year, it will require planting an additional 12,015 trees; approximately 6,419 large shade trees and 5,596 small trees at a rate of or 1,200 trees planted annually.

The city also requested statistics for canopy by the following geographies:

- Streets
- Floodplains
- Census Block Groups
- Zoning
- Parcels

The canopy data and the possible planting area map can inform tree planting decisions to meet many goals such as walkability, stormwater mitigation, energy savings or economic revitalization. Knowing the distribution of canopy for different types of properties allows the city to craft more specific strategies for achieving their canopy goal of increasing tree cover by 2% and ensuring that canopy is distributed equitably across the landscape. The following maps can be used to prioritize where to start planting and for public awareness of such planting needs.

East Providence Percent Land Cover 2021

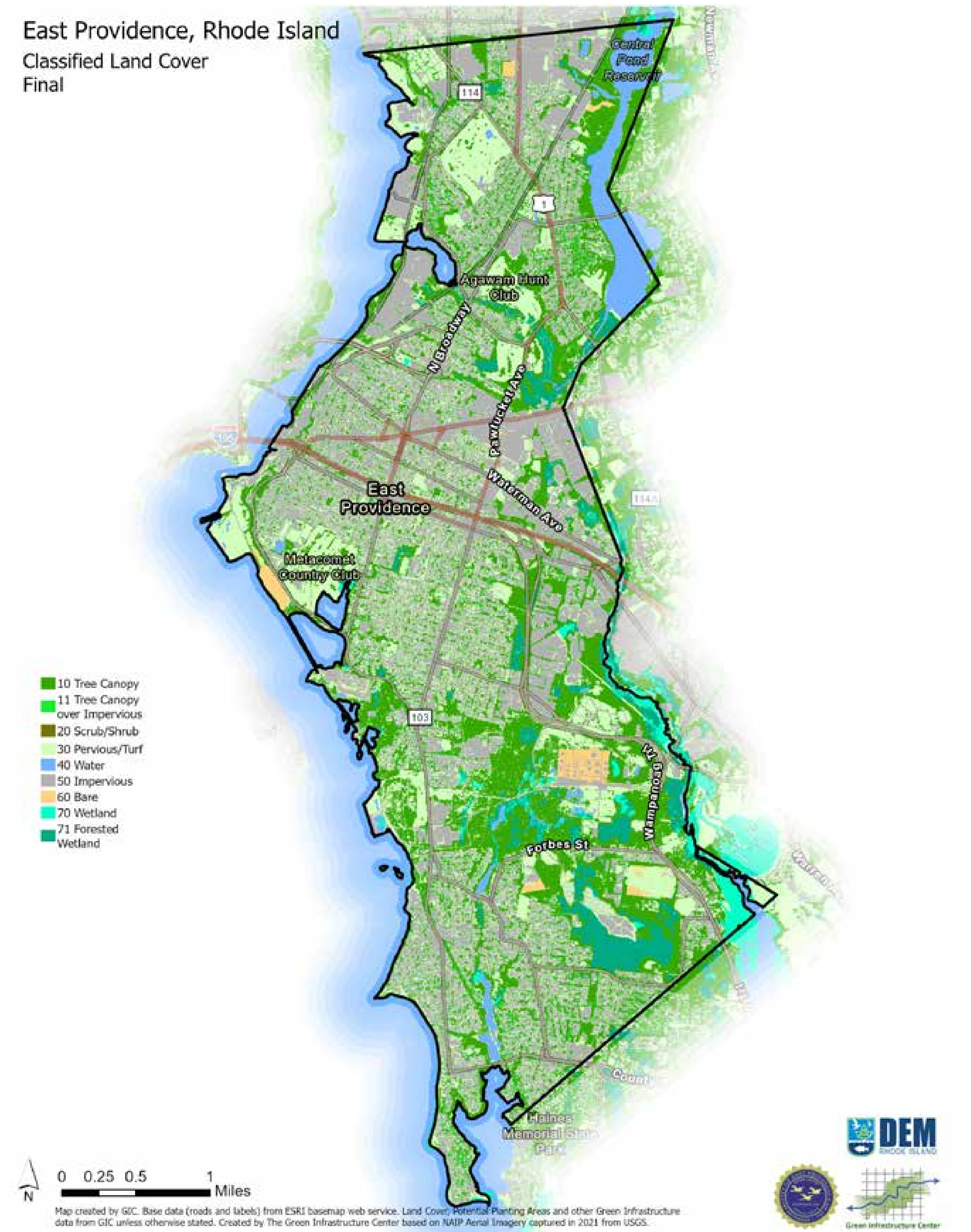


Citywide forest cover is 34%.

One mature tree can absorb thousands of gallons of water per year.

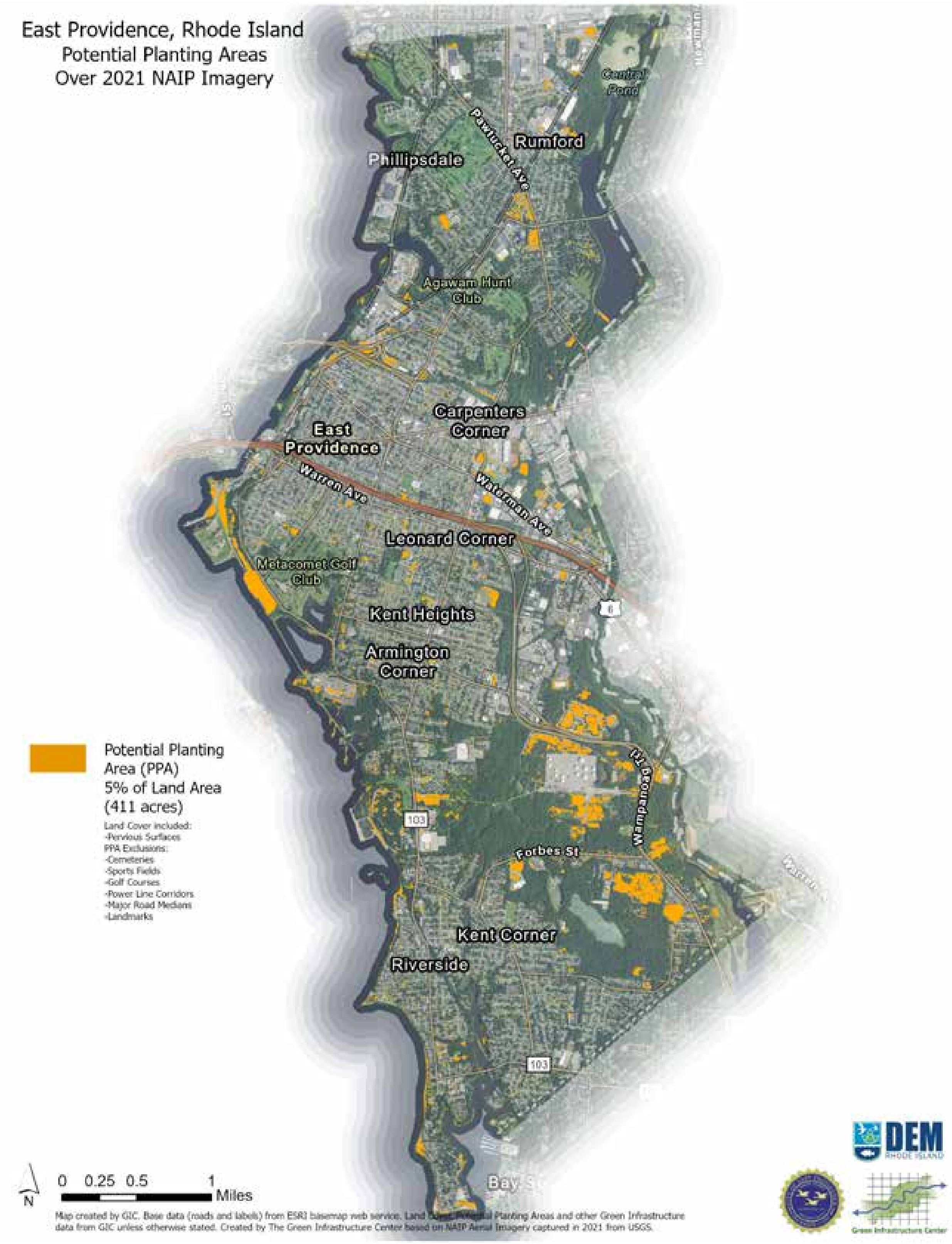
Map of City Land Cover and Tree Canopy

This map shows the tree canopy of the city which covers 34% of the area.



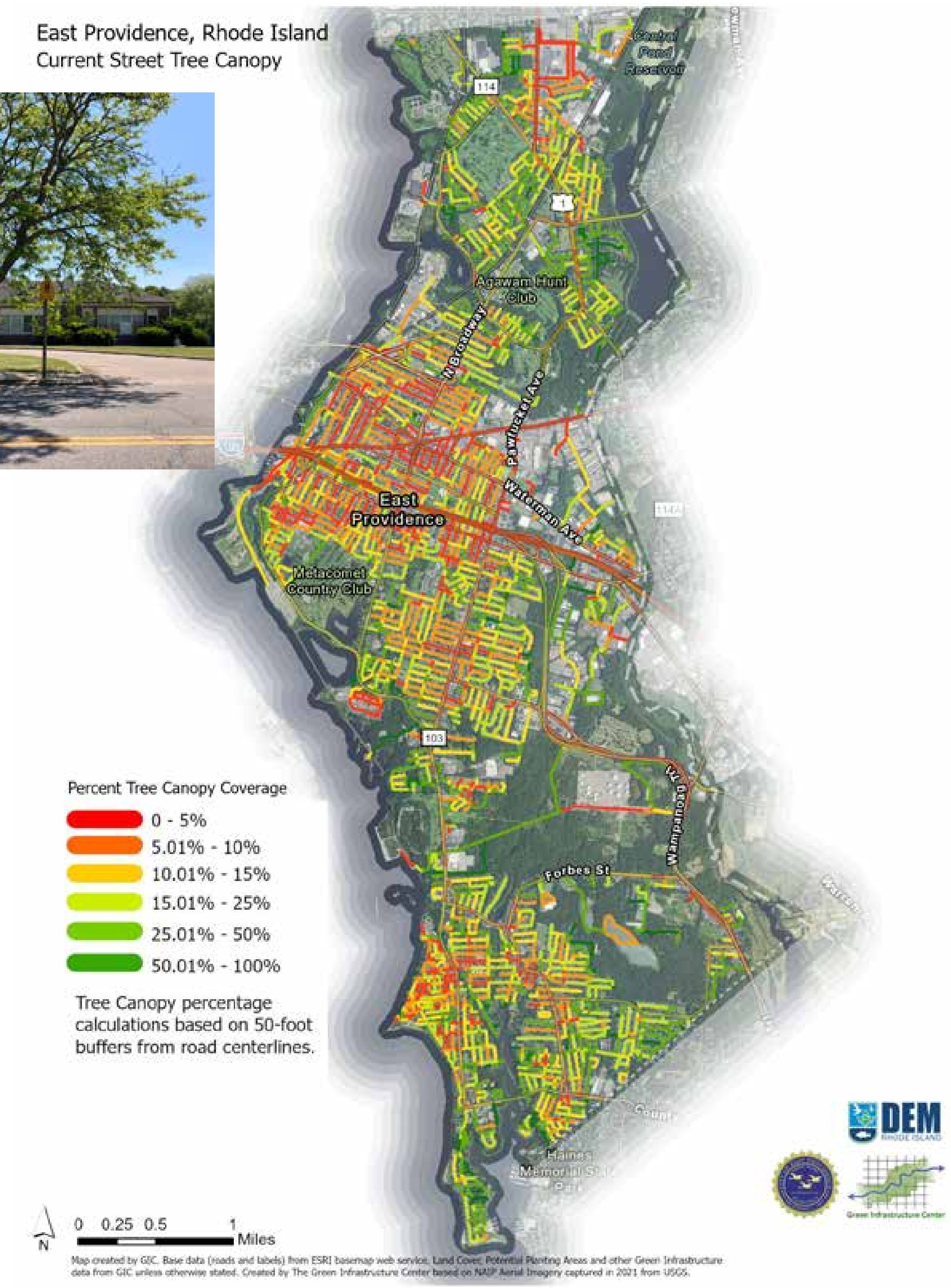
Map of Possible Planting Areas

Potential Planting Area (PPA) shown in orange depicts areas where it may be possible to plant trees. All sites would need to be confirmed in the field and may be on private or public lands.



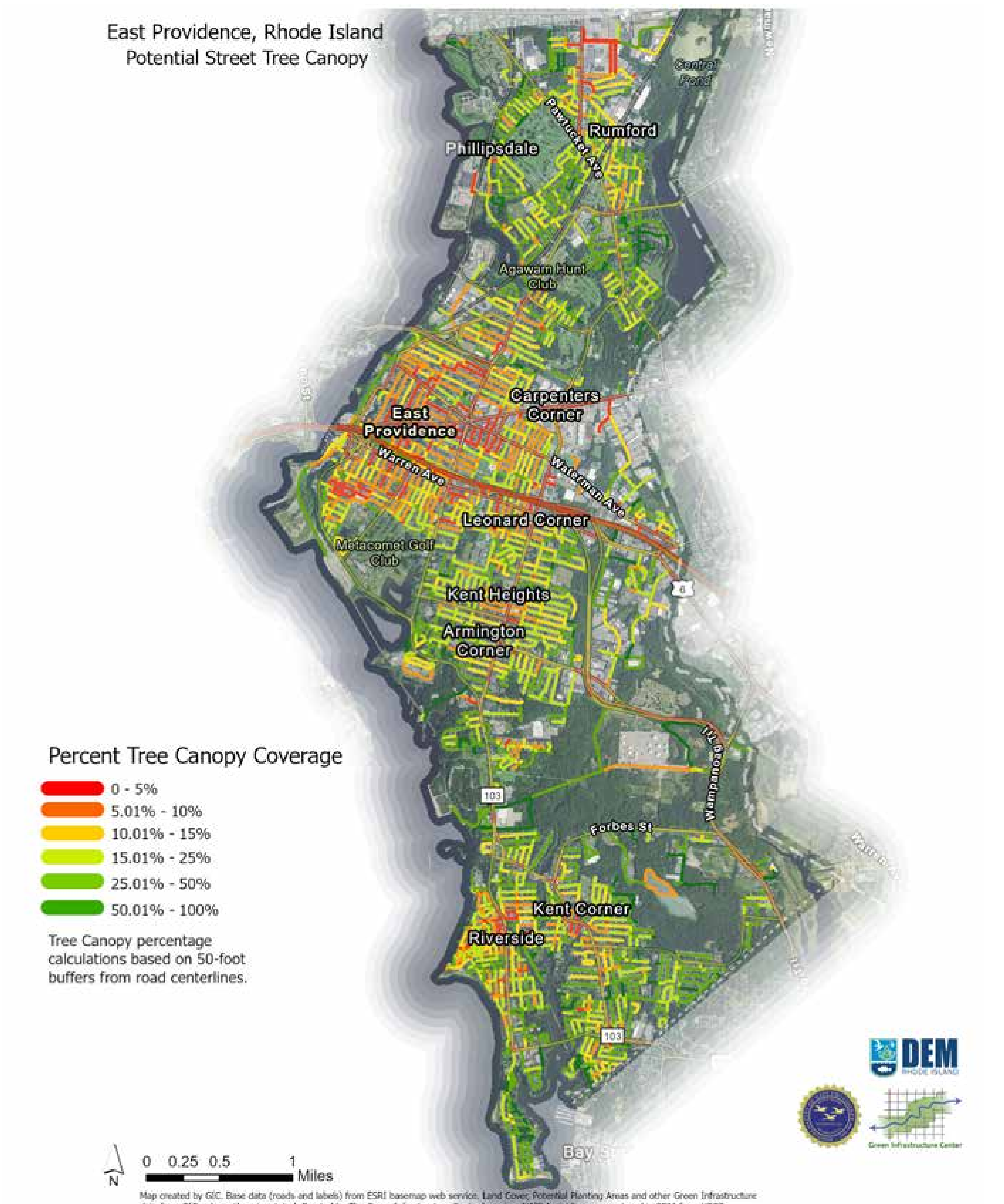
Map of Street Tree Coverage

Percent Street Trees is calculated using the Land Cover Tree Canopy and road centerlines, which are buffered to 50 ft. outward from each road segment's centerline. The percent value represented is the percentage of tree cover within that 50 ft. buffer. This map shows which streets have the most canopy (dark green) and which have the least (red). Streets lacking good coverage can be prioritized for tree plantings to facilitate uses, such as Safe Routes to School or beautifying a shopping district.



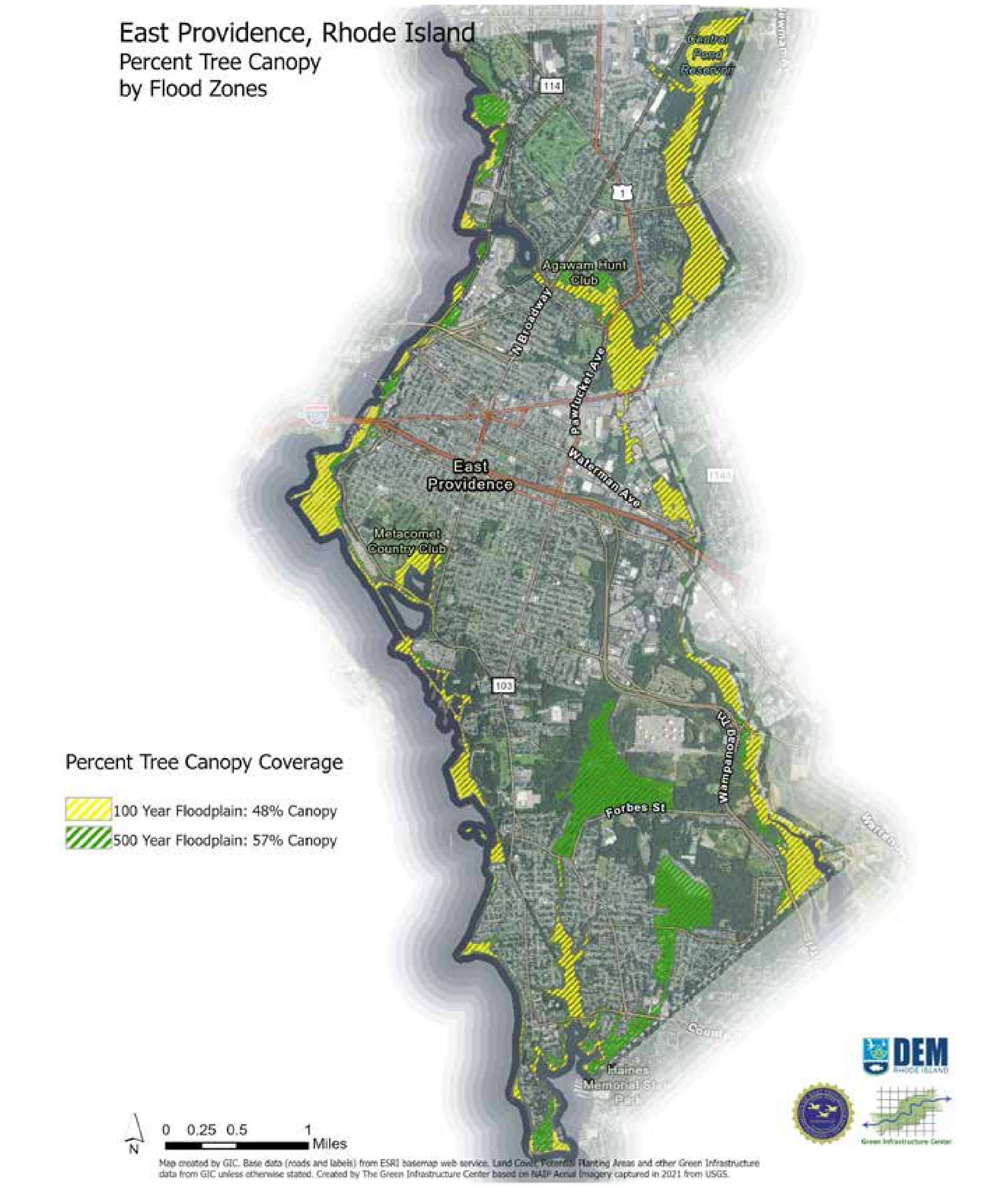
Map of Potential Street Trees

The potential street trees map shows which streets could support additional tree canopy if planted with more trees. Greater canopy coverage along streets and sidewalks can keep neighborhoods cooler and more walkable.



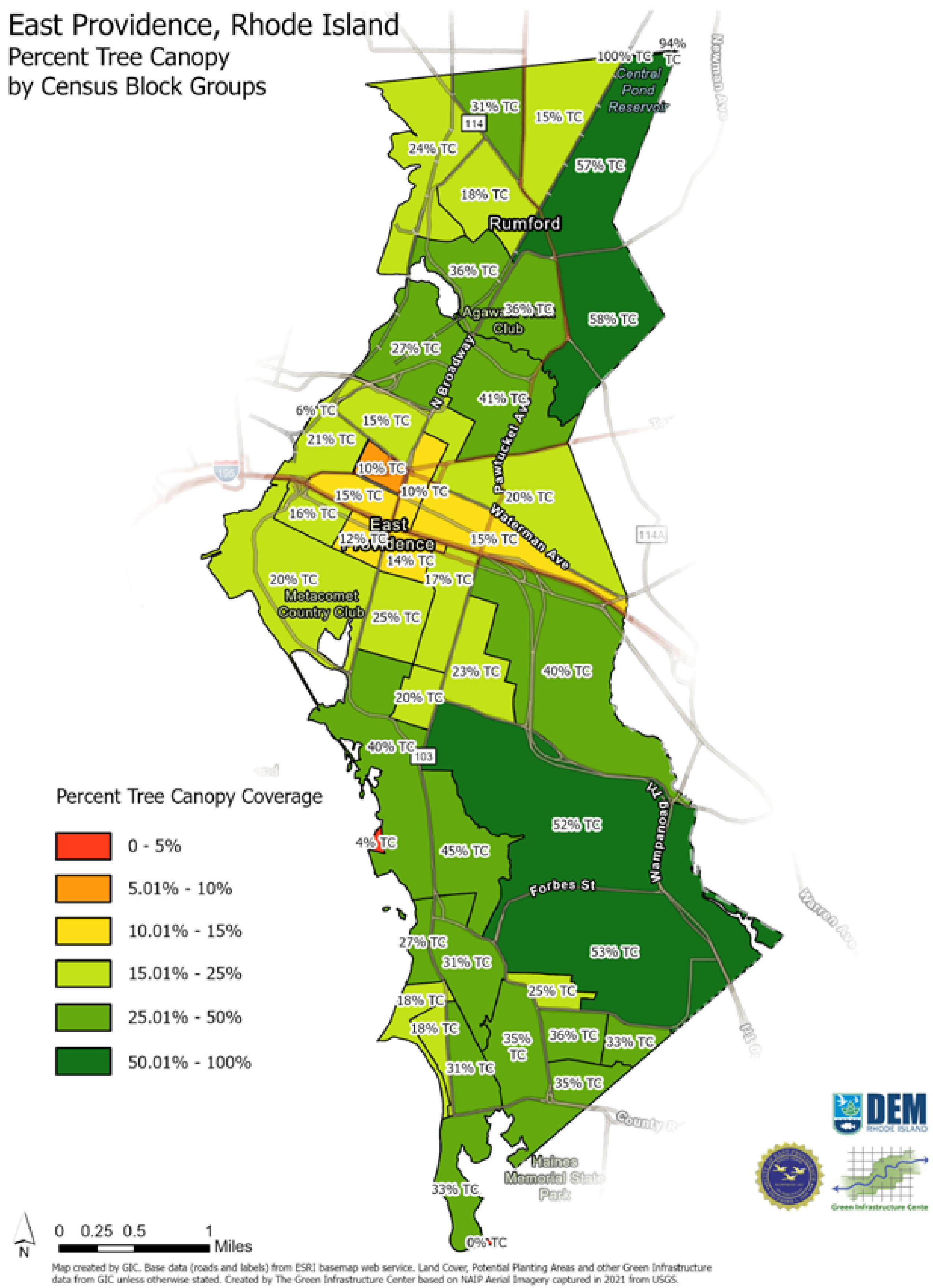
Map of Floodplain Coverage

Flood zones are areas of the city more prone to flooding. Trees play a vital role in capturing rainfall and soaking up stormwater which can reduce the amount of nuisance flooding in the city.



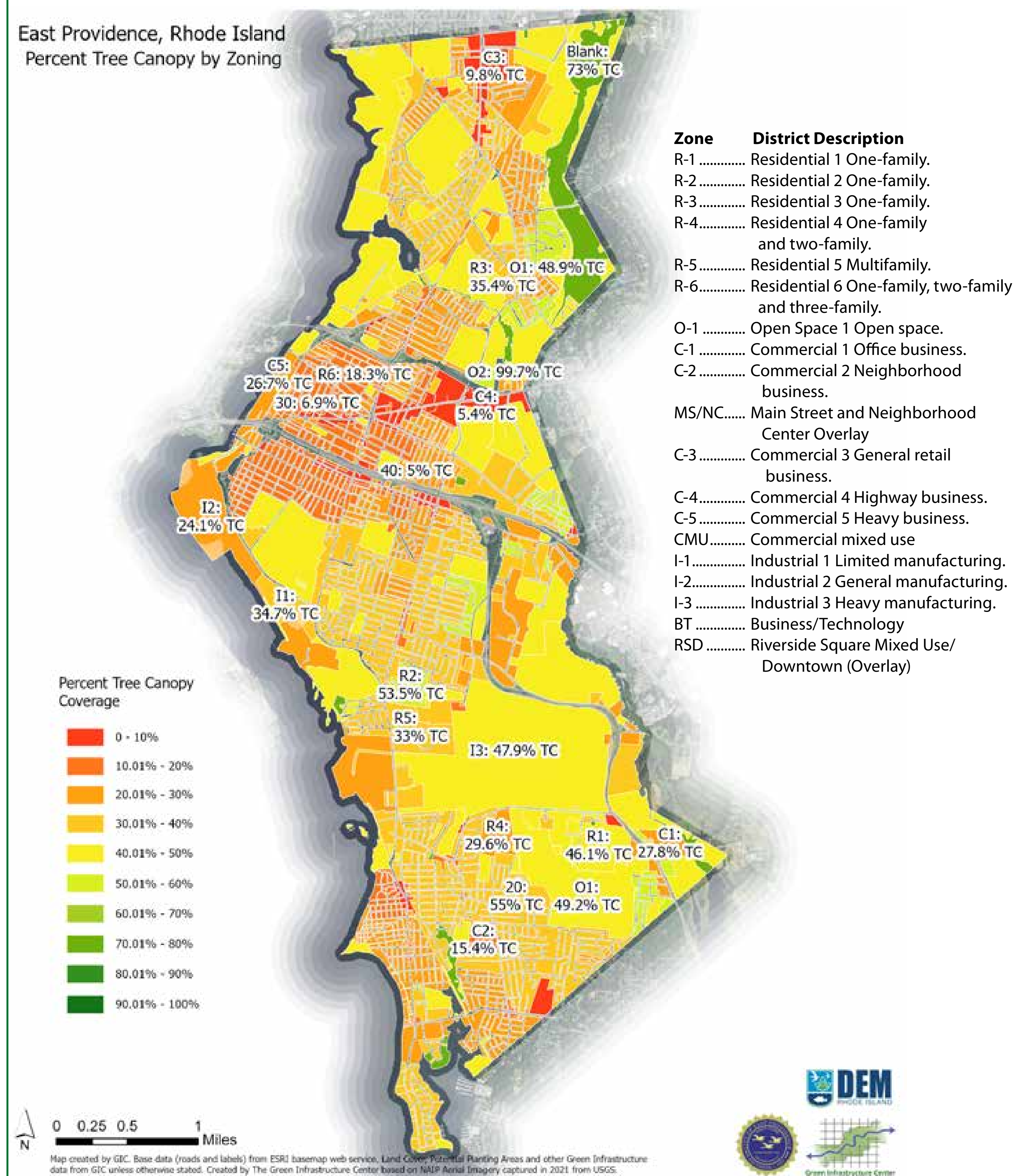
Map of Census Block Group (CBG) Coverage

This map shows that not all tree canopy is evenly distributed across neighborhoods in East Providence. The city can use this data to prioritize low-income and minority neighborhoods for more tree plantings and future tree giveaways.



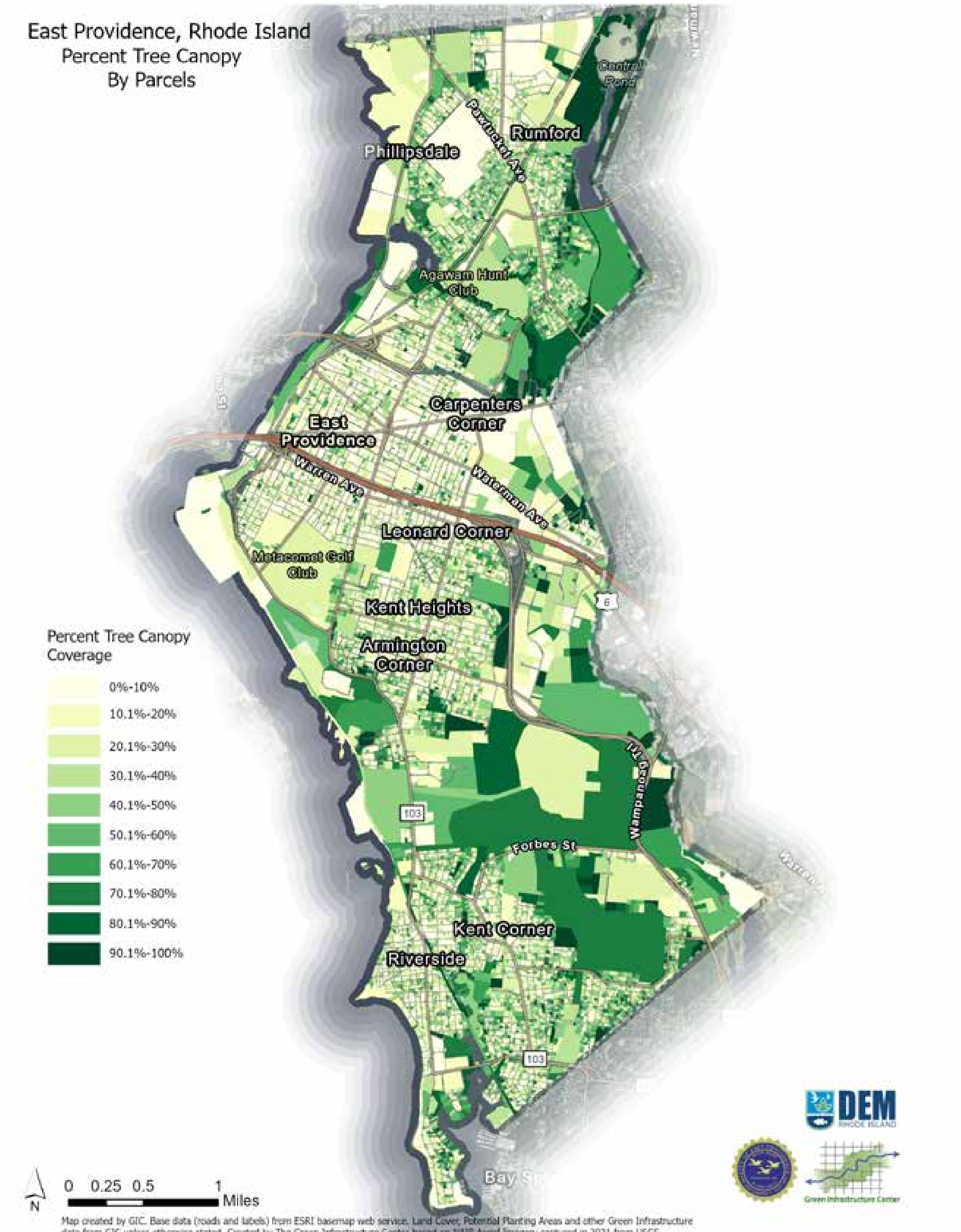
Map of Zoning Coverage

This map depicts canopy by zoning classes. On average, lower impact zoning classes such as residential zones have greater tree canopy and potential planting areas than do higher intensity classes such as commercial or industrial.



Map of Parcel Coverage

Every city parcel was analyzed for tree canopy cover. The data show that some residential properties lack sufficient canopy and have potential for more trees, particularly in neighborhoods of Watchemoket and Kent Heights.

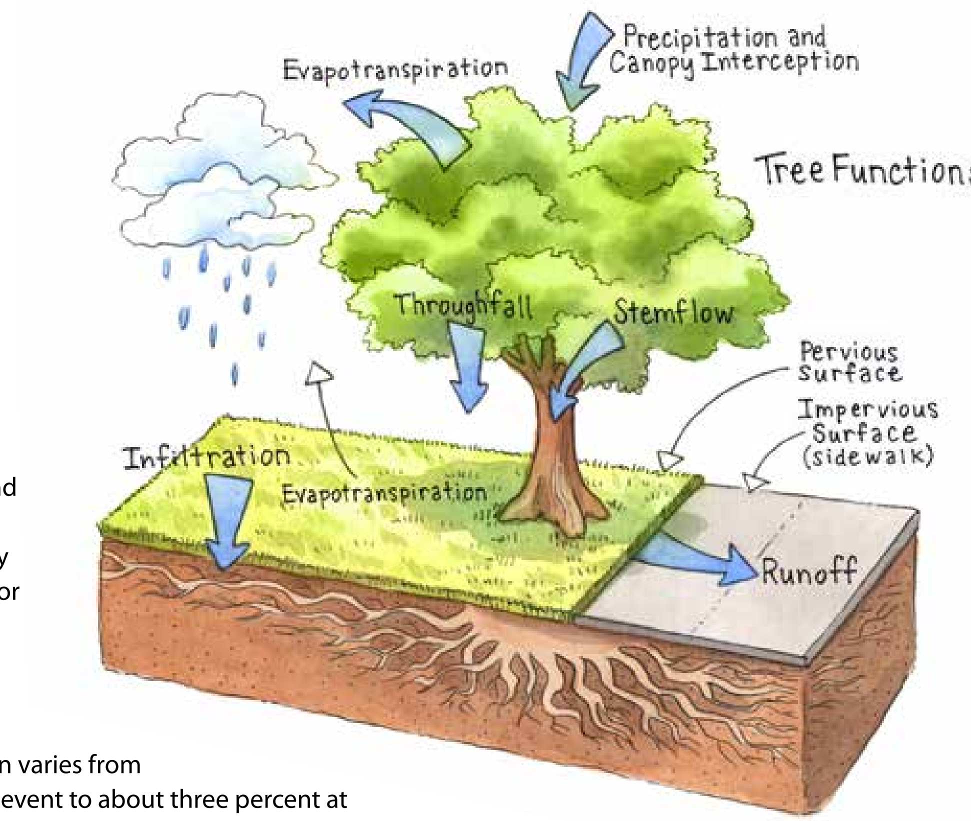


Ecosystem Services Modeling

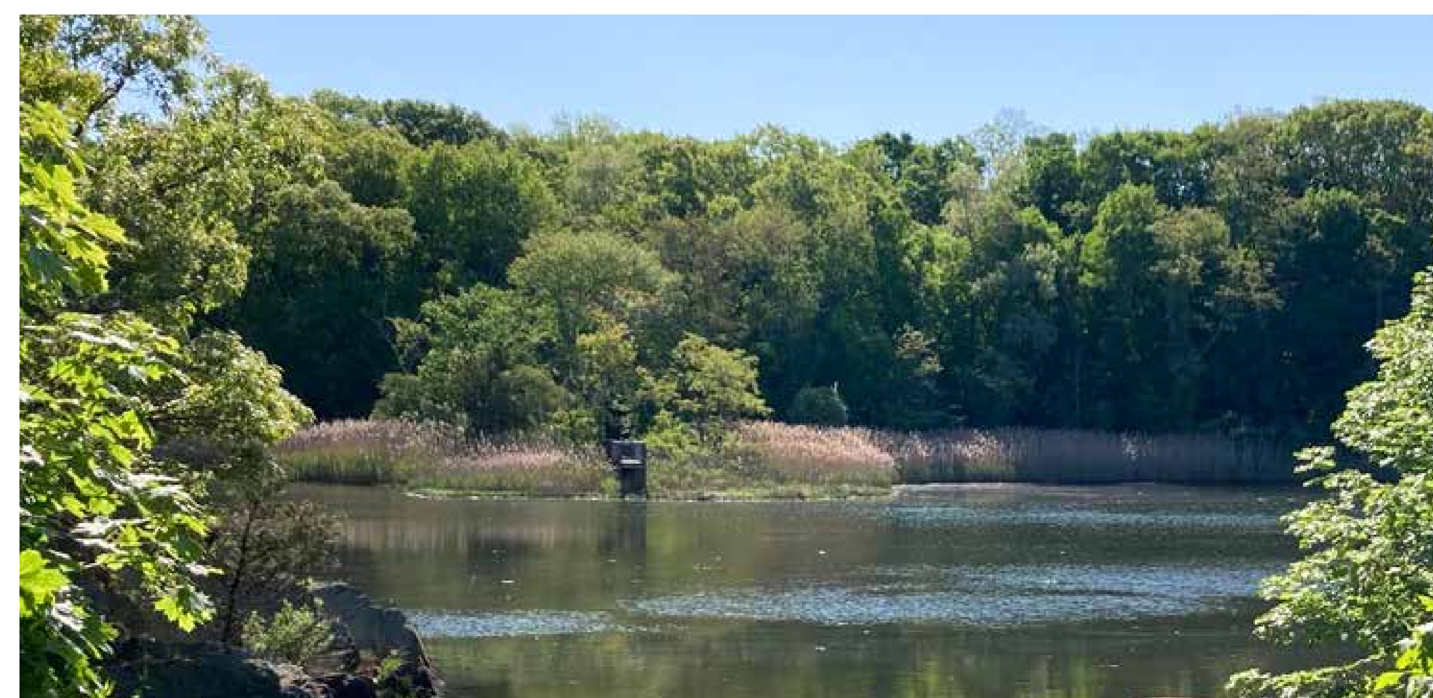
Methods to Calculate Tree Benefits

Stormwater Uptake Modeling

The best land cover for taking up stormwater is the urban forest. The GIC evaluated stormwater runoff and uptake by the city's tree canopy using the GIC's Trees Stormwater Calculator (TSW) Tool. The TSW tool estimates the capture of precipitation by tree canopies and the resulting reductions in runoff yield. It considers the interaction of land cover and soil hydrologic conditions. It can also be used to run 'what-if' scenarios, specifically losses of tree canopy from development or storms and increases in tree canopy from tree planting programs.



Trees intercept, take up and slow the rate of stormwater runoff. Canopy interception varies from 100 percent at the beginning of a rainfall event to about three percent at maximum rain intensity. Trees take up more water early on during storm events and less water as storm events proceed and the ground becomes saturated (Xiao et al., 2000). Many forestry scientists, as well as civil engineers recognize that trees have important stormwater benefits (Kuehler 2017, 2016). See diagram of tree water flow at right.



		Current Tree Cover	Current Impervious Cover	Tree H20 Capture	Increased H2O w/xx% tree loss	Added H2O Capture w/xx% PCA	Adjusted Tree Cover from loss and gain scenarios	Pick an Event	Pick a loss scenario		Converted Land			Canopy Added	Enter % canopy to add
	East Providence — Urban Tree Canopy Stormwater Model — version May 4, 2022														
	The Green Infrastructure Urban Tree Canopy Stormwater Model estimates stormwater runoff yields for current and potential land cover. The methodology is based upon the NRCS TR-55 method for small urban watersheds. It is used to provide better estimates using GIC's high-resolution land cover and modeling of potential canopy area.														
				million gallons											
	TOTALS	34.4%	35.6%	8.8	-	-	34.4%								
	Statistics by Drainage Basin (current settings)							Variable							Variable
	Area	%		million gallons			%	Event	% UTC loss	% FOS Loss	% Imperv	Max TC Possible	Maximum Potential Added Canopy Area	% Canopy Added	% of PCA achieved
1	Seekonk River-Providence River	33.6%	35.9%	5.1	-	-	34%	1yr / 24 hour	0%	0%	0%	41.4%	7.8%	0.0%	0%
2	Ten Mile River	34.8%	39.8%	1.3	-	-	35%	1yr / 24 hour	0%	0%	0%	39.4%	4.5%	0.0%	0%
3	Barrington River-Warren River	36.0%	38.9%	2.4	-	-	36%	1yr / 24 hour	0%	0%	0%	46.3%	10.1%	0.0%	0%

The Trees to Offset Stormwater Tool (TSW) allows the city to see the water uptake by existing canopy and model impacts from changes, whether positive (adding trees) or negative (removing trees and adding impervious surfaces).

Removal of mature trees and existing forests generates the greatest impacts for increasing stormwater runoff.

The amount and type of open space under and around the tree and the condition of surface soils affect the infiltration of water. The TSW tool developed for East Providence has a data field to hypothetically add trees to determine stormwater uptake from new tree planting. The TSW tool applies the PPA data to determine how many more trees could be planted. The tool also calculates the amount of nitrogen, phosphorus and sediment the trees and their surrounding soils take up. For more about the stormwater calculator tool, see Appendix B.

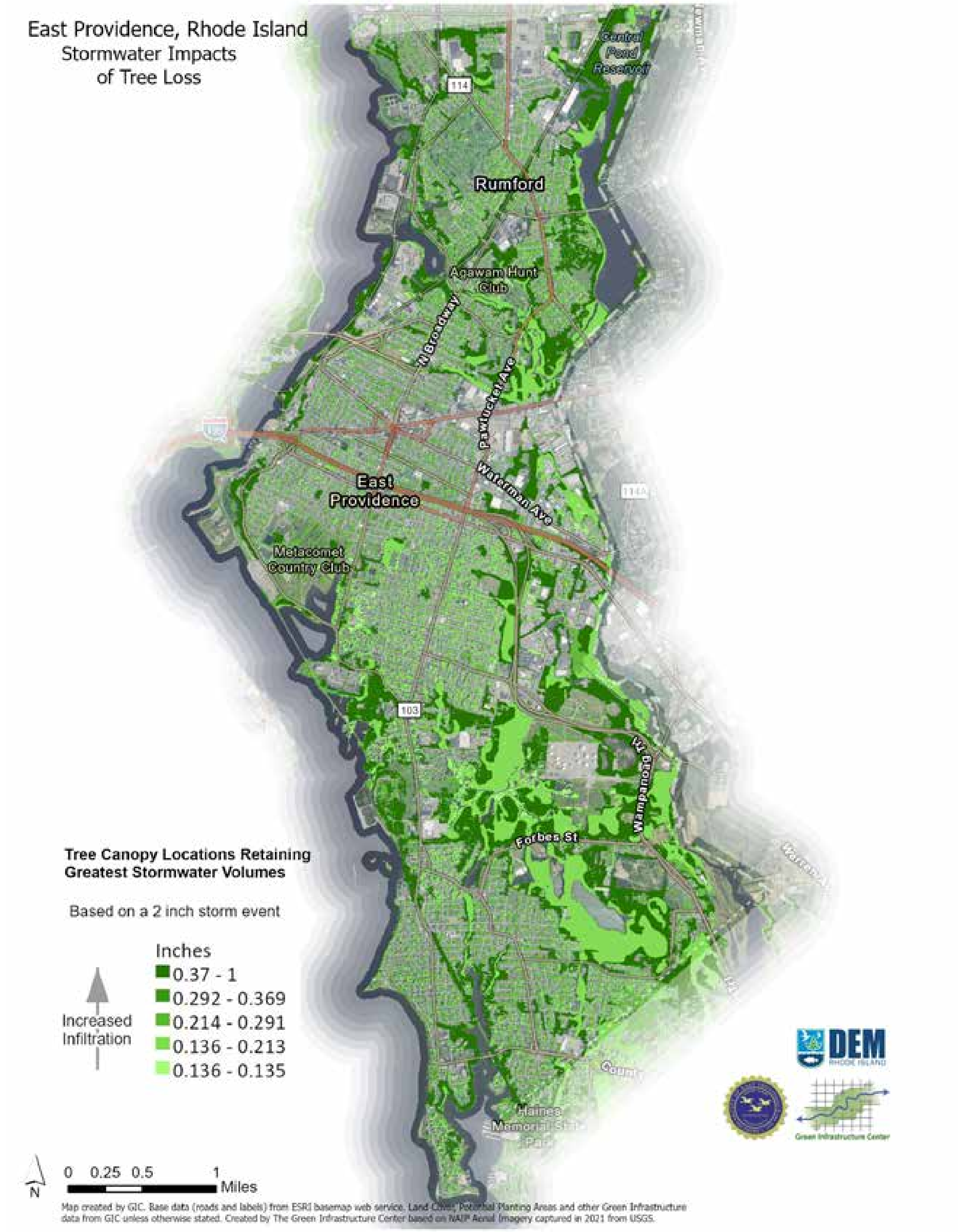
The TSW model is a tool for seeing the stormwater impacts of adding or losing tree canopy and the resulting pollution increases or decreases.

The TSW model is a tool for seeing the stormwater impacts of adding or losing tree canopy and the resulting pollution increases or decreases (nitrogen, phosphorus, sediment). For example, the model shows that for a hypothetical 5% loss of tree canopy for the city, during a 10-year storm event, an additional 1.1 million gallons of rainfall runoff would occur: that's more than three Olympic swimming pool's water volume. Conversely, if half of each plantable area were covered with new trees – increasing tree canopy – the TSW model shows that trees could capture an additional 2 million gallons of water during the same storm; or about four Olympic pools' volume of water.

Removal of mature trees and existing forests generates the greatest impacts for increasing stormwater runoff. As more land is developed, the city should seek to maximize tree conservation for maintenance of surface water quality and groundwater recharge. The following maps show areas that are the most important to retain trees for stormwater uptake and those areas where tree planting will have the most benefits for stormwater uptake. This is based on the types of soils present.

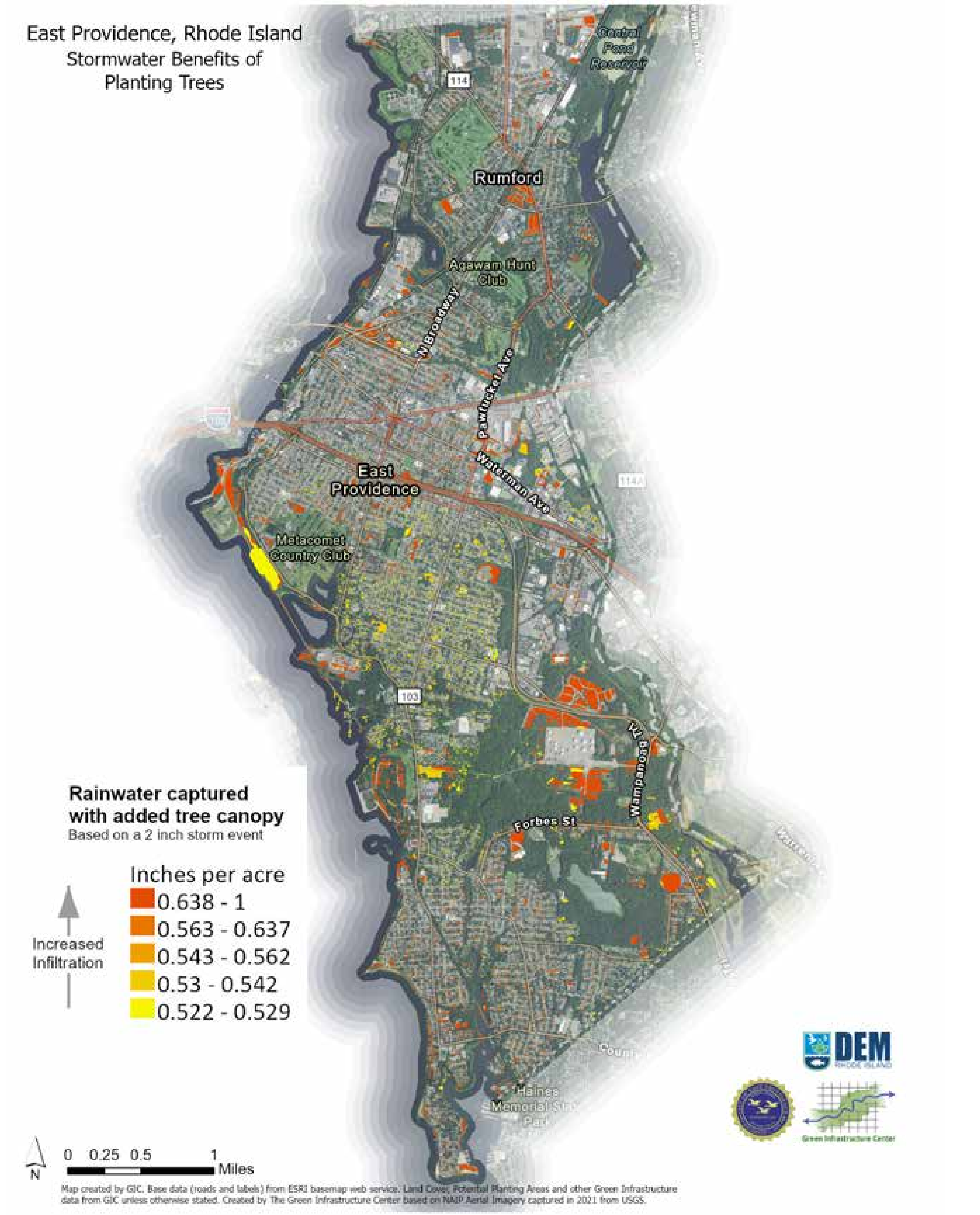
Map of Stormwater Impacts of Tree Loss

This map identifies existing mature tree canopy that is in the best location (in dark green) for retaining stormwater on site.



Map of Stormwater Benefits of Planting Trees

This map identifies the best planting areas to plant trees to infiltrate stormwater into the soil.



Investments in canopy at the neighborhood level can improve the respiratory health of residents.

Air Quality Pollution Removal Values

Air quality pollution removal values were calculated by applying the multipliers used by the i-tree models. I-Tree is a peer-reviewed software suite from the USDA Forest Service that provides urban and rural forestry analysis and benefit assessment tools. It provides standard pollution removal values per acre for various air pollutants. The following i-Tree model values for urban areas were used to derive the pollution removal values per acre of tree canopy.

Carbon monoxide (CO) affects how quickly greenhouse gases such as methane breakdown, which are linked to climate change and global warming. Carbon is another element that contributes to climate change mainly in the form of carbon dioxide. Trees sequester carbon from carbon dioxide in their leaves, trunk, and roots, and prevent it from being released into the atmosphere where it can contribute to climate change.

Ground level ozone O3 can cause the muscles in people's airways to constrict, trapping air in the alveoli, leading to wheezing and shortness of breath, which is particularly harmful to those with respiratory diseases or chronic conditions, such as asthma. Nitrogen Dioxide (NO2) and Sulphur Dioxide (SO2) also irritate airways in the respiratory system and aggravate respiratory conditions such as asthma.

PM10 is particulate matter measuring 10 micrometers or less in diameter and PM2.5 is particulate matter 2.5 micrometers or less in diameter (a human hair is about 100 micrometers = about 40 fine particles). PM2.5 is generally described as fine particles. Finer particles have the potential for greater harm since they may lodge deeper in the lungs. Trees are able to filter and clean particles from the air.

Well-treed neighborhoods suffer less respiratory illnesses, such as asthma (Rao et al, 2014). This means that investments in canopy at the neighborhood scale can increase the health of residents.

Pounds of air pollution and greenhouse gases removed annually by all trees in East Providence

CO (carbon monoxide)	NO_2 (nitrogen dioxide)	O_3 (ozone)	PM_{10}* (particulate matter 10 microns)	$PM_{2.5}$ (particulate matter 2.5 microns)	SO_2 (sulphur dioxide)	CO_2seq (carbon dioxide sequestered) in lbs	CO_2stored ** (carbon dioxide stored in lbs)
550	5,825	58,294	10,124	2,576	1,683	28,069,255	331,035,110

*PM = Particulate matter
**CO_2 stored is not an annual rate but a total amount of carbon stored.

Codes, Ordinances and Practice Review

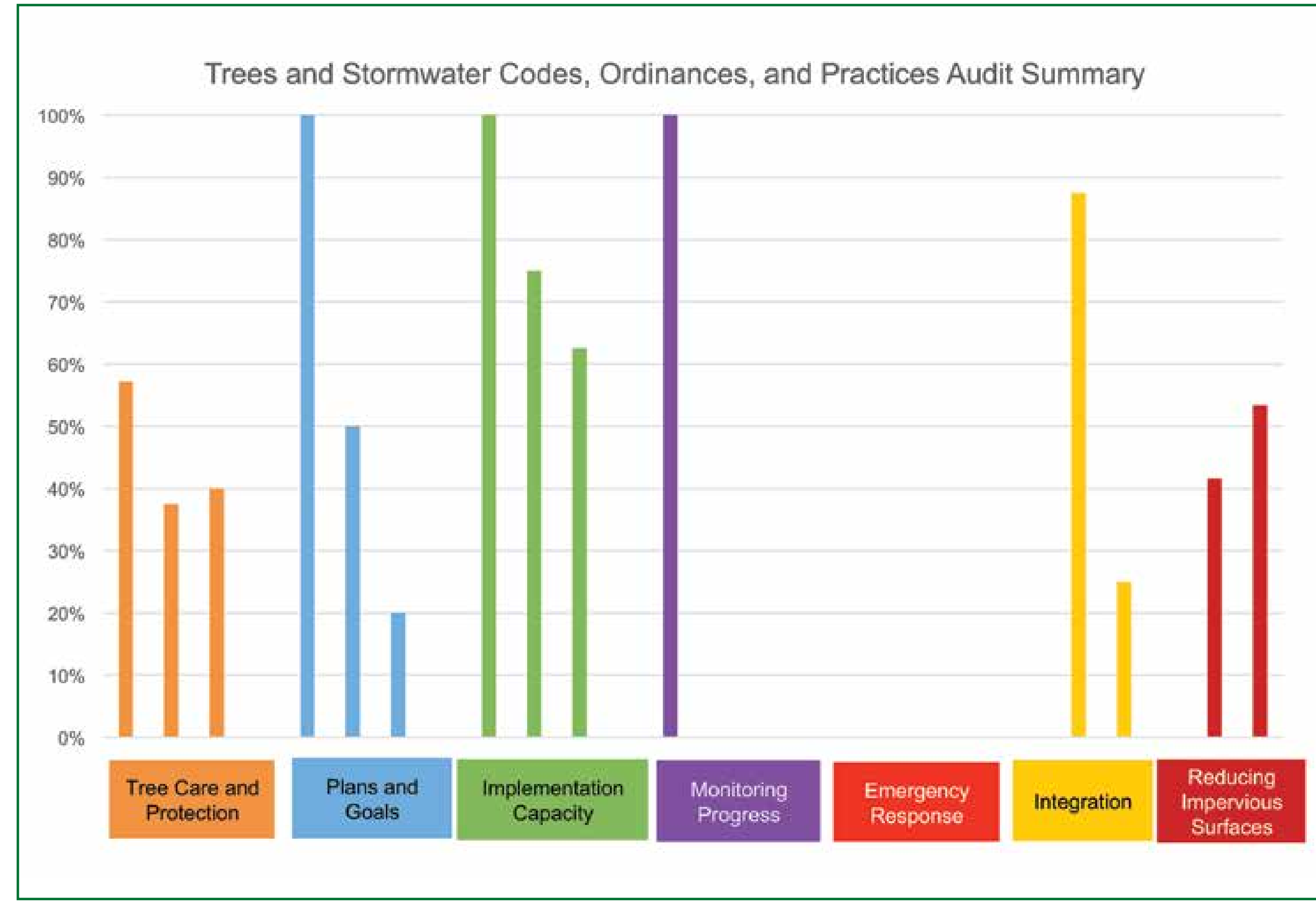
This review determined which practices create a healthy urban forest (e.g., tree planting and care standards), increase impervious surfaces (e.g., too much parking required) and protect or restore pervious surfaces (e.g., conserving trees or requiring open spaces).make the city more impervious (e.g., too much parking required) and which make it more pervious (e.g., conserving trees or requiring open spaces). Documents reviewed during the codes, ordinances and practices analysis for the project include relevant sections of the city's current code that influence urban forest practices, runoff or infiltration. Data were gathered through analysis of city codes and policies, as well as interviews with city staff, whose input was incorporated directly on the spreadsheet summary prepared by the GIC. The spreadsheet provided to the city lists all the codes reviewed, interviews held and relevant findings (see sample below).

Points were assigned to indicate what percentage of urban forestry and planning best practices have been adopted to date by the city. The spreadsheet tool created for city codes can also serve as a tracking tool and for determining other practices or policies the city may want to adopt in the future to strengthen the urban forestry program or to reduce impervious land cover. The less city land that is paved, the more room there is to add trees.

Categories the city scored best in were "Plans and Goals," "Implementation Capacity," and "Monitoring Progress," while "Tree Care and Protection", "Emergency Response", "Integration" and "Reducing Impervious Surfaces" all had room for improvement. Best practices the city follows under "Implementation Capacity" include having a certified arborist on staff who manages the day-to-day operations of the urban forest and is also trained in Tree Risk Assessment Qualification (TRAQ). The city also has a Tree Commission that is actively engaged in the urban forest program and has a dedicated line item in the annual budget for urban forest management. The city is building the planning phase of its urban forestry program by collecting data, both in the form of a tree inventory and canopy mapping, to support strategic decision-making.

Staff							
Is a certified arborist on staff?	Yes		Yes they have two certified arborists on staff in the parks department. The code requires someone with a degree in arboriculture or equivalent professional equivalency.	Interviewed the planning staff. Sec. 14-53. City forester—Appointment; qualifications.	A certified arborist on staff aids municipalities in making informed decisions regarding tree health and tree placement. Municipalities with at least one certified arborist on staff or a consultant hired via contract score three points.	3	3
Is at least half of one staff member's job duties devoted to managing grants?	No	Planning Dept staff tend to be the de facto grant writers and managers for urban forestry projects			Grants are a viable and creative way to achieve targeted missions in a municipality. However, grant management and the paperwork that accompanies most grants is time consuming. Municipalities with at least half of one staff member's job duties devoted to managing grants or other funding sources score one point.	0	1
Is there a full time regular staff member that has authority over day-to-day urban forestry activities?	Yes		Tree warden/city arborist on staff who reviews tree permits and requests.	https://eastprovidenceri.gov/departments/parks/city-trees	Urban forest management is a full time job even in a relatively small municipality. Municipalities employing at least one full time staff member with authority over day-to-day urban forestry activities score three points.	3	3
Is an allied professional (such as a LA) on staff?	No			Interviewed the planning staff.	Allied professionals knowledgeable about trees, design, soil, and/or wetlands are able to provide urban forest management expertise. Municipalities with at least one allied professional score one point.	0	1
Is at least one staff member or consultant trained in tree risk assessment?	Yes		The city tree warden is trained in tree risk assessment.	Interviewed the planning staff.	Conducting tree risk assessments is a vital part of managing the urban forest. Municipalities with at least one staff member or consultant trained in tree risk assessment score two points.	2	2
Are staff allowed to/encouraged to attend continuing education events? How often does this occur? Do staff members and managers discuss current performance and staff goals at regular intervals (e.g. once per year)?	Yes	Yes, staff attend events. The arborist attend 3-4 events per year and the remaining members attend 1-2 per year.		Interviewed the planning staff.	Managers and department heads collaborate with staff to assess current performance and develop professional goals. Allow staff to attend at least two trainings per year. Municipalities where staff are encouraged/allowed to attend continuing education events at least two times per year and current performance and goals are discussed jointly between staff members and managers, score two points.	2	2

A snapshot of the types of questions or sections of code evaluated.



Summary scores for city codes and policies within each category. The city scored best in 'Plans and Goals' and 'Implementation' but had room for improvement in 'Tree Care and Protection', 'Emergency Response', 'Integration' and 'Reducing Impervious Surfaces'.

Recommendations

Tree Care and Protection

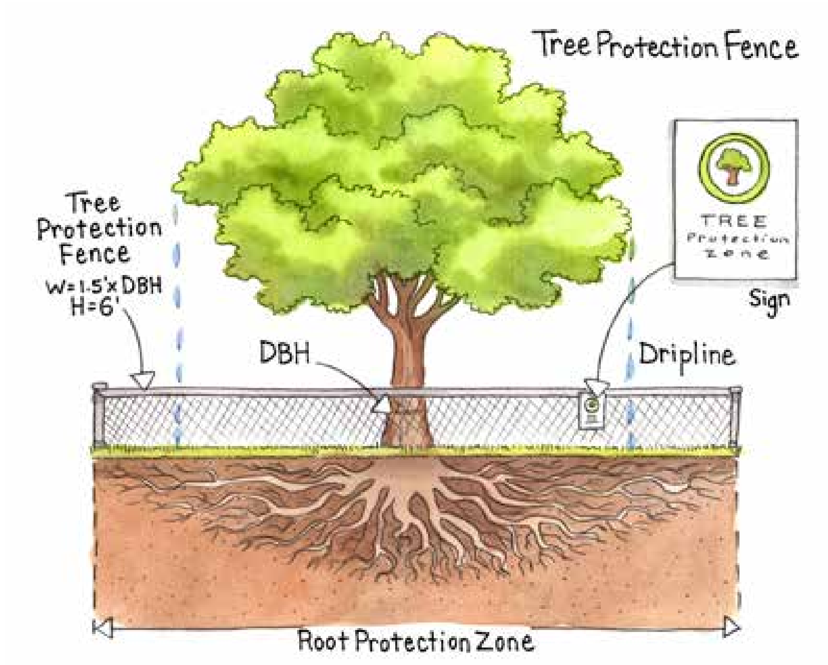
The city should strengthen tree protection requirements to be more robust than under its current ordinance. Currently tree protection only applies to public trees. The city should expand tree protections to include trees on private property. The urban forest is part of the greater community fabric and as such the impacts of tree loss on private property impact the entire city. Updating the tree ordinance to protect private trees will minimize the loss of trees during development. In situations where trees must be removed to accommodate the development, require the replacement of those trees elsewhere on site or require the developer pay a fee into a tree mitigation fund in-lieu of planting. Establishing a tree mitigation fund that allows funds to be used to plant trees on public and private property will give greater flexibility to plant trees where they are most needed. The tree replacement fee should be strong enough to discourage the wholesale tree removal on a site.

The city should increase the tree protection zone from its current 8 square feet from the base of the tree to the Critical Root Zone (CRZ). The Critical Root Zone is the zone where small roots at the radial extents of the tree root area uptake water and absorb nutrients. Protection of these roots is critical for the optimal health of a tree. Many cities require that tree protection fences be placed at the dripline. While protection at the dripline is an accepted practice, it does not adequately protect the roots. Instead, the city should require placement of tree protection fencing at a distance 1.5' times the tree's diameter at breast height (DBH) from the tree. For example, a 20-inch DBH tree would need its CRZ protected out to a distance of 30-feet.

The ordinance should also include detailed standards for what constitutes tree protection mechanisms. The most common form of tree protection is tree fencing. It is a physical barrier that keeps people and machines out of a tree's critical root zone during construction. However, some municipalities only require plastic orange fencing and wooden stakes. This type of fencing can be removed or trampled easily and reduces protection effectiveness. Without effective barriers, even trees designated to be saved may suffer development impacts such as root compaction and trunk damage. The city should require sturdy metal chain link fencing in high-risk areas (e.g., near heavy construction equipment and active site grading) and use orange plastic fencing in lower risk areas (e.g. along the tree line at the edge of a development property).

The city currently does not require tree protection signage. Tree protection signage communicates how work crews should follow tree protection requirements. It also informs construction crews and citizens about the consequences of violating city code. Construction crew members may not understand that building materials may not be placed in tree protection zones and that moving the protective fencing around the tree is never permitted. The city should design a standard tree protection sign which summarizes the dos and don'ts of working near and around tree protection zones. Additional training may be helpful to ensure that developers comply with the city's tree ordinances and understand how to protect trees during construction. If the work crews are of different nationalities, consider signage that has multi-lingual instructions.

Other examples of best management practices for tree protection include require the severing of roots of nearby trees prior to being removed, require thick mulching (no more than 4-5") if heavy equipment is to be driven in the critical root zone, encourage (or require) boring versus trenching for utilities and irrigate protected trees during construction during periods of drought.



Tree Protection Fence and Signage

In urban environments, many trees do not survive to their full potential life span. Factors such as lack of watering or insufficient soil volume and limited planting space put stresses on trees, stunt their growth and reduce their lifespans. For every 100 street trees planted, only 50 will survive 13-20 years (Roman et al 2014). This means that adequate tree well sizing standards are a critical factor in realizing the advantages of a healthy urban forest.

To encourage proper planning, planting and design for trees on sites, the city should designate root soil volume and soil surface area standards. Tree roots need adequate soil volume

Soil volume and soil surface area standards for various sizes of trees.

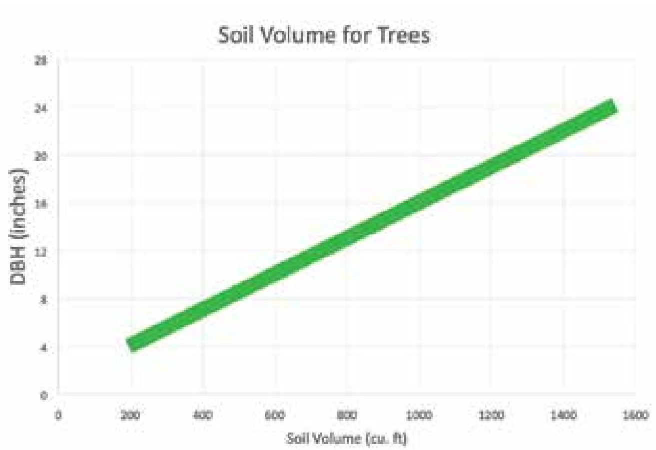


Table 1. Soil requirements for trees based on their size at maturity.

Tree Size at Maturity	Total Soil Area*	Distance From Paved Surface
SMALL Height: less than 30 ft	10 ft x 10 ft	2 ft
MEDIUM Height or less than 50 ft	20 ft x 20 ft	6 ft
LARGE Height or spread greater than 50 ft	30 ft x 30 ft	10 ft

*Measurements for when rootable soil depth is 3 feet or greater. For soil less than 3 feet deep, smaller maturing trees are recommended

Planting trees in the right place can avoid harmful over pruning.

and surface area to absorb water and promote gas exchange for healthy root growth. At a minimum, large canopy trees require 1000 cubic feet of soil volume to thrive. From a standpoint of hazard mitigation, the most critical factor for the ability of a tree to withstand hurricane force winds is adequate soil volumes to allow for proper tree anchorage into the ground and reduce the risk of falling over (Duryea 2007). The following table provides recommended soil volume and soil surface area standards for healthy tree growth and resistance to wind. In areas where space is tight or where heavy uses occur above, underground tree support cells can be used to stabilize and direct tree roots towards areas with less conflicts (e.g., away from pipes).

In addition, large trees should not be planted where they may interfere with overhead lines. The city can promote better tree planting by specifying non-interference with utilities in the tree ordinance and on intake forms for street tree and tree setback plantings on private property. These and other practices, implemented to provide long term care, protection and best planting practices for the urban forest, will ensure that investments in city trees will pay dividends for reducing stormwater runoff, as well as cleaner air and water, lower energy bills, higher property values and natural beauty long into the future.

Emergency Response

Recommended areas of improvement for "Emergency Response" were the inclusion of trees and built green infrastructure practices such as bioswales, rain gardens, etc. into future Hazard Mitigation Plan updates. Trees are a low cost, low impact solution to managing stormwater runoff. Specifically calling out green infrastructure practices and trees in the plan opens opportunities for federal funding through FEMA's grant programs. Identifying trees as green infrastructure and documenting the role they play at managing stormwater on public property and in rights-of-way makes them eligible for funding assistance through FEMA's Public Assistance grant program if the city experienced a federally declared disaster.

Another area of improvement is establishing an annual program to assess tree risk for public trees. The city recently completed a tree inventory and hired a consultant to assess tree condition and flag trees. An annual Level-1 tree risk assessment of public trees, also known as a windshield survey, is a simple and relatively quick way to assess trees in the city for potential risk. This type of survey can help the city track trees with potential hazards and follow-up for a more detailed assessment and mitigation. Using the recently completed tree inventory the city can develop a risk management program for city trees and mitigate potential impacts from natural disasters such as winter storms.

Integration

Recommendations under "Integration" include incorporating urban forestry data (canopy data, tree inventory) throughout city departments and systems. Integrating this data also allows for various city staff to use and incorporate the data into their work such as planning staff who can use the data in daily and long-range planning. In addition, by making the canopy data available online through the city's GIS portal it can provide information to the public about this important city asset. Integrating this data also allows for staff to understand the resources on site during the development review process.

Tree planting or preservation opportunities can be realized throughout the development process. A first step is to engage in constructive collaboration with developers. The city holds planning concept reviews, but they do not include discussions on minimizing impacts to trees. Someone from the city knowledgeable in tree health and care should attend all scheduled reviews. Greater encouragement for these meetings and funding for additional staffing within the city's urban forestry program could expand the frequency and benefits derived from these meetings.

Actively promoting development designs that minimize the loss of urban forest canopy and habitat is key to continued progress in expanding city canopy cover. The GIC has found that economic arguments (real estate values for treed lots, access to open spaces, and rate of sales) are usually the most compelling way to motivate developers to take the extra effort and care to design sites and manage construction activities to manage tree conservation. This will facilitate site designs which save more trees and thereby require less constructed stormwater mitigation. Many developers are willing to cooperate in such ventures, as houses often sell for a premium in a well-treed development.

Reducing Impervious Surfaces

The city contains 37% impervious surfaces which create environmental problems such as nuisance flooding and urban heat island effect. Policy measures to reduce the amount of impervious surface created in future developments will mitigate these impacts. Also, reducing impervious surfaces can potentially create more space available for new tree plantings and healthy tree growth. One recommendation is the city adopt a Complete Green Streets policy. A Complete Street is a street section that integrates infrastructure for cars, bicyclists and pedestrians. A Complete Green Street also integrates low impact development (LIDs) practices such as bioswales and trees into street cross-sections. The city should revise its parking lot standards to require trees planted in recessed landscaped areas in parking lots with curb cuts or without curbs that can also function as temporary stormwater runoff collection and infiltration areas. These recessed tree islands designed dimensions should be increased from the minimum 10 square feet amount of landscaped area per parking space to greater than 25 square feet. The city can provide a suite of alternative stormwater best management practices and incentivize developers to pick and choose from ones on the list to use in managing more stormwater on site.

Planning Process and Community Engagement

Steering Committee

The first step in GIC's planning process was to develop the process was develop a steering committee of city staff and tree commission members to provide their knowledge and expertise when reviewing data, maps and tools. The steering committee participated in a series of six workshops each focused on a different area of analysis presented in this report. Using final land cover, Potential Planting Areas (PPA) data and each of the analyses, the steering committee created a list of proposed strategies and a proposed canopy goal. The proposed goal and strategies along with a summary of the results from the canopy study and codes audit were presented to the general public at two separate open houses in the Fall of 2023. The open houses were an opportunity for the public to learn the results of the study and vote on the proposed goal and strategies developed by the steering committee. The voting results were reported to the steering committee which influenced the final strategies chosen. This process is only a first step in thinking strategically and engaging the public on a broader scale around the urban forest. This information and community feedback will support future urban forest planning for the City of East Providence.

The East Providence community attended open houses in the fall of 2023 to review maps and learn more about the city's tree canopy.

Public Open House and Input

The Green Infrastructure Center held an open house on October 2, 2023 at the Weaver Library to share maps and findings from the canopy study with the public. GIC also presented the city's proposed canopy and strategies for increasing canopy or reducing its loss. Thirty-six members of the community showed up to learn more about the tree canopy and vote on the city's proposed strategies.

In addition, a second public meeting was organized by the community group East Providence Urban Forest (EPUF), a group of residents who care for the city's urban forest and are interested and concerned for its care and management. The meeting was held on November 28, 2023 and twenty-two people attended to listen to a summary of the tree canopy study, review maps and vote on proposed strategies.

The Top Five Strategies

Voted Highest by the Public

- **Revise landscaping requirements for parking lots in Commercial and Office zones. (36 votes)**
- **Retrofit impervious commercial properties with new trees.** *(30 votes)*
- **Educate the public on the importance of trees to public health and the environment.** *(26 votes)*
- **Build and train a youth workforce to help manage the urban forest.** *(24 votes)*
- **Revitalize street corridors with tree plantings.** *(24 votes)*

Informing other existing planning efforts with East Providence

Urban forest planning has roots in other existing planning efforts in the city. The following plans highlight previous community input for managing the urban forest resource. The data from this study and many of the strategy ideas developed during the course of this project can be carried forward across other planning efforts in the city and showcase more progress at achieving many of these stated goals. The integration of canopy data and planning of the city's green infrastructure will make other types of planning more successful by achieving many different goals.

East Providence's Comprehensive Plan

Natural Resources Element Strategies:

- Protect and maintain important landscapes, wildlife corridors, and natural features.
- Enhance the City's green infrastructure.
  - — Use "nature-based solutions" to address impacts of rain runoff, flooding, urban heat island effect, etc.
  - — Increase tree canopy.
  - — Reduce pavement and other impervious surfaces.

Sustainability and Resiliency Element Strategies:

- Mitigate and adapt to the impacts of climate change.
  - — Prioritize infrastructure for upgrades, investments.
  - — Identify where City operations/practices can be more environment-friendly.
- Educate residents and businesses on how they can be more resilient.
  - — Guidance on resources for best practices for businesses.
  - — Outreach to residents to be environmental stewards at home.

Residential properties play a key role in the stewardship of the urban forest.

Local Hazard Mitigation Plan: A Multi-Hazard Mitigation Strategy 2022, Strategies:

- Establish a comprehensive tree program.
- Work with National Grid to determine rotating schedule of tree trimming activities and other line maintenance.
- Outreach to residents regarding trees on private property.

East Providence, Municipal Resilience Program, Community Resilience Building Workshop Summary of Findings, June 2021

Environmental Challenges and Concerns:

- Increasing impacts on tree health from pests and pathogens resulting in a number of dead and damaged trees posing risks to power lines and blocking roads during emergencies.

Increasing tree canopy at schools and playgrounds is a priority.

Stormwater basins can be planted with trees where maintenance access is not prohibited to provide additional stormwater capture.

- No formal tree and debris management plan for both routine maintenance and disaster response.
- Need to integrate tree equity score information as guide for comprehensive tree management plan.

Actions:

- Increase shade tree canopy at all schools – particularly on playgrounds and outside areas used by student and teachers - across the system.
- Update tree removal section of hazard mitigation plan and update existing urban and other tree planting strategies to include consideration of new environmental conditions (temperature, pests, pathogens, diseases, etc.).
- Renew funding for tree planting program as part of tree management plan which accounts both for both the expansion of the urban tree canopy balanced with management along power lines to prevent outages.
- Develop a community engagement strategy to foster support for open space regarding climate adaptation efforts, forest canopy management and expansion, stormwater management and floodplain management.

Strategies and Recommendations

The strategies in this report were developed in workshops with the technical advisory committee and voted on by community members. GIC made additional recommendations. All strategies and recommendations are based on the land cover and ecosystem service modeling, analysis of the tree canopy and potential planting areas and the codes, or ordinances and policy review.

The top strategies and recommendations to improve tree canopy cover in East Providence listed in priority order include:

1 Amend the landscaping ordinances requirements to include a greater |number of tree plantings in Commercial and Office zones.

Trees are an important part of the city's infrastructure and need to be planned for in future developments, particularly in land uses with a lot of impervious surfaces such as commercial and office zones. City staff should amend the landscape ordinance to require a greater number of trees through wider buffers and/or minimum pervious surface requirements. Other code revisions can include increasing tree canopy requirements in parking lots to provide more shade for shoppers.

Additional GIC Recommendations

- **Require and enforce 600, 1,000, and 1,500 cubic feet soil volume planting requirements for small, medium, and large trees respectively.**

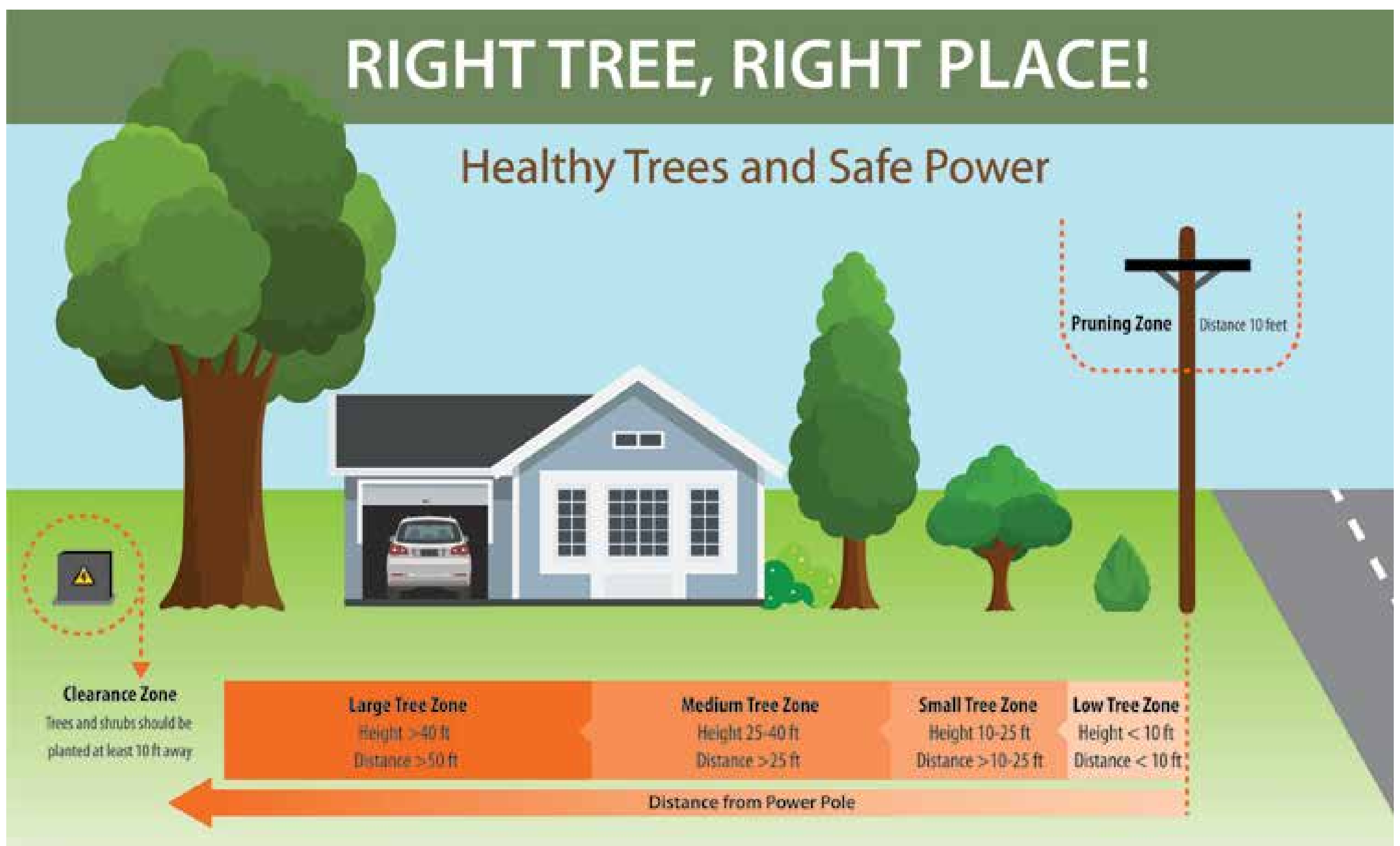
  At a minimum, canopy trees require 1,000 cubic feet of soil volume to thrive, as recommended by the Environmental Protection Agency (Stormwater to Street Trees, 2013). Soil volume allows for adequate room for root growth, which will help keep the tree healthier for longer, further extending the return on investment in green infrastructure. Greater soil volume and soil areas will also decrease a tree's risk of failure during a storm by providing adequate area for root anchoring.

2 Retrofit commercial properties with green infrastructure to mitigate stormwater runoff.

In addition to amending the code to retain and promote healthy tree growth into the future, the city should pilot retrofits on older development sites with green infrastructure practices. One potential area are the parking lots near the Walgreens on Warren Ave. These impervious surfaces drain into the roadway and cause nuisance flooding downhill underneath the South 114 overpass. By removing 1-2 parking spaces, stormwater could be captured onsite in swales and minimize flows downhill. Other properties in the area, including residential properties could plant more trees to help capture stormwater and reduce runoff volumes. Install signage for stormwater infrastructure demonstration projects to educate residents and the general public.

3 Educate the public on the importance of trees to public health and the environment.

Community engagement around the urban forest is a challenge for many municipalities. However, as most of the city's urban forest is in private ownership, the community should be engaged in urban forestry management and tree planting. Educate the public about the tree canopy and how much planting space is available to plant trees. Use the ecosystem service benefits data to communicate the impact trees have on public health and partner with the East Providence Health Equity Zone (HEZ) to implement tree planting projects. Develop a media campaign for the public to build community support. Include infographics with social media posts and tree giveaways, such as "*Right Tree, Right Place*" and planting brochures to aid in proper siting and planting of trees on private property. Partner with other groups in the region on expanding education around green infrastructure.

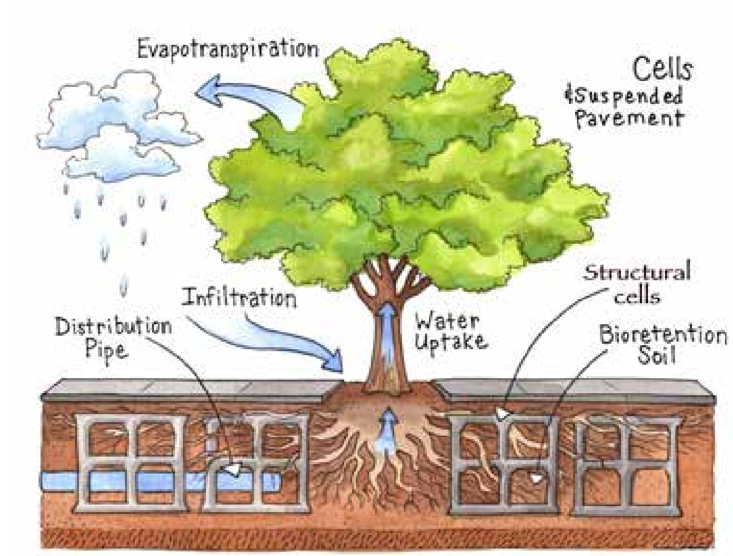


4 Build and train a youth workforce to help manage the urban forest.

Educating the next generation of tree stewards and workforce is critical to sustainably managing the urban forest over time. This workforce will also be necessary to help maintain built green infrastructure that manages stormwater runoff. Developing partnerships with schools, teachers, nonprofits and community groups will be essential for building the specialized knowledge and skills to manage urban trees. The city has a significant component to its IRA grant to build this workforce and engage with youth on urban forestry.

5 Continue tree plantings in rights-of-way and for key streets where green infrastructure and shade are needed.

The city planted 147 trees in 2022 in city rights-of-way and aims to plant 200 trees in 2023. In addition, the city has a tree setback planting program, where private landowners can request a tree planted within 20 feet of the public right-of-way. The setback program is an excellent way of getting tree canopy into the public right-of-way but planting the tree in better site conditions (e.g., residential yards) for the tree health and growth (assuming no conflicts with overhead or underground utilities). The city can use the street tree coverage map developed by GIC to target streets with low tree canopy coverage with potential for an increase in canopy and that higher-than-average surface temperatures to increase shade along city streets.



Structural Cells and Suspended Pavement are techniques to integrate trees in highly impervious areas.

Photo credit: Acton Wakefield Watersheds Alliance (AWWA)

Infiltration trenches are a low-cost, low-tech way of reducing urban stormwater runoff on private property. This type of practice is compatible with tree plantings for added stormwater mitigation value.

6 Require low impact development (LID) practices in new upland developments. Identify strategic locations to plant more trees for stormwater mitigation.

Sabin Point Park's outfall is located at the beach and the city has water quality issues with stagnant stormwater being flushed during high intensity rainfall events. There is opportunity in the Riverside neighborhood at the top of the hill for tree planting efforts which can capture some of that stormwater and reduce the volume flowing downhill. The neighborhood lacks curbs along most streets which can allow for other green infrastructure practices such as infiltration trenches which are gravel bed trenches that run parallel to the roadway and are covered by lawn, but allow for stormwater to infiltrate and be held in the substrate. This type of project could be an excellent partnership opportunity with local area nonprofits such as Groundwork Rhode Island to plant trees on private property, build rain gardens and install infiltration trenches.

7 Require impervious surface reductions and tree plantings in floodplain redevelopments.

The city should update the floodplain ordinance to be aligned with recent planning efforts such as the Natural Resources Element of the East Providence Comprehensive Plan (2023), the Community Resiliency Building Workshop (2021) and the Local Hazard Mitigation Plan (2022). These public documents reference keeping as much of the floodplain as possible in a natural state and reducing impervious surfaces. In contrast the city's floodplain ordinance does not mention natural land cover as the preferred land cover type in the floodplain nor does it reference standards or incentives for reducing impervious surfaces. The city does prioritize floodplains as a criteria when it considers properties for conservation, but it needs to update the code to be provide consistency towards future development.

Partnering with schools and engaging with students on tree planting and care is an excellent way to create the next generation of tree stewards in the community. Photo credit: EPUF

8 Develop partnerships to plant more trees at low-canopied schools.

The City of East Providence secured a $750,000 grant through the Inflation Reduction Act (IRA) to plant trees at low canopied and disadvantaged schools. The city is putting together a steering committee to help implement the IRA grant over the next five years. They will create a work plan to map out project locations and over what timeframe.

Tree giveaways are one of the most popular and cost-effective ways to get trees planted on private property and provide an opportunity to educate the public on proper tree planting, care and maintenance.

Tree giveaways and community tree plantings are popular and cost-effective ways to get trees planted onto private property. The city has held several tree giveaways for residents. Photo credit: EPUF

9 Identify priority tree planting areas using data. Hold public tree giveaways.

To realize its goal of 36% canopy cover, the city will need to replace canopy lost from development, storms, old-age and pests as well as plant thousands of new trees. Using the Potential Planting Areas (PPA) data the city can develop a strategy to plant neighborhoods that have low canopy. The city is going to examine what opportunities exist in disadvantaged neighborhoods and focus efforts there first. The city will need to plant thousands of trees and foster active participation from the community to plant trees on private property. Tree giveaways are one of the most popular and cost-effective ways to get trees planted on private property and provide an opportunity to educate the public on proper tree planting, care and maintenance.

10 Develop an urban forest management plan for the city. Develop an urban forest pest action plan to mitigate tree loss.

An urban forest management plan (UFMP) details the process for managing the city's urban tree canopy. It is used to achieve local government and community goals to proactively manage the city's urban canopy and achieve long term benefits. A UFMP also informs budgeting for urban forest maintenance or planting. An urban forest management plan requires data to inform it including canopy and tree inventory data. Now that the city has these data it can develop a comprehensive management plan. According to the tree inventory data, 8% of the city's public trees are a species of ash trees. Ash trees are vulnerable to the invasive insect pest, Emerald Ash Borer (EAB) which bores into the tree and kills it. At this time there are no permanent treatment options for EAB. The tree inventory analysis makes some management recommendations based on a subsample of ash trees. The city as a part of a good management plan should devote a section to the long-term management and replacement of ash trees in the community and identify potential action steps for other future pest outbreaks.

This tree is not adequately protected from ongoing construction. Heavy machinery driving over roots and parked near trees can compact the soil, damage roots and lead to the decline in tree health or mortality.

Additional GIC Recommendations for East Providence

- **Update the tree protection ordinance to include protecting trees on private property and require tree mitigation when significant trees must be removed to accommodate development.** As recommended during the codes and ordinances audit, trees are part of the city's infrastructure and impact both public and private properties alike. By increasing the protection of trees on private property, the city can conserve and minimize tree canopy loss over time. Tree mitigation should be strong enough to limit the wholesale clearing of trees on a site, but not so punitive to limit necessary development. A tree mitigation fund should also be flexible to allow for tree plantings on both public and private property.

- **Incentivize developers to incorporate and retain mature trees on sites and protect those trees during construction.** Large mature trees provide greater and more immediate ecosystem service benefits than newly planted trees used for mitigation. The city's code can be amended to incentivize retention of mature trees for meeting stormwater requirements. Other types of incentives include faster permitting for preserved trees or patches of forest. The tree preservation code should also provide specific protections for mature trees during the construction process such as require fencing a distance of 1.5' times the tree's diameter at breast height (DBH) from the tree, exclude storage and staging of materials near the tree, place clearly visible signage and avoid trenching utilities that would impact tree roots. Existing large trees should be indicated on site plans along with tree protection measures.

- **Continue the integration of planning for trees in all planning and pre-development activities.** Holding pre-development conferences before sites are designed allows for creative solutions for tree retention to be considered as well as to calculate potential stormwater impacts from tree removal or planting. Sketching these site design ideas to protect trees early on allows for exploration of ideas for tree conservation before extensive funds are spent on site planning.

Continued

Additional GIC Recommendations
for East Providence *(continued)*

Codify the role of trees as green infrastructure within the Hazard Mitigation Plan.
The Federal Emergency Management Agency's (FEMA), Public Assistance grants support "Plantings (such as trees, shrubs, and other vegetation) are eligible [for funding] when they are part of the restoration of an eligible facility for the purpose of erosion control, to minimize sediment runoff, or to stabilize slopes, including dunes on eligible improved beaches. Plantings required to mitigate environmental impacts, … are only eligible if required by a Federal, State, Territorial, Tribal, or local code or standard permit that meets the criteria described in Chapter 2:VII.B.7." (FEMA, 2020). In order for trees to be eligible by FEMA under the Public Assistance Grants for reimbursement, documentation on the role those trees play in mitigating stormwater or erosion is necessary. Adopting trees as a hazard mitigation strategy and policy can establish precedent for the role of trees as green infrastructure (note: additional documentation steps are required). Adding trees as green infrastructure can also be used to justify funding tree planting as green infrastructure under FEMA's Hazard Mitigation and Building Resilient Infrastructure and Communities (BRIC) grant programs.

East Providence community members helped collect tree inventory data. Tree inventory data provides additional context to urban forest management such as species composition and age diversity. Photo credit: EPUF

Use public tree inventory data to track city assets.
The city and a group of dedicated volunteers collected a tree inventory for all public trees in the city. This dataset is a valuable data source that can inform other areas of urban forest management such as species composition, relative age of the urban forest and maintenance regimes. The data should also be integrated into the city's asset management tracking systems where other types of public infrastructure are tracked and managed. This will allow the city to track and monitor its assets for tree locations, condition and maintenance needs as further work is conducted over time. These data are critical for securing future FEMA reimbursement to replace trees under its Public Assistance grants available after federally-declared disasters.

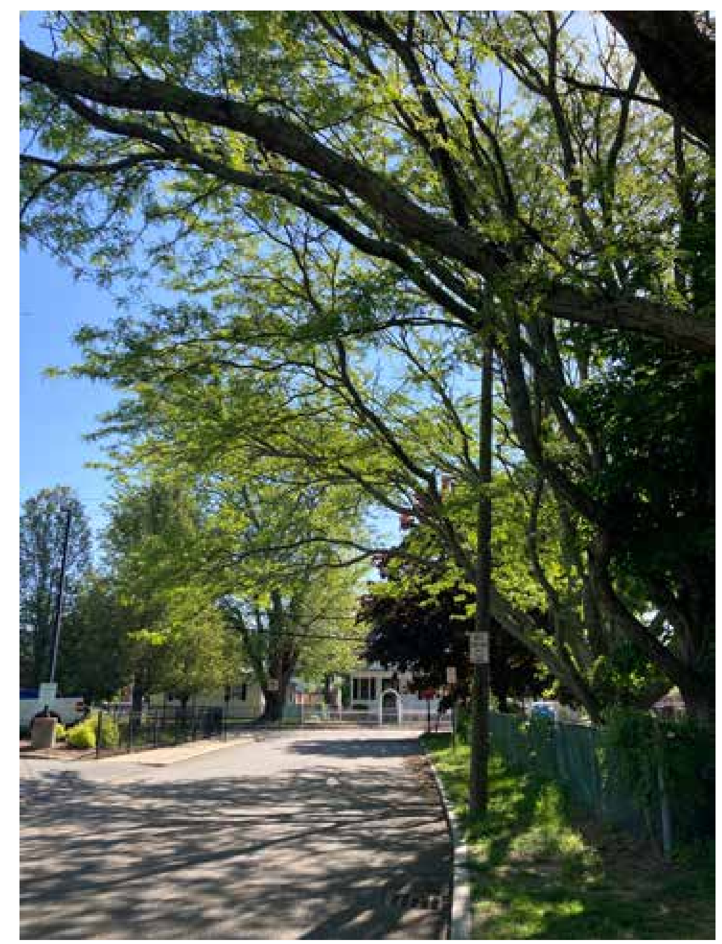
Proactively conduct annual tree risk assessments in highly trafficked areas of the city. Tree risk assessments can be used to determine and develop plans to mitigate tree risks, such as diseased limbs that may fall. The city received a grant award from the Rhode Island Division of Forest Environment to assess and flag tree risk as part of analysis pf the tree inventory data. This information is a great baseline dataset the city can use to develop a risk management program for city trees. In highly trafficked areas, a Level-1 assessment, also known as a windshield survey, should be done annually for all public trees. Implementing proactive tree risk assessments will reduce overall risks and potential losses. The city should develop a formalized tree risk assessment program to ensure this work is being done consistently every year.

Conduct a land cover assessment every four to six years to compare tree canopy coverage change over time. Tree canopy coverage should be expanded and maintained to promote public health, walkability, water quality and groundwater recharge. Regular updates to land cover maps also track trends (losses or gains) in the canopy over time, monitoring and support adaptive management for prioritizing planting strategies. This will also be useful measure to help the city track its progress and outcomes of its federal tree planting grant from the U.S. Forest Service.

Conclusion

The community of East Providence has made significant progress to collect data for the management of its urban forest. These data (tree inventory, canopy data, codes audit) provide a variety of assessments that can inform actions and strategies moving forward. Implementing these strategies and recommendations will significantly reduce the impact of stormwater sources (impervious cover) and benefit the local ecology by using native species (trees and other vegetation) to uptake and clean stormwater along with other ecosystem service benefits (air quality, urban heat island, etc.). It will also lower costs of tree cleanup after storms since proper pruning or removal of trees deemed to be at risk can be done before storms occur.

East Providence should use the canopy map and updates to track canopy change over time and prioritize increasing canopy by neighborhoods to restore lost canopy. The city can use the canopy data, analysis and recommendations and stormwater calculator tool to continue to create a safer, cleaner, cost-effective and more attractive environment for all.



Next Steps

An urban forest management plan is another key plan the city should develop to ensure that it has detailed and actionable processes to care for and manage its trees. Grant funding is available from the Rhode Island Division of Forest Environment's Urban and Community Forestry Program for such activities. A key aspect of urban forest management is integrating urban forestry within emergency response plans. This should be coordinated with the Rhode Island Emergency Management Agency and adjacent communities who share similar concerns about storm debris and removal or repurposing. Given the many benefits that trees provide (increased groundwater infiltration, soil stability, and reduced runoff and flooding, shade and better air quality), the city should plan for funding and replacement tree plantings following natural disasters. Codifying trees as green infrastructure to mitigate stormwater and erosion will make them eligible for replacement under FEMA's Public Assistance grants. Tree inventory data (location, species, trunk diameter, photo) the city collected recently will support the necessary documentation to claim a tree as eligible for reimbursement if lost or damaged by a federally-declared storm or other natural disaster. Including tree maintenance records and expenditures as part of the city's asset management system will demonstrate the role trees play as critical green infrastructure.

Lastly, it is recommended that the city conduct a land cover assessment every four to six years to compare tree canopy change over time and track progress towards the 36% coverage goal. Keeping tree canopy coverages at levels that promote public health, walkability, and clean water is vital for livability and for meeting state water quality standards. Regular updates to land cover maps allow for this analysis and planning to take place and to identify and address negative trends as well. These and other practices, implemented to provide long term care, protection and best planting practices for the urban forest, will help ensure that investments in city trees will pay dividends for reducing stormwater runoff as well as clean air and water, lower energy bills, higher property values and natural beauty long into the future.

Appendixes

Appendix A: Land Cover Analysis Methods

This section provides technical documentation for the methodology used to classify land cover and create Potential Planting Spots (PPS) and Potential Canopy Area (PCA) scenarios for the city. Land cover classifications are an affordable method for using aerial or satellite images to obtain information about large geographic areas. Algorithms are trained to recognize various types of land cover based on color and shape. In this process, the pixels in the raw image are converted to one of several types of pre-selected land cover types. In this way, the raw data (the images) are turned into information about land cover types of interest, e.g., what is pavement, what is vegetation. This land cover information can be used to gain knowledge about certain issues; for example: What is the tree canopy percentage in a specific neighborhood?

Method

Satellite imagery from the National Agricultural Imagery Program (NAIP) distributed by the USDA Farm Service Agency was classified to determine the types and extent of different land covers in East Providence.

1. Canopy maps were created using the NAIP imagery, captured in 2021. Current LiDAR data was not available at the time of classification, so we used an ArcGIS extension called Feature Analyst to identify the tree canopy. Feature Analyst employs machine learning for feature classification, and we trained it to compete the classification by digitizing canopy samples, which were then fed to the learning model, along with NDVI values calculated from the NAIP imagery.
2. Once we had an accurate canopy classification, we proceeded with obtaining the remaining land cover classes:
3. Tree Canopy over impervious are canopy features that overlapped Impervious surfaces primarily created from existing vector data.
5. Wetlands were identified using the National Hydrography Dataset.
6. Wooded wetlands were identified based on where NDVI is above 0 OR feature height is above 10 ft and intersects NHD water/wetland.
7. Turf/Pervious are features identified as "green" or typically above 0 in NDVI but were not identified as canopy by Feature Analyst.
8. Impervious surfaces were created by buffering road centerlines, along with building
9. Bare earth is sometimes confused with Impervious surfaces, but typically had a NDVI value closer to 0.

A Confusion matrix was run to test the accuracy of the canopy data which resulted in ....

CLASS VALUE	Tree Canopy	Pervious	Water*	Impervious	Bare Earth	Wetland	Total	Accuracy	Kappa
Tree Canopy	32	0	0	0	0	0	32	100.0%	0
Pervious	0	23	0	2	0	0	25	92.0%	0
Water*	0	1	4	0	0	0	5	80.0%	0
Impervious	0	1	0	26	0	0	27	96.3%	0
Bare Earth	0	0	0	0	6	0	6	100.0%	0
Wetland	0	0	0	0	0	5	5	100.0%	0
Total	32	25	4	28	6	5	100	0.0%	0
P_Accuracy	1	0.92	1	0.93	1	1	0	96.0%	0
Kappa	0	0	0	0	0	0	0	0.0%	0.95

The result of this confusion matrix allowed GIC to determine that the overall land cover classification had an accuracy of 96%.

Note: Bare earth is easily mis-identified with pervious surfaces. Curve numbers in the TSW Calculator are similar and this does not affect analysis. In some places, sidewalks or golf cart paths were identified as bare earth under canopy. There are few places like this, and the overall area of the class is small – so the percentage may appear high.
NAIP Imagery from 2021 was used for the land cover classification.

*The one misclassified water point is due to NHD data. A small body of water was recorded in that location, that has since dried up.

NAIP Image 2021

Potential Planting Area (PPA)

Potential Planting Spots (PPS)

Potential Canopy Area (PCA)

Potential Planting Area Dataset

The Potential Planting Area dataset has three components. These three data layers are created using the landcover layer and relevant data in order to exclude unsuitable tree planting locations or where it would interfere with existing infrastructure.

- **Potential Planting Area (PPA)**
- **Potential Planting Spots (PPS)**
- **Potential Canopy Area (PCA)**

The Potential Planting Area (PPA) is created by selecting the landcover features that have space available for planting trees, then eliminating areas that would interfere with existing infrastructure.

Initial inclusion selected from GIC-created land cover pervious surfaces class.

Exclusion features applied:

- The pervious surfaces were buffered in 10 ft. from all impervious surfaces including buildings and roads.
- Playing fields (i.e.: baseball, soccer, football) as well as golf courses, cemeteries, airports and other incompatible land uses were identified where visually possible. (Digitized by GIC)
- Power Line Corridors and Major Road Median exclusions were created by buffering their representative line data.
- Once this initial phase was completed, the Potential Planting Area data were reviewed by the city and manually edited to best represent city expectations of where planting was allowed (e.g., not on play fields). In addition, areas that were known to be planned for development were removed.

This additional work to exclude known areas that cannot be planted resulted in a more accurate and realistic calculation of plantable areas and the number of new trees that can be added.

Potential Planting Spots. The Potential Planting Spots (PPS) are created from the PPA. The potential planting areas (PPA) are run through a GIS model that selects spots a tree can be planted depending on the size tree's that are desired.

- Tree planting scenarios were based on a 20 ft. and 40 ft. mature tree canopy with a 30% overlap. Therefore, the planting spots are 16 ft. and 32 ft. apart respectively.

Potential Canopy Area. The Potential Canopy Area (PCA) is created from the PPS. The possible planting spots are given a buffer around each point that represents a tree's mature canopy. First, larger canopy trees are digitally added, followed by smaller trees in the remaining spaces. Planting spots were assigned a buffer of 10 or 20 ft. to result in 20 and 40 ft. tree canopy that overlaps by 30%. This reduces gaps that would be found at the corners of adjacent circles and reflects the reality that trees overhang and intermingle with adjacent trees.

Appendix B: Trees to Offset Stormwater Calculator

The trees and stormwater calculator (TSW) tool developed by GIC uses modified TR-55 curve numbers to calculate stormwater uptake for different land covers, since they are widely recognized and understood by stormwater engineers. A canopy interception factor is added to account for the role trees play in interception of rainfall based on location and planting condition (e.g., trees over pavement versus trees over a lawn or in a forest).


Tree over street


Trees over forest


Tree over lawn


Tree over parking lot

Cities usually use TR-55 curve numbers developed by the Natural Resources Conservation Service (NRCS) to generate expected runoff amounts. The modified TR55 curve numbers (CN) provided by GIC includes a factor for canopy interception. Cities can use the stormwater calculator tool for setting goals at the watershed scale for planting trees and for evaluating consequences of tree loss as it pertains to stormwater runoff. Curve numbers produced for this study can be utilized in the city's modeling and design reviews.

Tree canopy reduces the proportion of precipitation that becomes stream and surface flow, also known as water yield. A study by Hynicka and Divers (2016) modified the water yield equation of the NRCS model by adding a canopy interception term (Ci) to account for the role that canopy plays in capturing stormwater, resulting in:

$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

Where **R** is runoff, **P** is precipitation, **Ia** is the initial abstraction (the fraction of the storm depth after which runoff begins), and **S** is the potential maximum retention after runoff begins for the subject land cover **(S = 1000/CN – 10)**.

Major factors determining **CN** are:

- The hydrologic soil group (defined by surface infiltration rates and transmission rates of water through the soil profile, when thoroughly wetted)
- Land cover types
- Hydrologic condition – density of vegetative cover, surface texture, seasonal variations
- Treatment – design or management practices that affect runoff

This new approach allows for more detailed assessments of stormwater uptake based on the landscape conditions of the city's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks because the conditions and the soils in which the tree is living affect the amount of water the tree can intercept.

The analysis can be used to create plans for where adding trees or better protecting them can reduce stormwater runoff impacts and improve water quality. This methodology was developed and tested in 13 communities in the south under a grant from the Southern Region of the USDA Forest Service. For more about the project, please visit http://www.gicinc.org/trees_stormwater.htm

Appendix C: Bibliography

______ Appendix: Hynicka, Justin, and Marion Divers. “Relative reductions in non-point source pollution loads by urban trees.” in Cappiella, Karen, Sally Claggett, Keith Cline, Susan Day, Michael Galvin, Peter MacDonagh, Jessica Sanders, Thomas Whitlow, and Qingfu Xiao. “Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion.” (2016).

________Runoff and infiltration graphic. EPA Watershed Academy Website. Accessed September 01, 2022: https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=170

_______“Complete Green Streets. Smart Growth America.” Website accessed September 01, 2022: https://smartgrowthamerica.org/what-are-complete-streets/

_______ Penn State Extension, Trees and Stormwater: Website accessed Jan. 1. 2020 https://extension.psu.edu/the-role-of-trees-and-forests-in-healthy-watersheds

_______“Stormwater to Street Trees.” U.S. Environmental Protection Agency, September 2013. EPA report # EPA 841-B-13-001. Web site accessed September 01, 2022: https://www.epa.gov/sites/production/files/2015-11/documents/stormwater2streettrees.pdf

Akbari, Hashem, Melvin Pomerantz, and Haider Taha. “Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas.” in *Solar energy*, Vol. 70, No. 3 (2001): pp295-310.

Benedict, Mark A., and Edward T. McMahon, “*Green Infrastructure: Linking Landscapes and Communities*.” Washington, D.C.: Island Press, 2006.

Benedict, Mark A. and Edward T. McMahon, “*Green Infrastructure: Smart Conservation for the 21st Century*.” Washington, D.C., Sprawl Watch Clearing House, May 2002. Accessed September 01, 2022: http://www.sprawlwatch.org/greeninfrastructure.pdf

Booth, Derek B., David Hartley, and Rhett Jackson, “Forest cover, impervious-surface area, and the mitigation of stormwater impacts.” in JAWRA *Journal of the American Water Resources Association*, Vol. 38, No. 3 (2002): pp 835-45.

Cappiella, Karen, Sally Claggett, Keith Cline, Susan Day, Michael Galvin, Peter MacDonagh, Jessica Sanders, Thomas Whitlow, and Qingfu Xiao. “Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion.” (2016).

Climate Project." *Urban ecosystems* 1, no. 1 (1997): 49-61.

Correll, Mark R., Jane H. Lillydahl, and Larry D. Singell. "The effects of greenbelts on residential property values: some findings on the political economy of open space." *Land economics* 54, no. 2 (1978): 207-217.

Duryea, Mary L., and E. L. I. A. N. A. Kampf. "Wind and Trees: Lessons Learned from Hurricanes: FOR 118/FR173, 9/2007." EDIS 2007, no. 20 (2007).

Dwyer, John F., E. Gregory McPherson, Herbert W. Schroeder, and Rowan A. Rowntree. “Assessing the benefits and costs of the urban forest.” in *Journal of Arboriculture*, Vol. 18 (1992), pp 227-34

Ellison, David, Cindy E. Morris, Bruno Locatelli, Douglas Sheil, Jane Cohen, Daniel Murdiyarso, Victoria Gutierrez et al. “Trees, forests and water: Cool insights for a hot world.” Global Environmental Change 43 (2017): 51-61.

Ernst, Caryn, Richard Gullick, and Kirk Nixon. "Conserving forests to protect water." *Am. Water W.* Assoc 30 (2004): 1-7.

Fazio, James R. “How trees can retain stormwater runoff.” in *Tree City USA*, Bulletin 55 (2010): pp1-8.

Federal Emergency Management Agency (FEMA), 2020, Public Assistance Program and Policy Guide, Version 4, Effective June 1, 2020.

Gregory, J.H., Dukes, M.D., Jones, P.H. and Miller, G.L., 2006. Effect of urban soil compaction on infiltration rate. *Journal of soil and water conservation*, 61(3), pp.117-124.

Gregory, Justin H., Michael D. Dukes, Pierce H. Jones, and Grady L. Miller. "Effect of urban soil compaction on infiltration rate." *Journal of soil and water conservation* 61, no. 3 (2006): 117-124.

Kuehler, Eric, Hathaway, Jon, and Tirpak, Andrew, “Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network.” in *Ecohydrology*, Vol. 10, No. 3 (2017).

McPherson, E. Gregory, and Muchnick, Jules, “Effect of street tree shade on asphalt concrete pavement performance.” in *Journal of Arboriculture*, Vol. 31, No. 6 (2005) p303-10.

McPherson, E. Gregory, David Nowak, Gordon Heisler, Sue Grimmond, Catherine Souch, Rich Grant, and Rowan Rowntree. “Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Project.” *Urban ecosystems* 1, no. 1 (1997): 49-61.

Meenakshi, Rao, L.A. George, T. N. Rosenstiel, V. Shandas, A, Dinno, "Assessing the relationship among urban trees, nitrogen dioxide, and respiratory health," *Environmental Pollution*, Volume 194, November 2014, Pages 96-104 https://phys.org/news/2014-09-trees-asthma-respiratory-diseases.html#jCp

Nowak, David John, E. Robert III, Daniel E. Crane, Jack C. Stevens, and Jeffrey T. Walton. "Assessing urban forest effects and values: Washington, DC’s Urban Forest." Resour. Bull. NRS-1. Newcity Square, PA: US Department of Agriculture, Forest Service, Northern Research Station, 24 p. 1 (2006).

Nowak, D.J., and Greenfield, E.J., 2012 “Tree and impervious cover change in U.S. cities.” in *Urban Forestry & Urban Greening*, Vol. 11 (2012); pp21-30. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1239&context=usdafsfacpub

Nowak, et al, (2010). *Sustaining America’s Urban Trees and Forests*. https://www.fs.usda.gov/nrs/pubs/gtr/gtr_nrs62.pdf

Roman, Lara A., Battles, John J., and McBride, Joe R. , “Determinants of establishment survival for residential trees in Sacramento County, CA.” in *Landscape and Urban Planning*, Vol. 129 (2014): pp22-31.

Roman, Lara A., and Frederick N. Scatena. "Street tree survival rates: Meta-analysis of previous studies and application to a field survey in Philadelphia, PA, USA." *Urban Forestry & Urban Greening* 10, no. 4 (2011): 269-274.

Souch, C. A., and Souch, C., “The effect of trees on summertime below canopy urban climates: a case study Bloomington, Indiana.” in *Journal of Arboriculture*, Vol. 19, No. 5 (1993): pp 303-12.

Tilt, Jenna H., Unfried, Thomas M., and Roca, Belen, “Using objective and subjective measures of neighborhood greenness and accessible destinations for understanding walking trips and BMI in Seattle, Washington.” in *American Journal of Health Promotion*, Vol. 21, No. 4, Suppl (2007): pp 371-9.

Wang, Jun, Endreny, Theodore A., and Nowak, David J., “Mechanistic simulation of tree effects in an urban water balance model.” in *JAWRA – Journal of the American Water Resources Association*, Vol. 44, No. 1 (2008): pp 75-85.

Wells, Nancy M., “At home with nature: Effects of ‘greenness’ on children’s cognitive functioning.” in *Environment and Behavior*, Vol. 32, No. 6 (2000): pp 775-95.

Xiao, Qingfu, E. Gregory McPherson, Susan L. Ustin, Mark E. Grismer, and James R. Simpson. “Winter rainfall interception by two mature open-grown trees in Davis, California.” in *Hydrological processes*, Vol. 14, No. 4 (2000): pp763-84.