Growing Shade & Enhancing the Urban Canopy

A Tree Canopy Improvement Strategy for the City of Norwalk

2018

WESTCOG

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Introduction

Welcome to the City of Norwalk's Tree Canopy Improvement Strategy. This document provides the City of Norwalk with a strategy for improving its tree canopy and by doing so improving the environment, health outcomes, and economic growth in the City.

This strategy synthesizes a wealth of data and research to give the City a holistic view of current conditions and potential for improvement. By incorporating elements of existing plans in Norwalk, this plan dovetails with ongoing efforts and supports future initiatives.

Funding for this project came from an American the Beautiful Grant managed by the Connecticut Department of Energy and Environmental Protection (CT DEEP). This document was prepared by the Western Connecticut Council of Governments (WestCOG) in partnership with multiple stakeholders within the City of Norwalk including the Tree Advisory Committee, the Norwalk Tree Alliance, the Coalition of Norwalk Neighborhoods, and the Department of Planning and Zoning. The opinions, findings, and conclusions expressed in this publication are those of WestCOG, and do not necessarily reflect the official views or policies of CT DEEP or the City of Norwalk.

Needs in Norwalk

In the 2008 US Forest Service survey, Norwalk ranked low for canopy cover, at number 135 of 169 municipalities in Connecticut, with 56.1% canopy green space. The average tree canopy cover in Connecticut in urban areas was 49.3%. The statewide average canopy cover was 64.5%.

In the same survey, Norwalk ranked highly for impervious surface cover, number 9 of the 169 municipalities in Connecticut, with 32.6% of land area as impervious cover. This low canopy cover and high impervious surface cover may have contributed to negative outcomes in Norwalk, which this document seeks to mitigate.

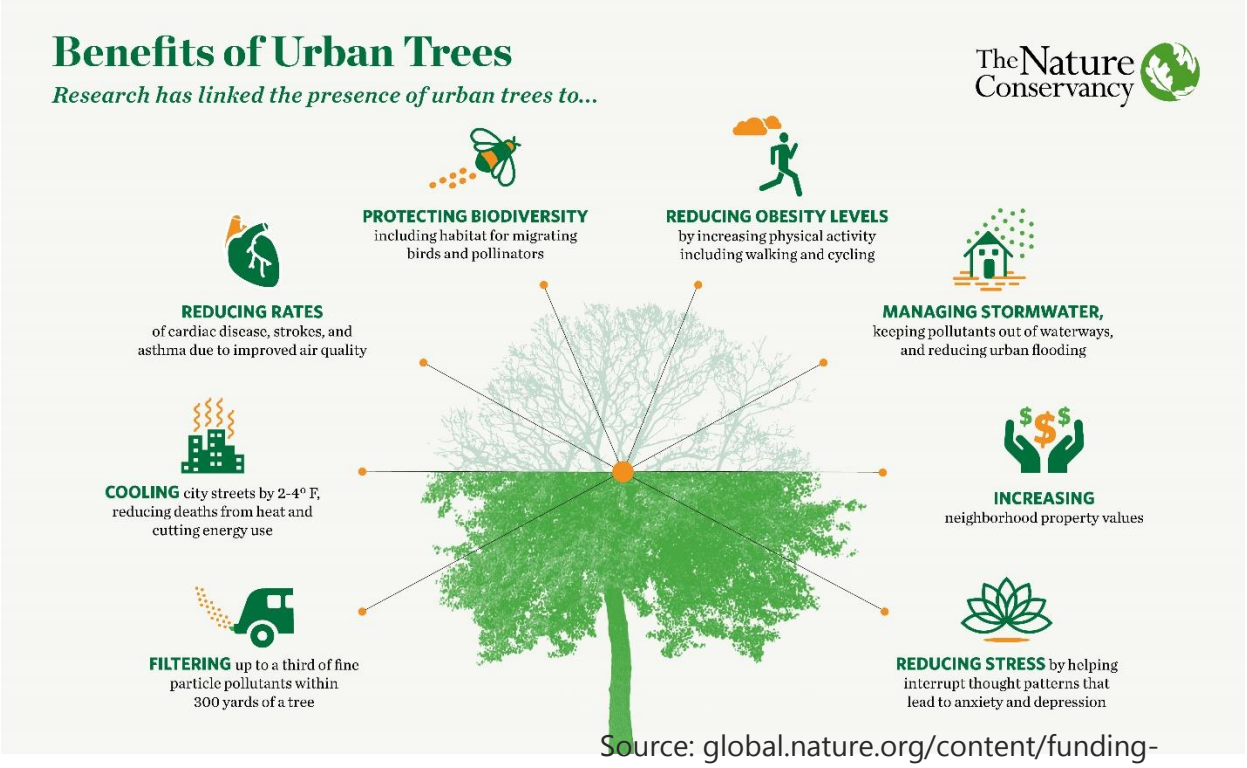
This dataset is very different from the one used by WestCOG in this document, therefore conclusions cannot be drawn between the growth or loss of canopy coverage over time. However, it does show Norwalk's standing relative to other municipalities, and indicates the need for a canopy improvement strategy in Norwalk.

Benefits of Trees

Trees are key to a healthy city. A flourishing urban tree canopy provides an array of benefits and services. These fall under three main categories:

- Environmental services – stormwater mitigation, air quality mitigation, ecological balance;
- Social enhancement – improved mental and physical health, contributing to a sense of place;
- Economic growth – increased housing prices, amplified commercial income.

These benefits give cities strong incentives to maintain a robust tree canopy. Understanding the positive outcomes of planting trees and embracing the importance of trees in the urban landscape can help improve the condition of communities across the United States.



Source: global.nature.org/content/funding-trees-for-health

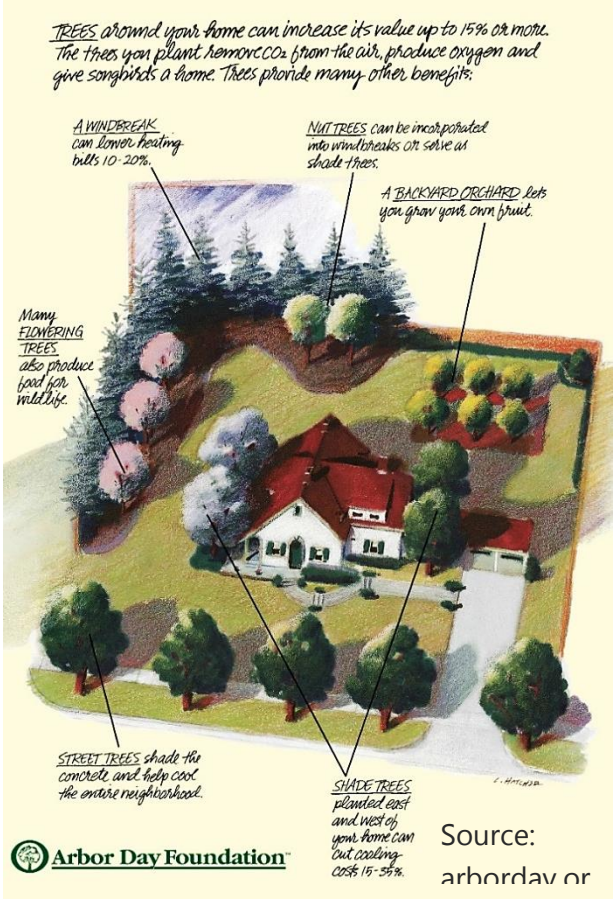
Temperature & Microclimate

Cities tend to be hotter than suburbs and rural areas. This is partly because urban environments have a greater percentage of impervious surfaces, such as paved roads, sidewalks, parking lots, and roofs. These sealed surfaces absorb sunlight, and as they heat up, they warm the surrounding air, contributing to the urban heat island effect.

The EPA describes a heat island as a built-up area that is hotter than the nearby rural areas. Their website states, "[t]he annual mean air temperature of a city with 1 million people or more can be 1.8 – 5.4°F (1 – 3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C)." Urban heat islands can increase peak energy demand and air conditioning costs during warmer months. They can increase air pollution, greenhouse gas emissions, and instances of heat-related illness and mortality, as well as negatively impact water quality.

Research from NASA (2015) shows that the daytime temperature difference between urban and vegetated land remains stable at 1.3°C [2.3°F], until the impervious cover on urban lands exceeds 35% of the land area, at which point the difference in temperature between vegetated land and urban land increases to 1.6°C [2.9°F]. According to NASA, "a rise of 1°C [1.8°F] can raise energy demands for air conditioning in the summer from 5 to 20 percent in the United States…. So even though 0.3°C [.5°F] may seem like a small difference, it still may have impact on energy use, …. especially when urban heat island effects are exacerbated by global temperature rises due to climate change." Trees can reduce the amount of heat absorbed by impervious surfaces and mitigate the urban heat island effect by shading streets and buildings. Thus, the demand for and the cost of air conditioning decreases along with energy use. The shade provided by trees can reduce air temperatures by up to 9°F (5°C). Through evaporation, a tree's release of water vapor further reduces air temperatures. Trees release excess water into the air as vapor through pores, or stomata, on leaf surfaces. As the vapor is released, it cools the surrounding air. This can reduce noon time peak temperatures by an additional 3.5°F to 5.5°F (1.9°C to 3.1°C). By providing shade and releasing water vapor, trees cool urban environments and reduce cooling costs.

Trees also reduce heating costs in the winter. Trees act as a wind barrier and can



Source: arborday.or

reduce wind speed by up to 60%. This prevents cool winter air from entering interior spaces, thereby reducing heating costs. For instance, a 50% wind speed reduction yields a 7% reduction in heating energy (Pickering et al, 2013).

To reduce cooling and heating costs, and save energy, it is best to plant deciduous trees on the east and west sides of buildings. Deciduous trees' loss of leaves in the fall allows more sunlight to reach building roofs when such heat can be the most beneficial. This allows trees to cast shade in the summer while enabling the sun to warm the building in the winter. To block wind and prevent cold air from penetrating interior spaces in the winter, evergreen trees should be planted on the north side of buildings.

Carbon Storage

Cities with traffic congestion, industrial activities, power plants, and other carbon emission sources release large amounts of carbon dioxide. Many urban areas are recognized as carbon "hot spots" because there tend to be a release of larger amounts of carbon. The increased carbon dioxide emissions form a dome over cities, increasing temperatures that in turn lead to increased concentrations of air pollutants which are harmful to human health.

As previously noted, trees can reduce the need for heating and cooling. As a result, power plants can decrease energy production and reduce the quantity of greenhouse gases released into the atmosphere. Planting an average of four shade trees per house is shown to decrease energy demands and lead to an annual carbon emissions reduction from power plants of 9,000 to 41,000 tons (Akbari, 2002).

Trees also actively absorb carbon from the air. The term "carbon sequestration" is used to refer to the process in which carbon dioxide is removed from the atmosphere and stored. Using energy from the sun, trees react carbon dioxide with water to create sugar. While much of the sugar is used by the tree for energy, the rest (carbon included) is stored in the tree as structure. Sequestered carbon makes up 45% of the dry weight of the plant, with large healthy trees storing the greatest amount of carbon (Nowak and Crane, 2002).

It is important to note in some cases, trees contribute to increased atmospheric carbon. This is because activities associated with tree maintenance, including the use of chain saws, chippers, stump removers, and trucks used to transport the machinery, burn fossil fuels and emit carbon dioxide into the air.

Air Quality

Due to high concentrations of traffic and industry, air quality is often significantly worse in cities than in a state or county. Consequently, pollution-related illnesses, which include upper and lower respiratory symptoms, bronchial asthma, lung function deficits, and air pollution related cancer, are more prevalent in urban areas. The pollutants of greatest public health concern are particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide. Trees improve urban air quality by removing

these harmful pollutants from the air and preventing the formation of compounds.

Trees remove air pollution in two ways, through uptake and interception. During uptake, stomata open during the day. This allows air, and airborne pollution, to move into the leaf. Once inside, some of the pollutants are trapped in the tree. The tree then releases oxygen into the atmosphere, further purifying the air. During interception, particulate matter, which includes soot, ash, and dust, adheres to the tree's surface. This reduces the local concentration of airborne particulate matter.

In addition to filtering out and trapping air pollutants, trees inhibit their formation altogether. As previously discussed, trees reduce air temperatures by providing shade and emitting water vapor. Some pollutants, such as ozone, require elevated temperatures to form. By lowering the air temperature, trees limit the formation of some pollutants. With fewer pollutants in the air, the air quality in urban areas improves, therefore reducing harmful impacts on human health.

While trees play a significant role in improving air quality, care must be taken to ensure low pollen producing and low volatile organic compound emitting trees are planted. This will minimize any potential negative effects and maximize the air purifying potential of trees.

Source: treesaregood.org

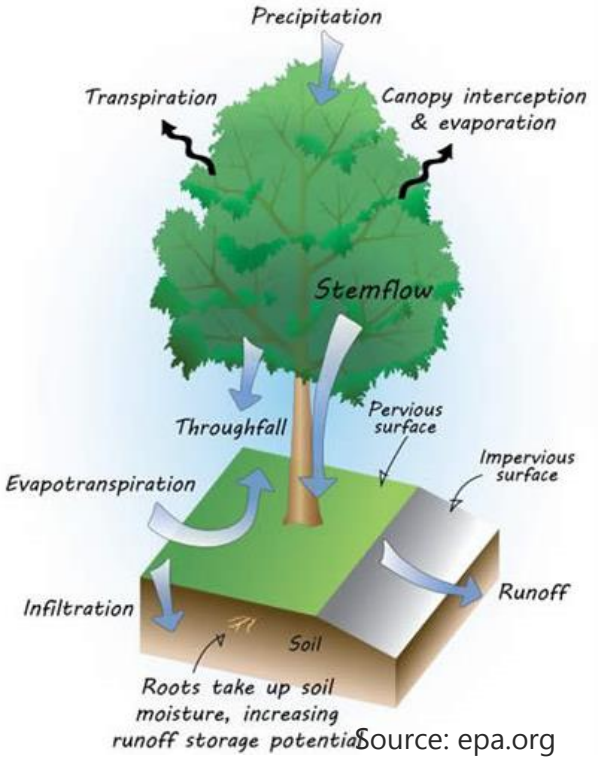
Stormwater

While cities typically promote more efficient and environmentally friendly use of land, energy, and materials than spatially-extensive suburban or rural developments, they also tend to have higher concentrations of impervious surfaces. Impervious surfaces are surfaces made of impenetrable materials such as concrete and asphalt, and they significantly impact the water cycle. Impervious surfaces prevent stormwater infiltration, diverting runoff directly into drainage infrastructure or surface waters. Not only does this increase in stormwater volume lead to severe flooding issues in many communities, but it is also one of the top contributors to water quality degradation nationwide. As stormwater moves across surfaces such as roads, parking lots, and lawns, it picks up pollutants and carries them into rivers, streams, lakes, and ponds. Research from the Office of Coastal Management indicates that the quality of surface water becomes significantly degraded with as little as 10% impervious cover in the drainage basin or watershed.

Healthy tree coverage can reduce stormwater runoff and peak flows in local waterways, resulting in substantial savings on drainage infrastructure, water treatment costs, and the need for flood controls. During rain showers, foliage intercepts rainfall. The rainwater is temporarily held on leaves and bark where it may later evaporate directly from the tree, flow down the trunk to the ground, or drip off the leaves. This interception slows the rate with which rainwater reaches the ground and reduces the volume of stormwater runoff.

This reduces the volumetric flowrate of water being diverted into drainage infrastructure, easing the load placed on aging infrastructure systems and reducing the need for flood controls. With less stormwater entering the drainage system, less stormwater is treated at water treatment facilities. Trees, particularly larger ones, are a cost-effective way to manage stormwater and lessen infrastructure and water treatment expenses (Pickering et al, 2013).

Trees also improve water quality. The area beneath trees is usually pervious and allows stormwater, along with any pollutants, to infiltrate the soil. Trees' roots take up degraded stormwater. Trees either store the pollutants or transform them into harmless chemicals. This on-site treatment of stormwater can reduce runoff and pollutant loads by 20% to 60%. Remaining stormwater that is not absorbed by trees



Source: epa.org

filters through the soil, recharging the groundwater below (Pickering et al, 2013).

Even though trees play a significant role in mitigating stormwater impacts in the urban environment, proper maintenance is required to ensure tree refuse does not clog pipes and outlets. Care must also be taken so that roots do not puncture underdrains and filter fabric or produce sidewalk heaves, leading to costly repairs. Tree placement should also be considered; trees must be planted in areas where they can most effectively absorb stormwater yet not obstruct utility lines. When properly planted and maintained, these concerns may be mitigated and trees can be used to effectively treat stormwater runoff.

Community Wellbeing

Livable cities are often identified as vibrant, walkable communities with a sense of place. While trees alone cannot make a city vibrant, walkable, or lend it a sense of place, they play a key role in achieving all three goals.

Street trees and the canopy they provide reduce crime. A 2015 study of New Haven, Connecticut found that greater tree canopy cover was associated with lower rates of violent, property and total crime, independent of [other confounding variables.]" Gilstad-Hayden et al found that a 10% increase in tree canopy was associated with a 15% decrease in violent crime, and with a 14% decrease in property crime.

Street trees also buffer pedestrians from the road, making sidewalks safer and more comfortable. Comfort and safety result in more pedestrians using the sidewalks. As the number of people on the street grows, the safety of the street — whether perceived or real — tends to rise, which in turn draws more people onto the street, producing a virtuous circle. A 2008 study by Naderi et al published in the Institute of Transportation Engineers Journal found that "that trees contribute to a sense of safety. The significant reduction in driver speeds in the suburban [model] indicates that street trees may provide positive operational values. Although collisions with trees are horribly fatal, there may be fewer crashes overall."

By encouraging people to travel the streets at human speed, and to interact with each other at a human scale, trees can foster the growth of social capital through interactions on the street. This leads to the development of a sense of identification with and pride in a place. Increased pedestrian traffic also benefits local businesses by increasing exposure. Businesses that are in districts with street trees report higher revenue. Thriving businesses draw additional traffic, which contributes to vibrancy and productivity in commercial corridors.

A 2003 study by Wolf used a national survey to determine public perceptions, patronage behavior, intentions, and product willingness to pay in relationship to varied presence of trees in retail streetscapes, and concluded, "creating and stewarding an urban forest canopy may enhance revenues for businesses in retail districts that offer diverse products at varied prices. …While many conditions contribute to perceptions by consumers of attractive, desirable shopping settings, this study suggests that

the urban forest should be a central element of retail place."

Trees also make the city more appealing. Trees convert streets, parking, sidewalks, and alleyways into more pleasant environments by providing shade and screening from or softening of unattractive sights, and to a lesser extent, sounds and odors. Trees' organic shapes, colors, and textures add a natural, humanizing component to the built environment, which in many places consists largely of concrete and asphalt. Trees can also serve as visual markers. Trees can define a diversity of places, from play areas and parks to shopping areas and property lines. Similar to the way architecture can tie a neighborhood together, artistic tree choice or a particular landscape design can be used to provide cohesive aesthetics. Trees were often an identifier of a street's identity and becoming their namesake e.g. Oak Street, Pine Hill Avenue, Chestnut Hill Road, etc.

When an area is well landscaped, it is more attractive, and more people want to live there. This is best demonstrated by comparing the sale prices of houses. The difference in sale prices between homes with trees versus homes without them represents the willingness of the consumer to pay for the benefits and shoulder the costs associated with trees. A study by Morales (1980) conducted in Manchester, Connecticut found that 6 - 9% of the total sales price of a house could be attributed to good tree cover.

While trees can help make a city vibrant and walkable and lend it a sense of place, making cities more attractive for homebuyers, trees also make communities healthier places to live. Studies in a variety of locations have found a link between exposure to nature and wellbeing. Stress, for instance, is often a health concern in cities. Stress related to urban living, work practices, and hazardous environments contribute to poor mental and physical health, especially among vulnerable segments of the population. Exposure to nature can facilitate the recovery from stress or other problems, make people more resilient against future stress, and enable people to concentrate and think more clearly. Trees play a key role in the urban environment, engendering a vibrant, walkable, and healthy community.

Source: Downtown Northampton

Drawbacks of Trees

While trees have benefits, they are not without costs. Fallen leaves from deciduous trees can clog gutters and storm drains. Roots may heave sidewalks and can disrupt other hard infrastructure. Branches can interfere with electrical infrastructure. Falling branches and trunks can damage property and create dangerous conditions during bad weather. Tree maintenance and removal can also become contentious issues between municipalities and the public.

In general, larger trees are more expensive to maintain than smaller trees, but increased benefits more than offset the difference. Pruning is usually the single greatest cost, followed by expenditures for tree planting, removal, administration, and hardscape repair. Guidance on how to avoid some of these cost through careful planting can be found in the Appendix A.

Heaving Sidewalk on Washington Street

Current Conditions

Tree Canopy

The city of Norwalk has the lowest canopy coverage of any municipality in the Western Connecticut Region (Table 1). Using imagery from 2015, WestCOG found that 61.5% of the Region is covered in tree canopy. This accounts for 216,643 acres of 352,206 acres. The table below lists canopy coverage by municipality. The three cities in the Region, Danbury, Norwalk, and Stamford, predictably have lower canopy coverage. Westport, Darien, and Greenwich also have low canopy coverage as they are also more urbanized areas.

Table 1: Canopy Coverage in the WestCOG Region

Percent Canopy Coverage	
Norwalk	39.2%
Westport	47.1%
Darien	47.7%
Greenwich	49.4%
Stamford	50.2%
Danbury	52.0%
Brookfield	59.5%
New Fairfield	60.0%
New Canaan	60.5%
WestCOG	61.5%
New Milford	62.7%
Bethel	63.8%
Bridgewater	68.1%
Ridgefield	68.5%
Wilton	70.7%
Sherman	71.2%
Newtown	71.5%
Weston	74.7%
Redding	78.3%

Trees and shrubs are found throughout Norwalk. Located in parks and green spaces, lining residential and commercial streets, and in private yards, the tree canopy covers approximately 44.2%[1] of Norwalk, or 6,519.2 acres of 14,751.9 acres. It is estimated that 280,275 trees contribute to this canopy.

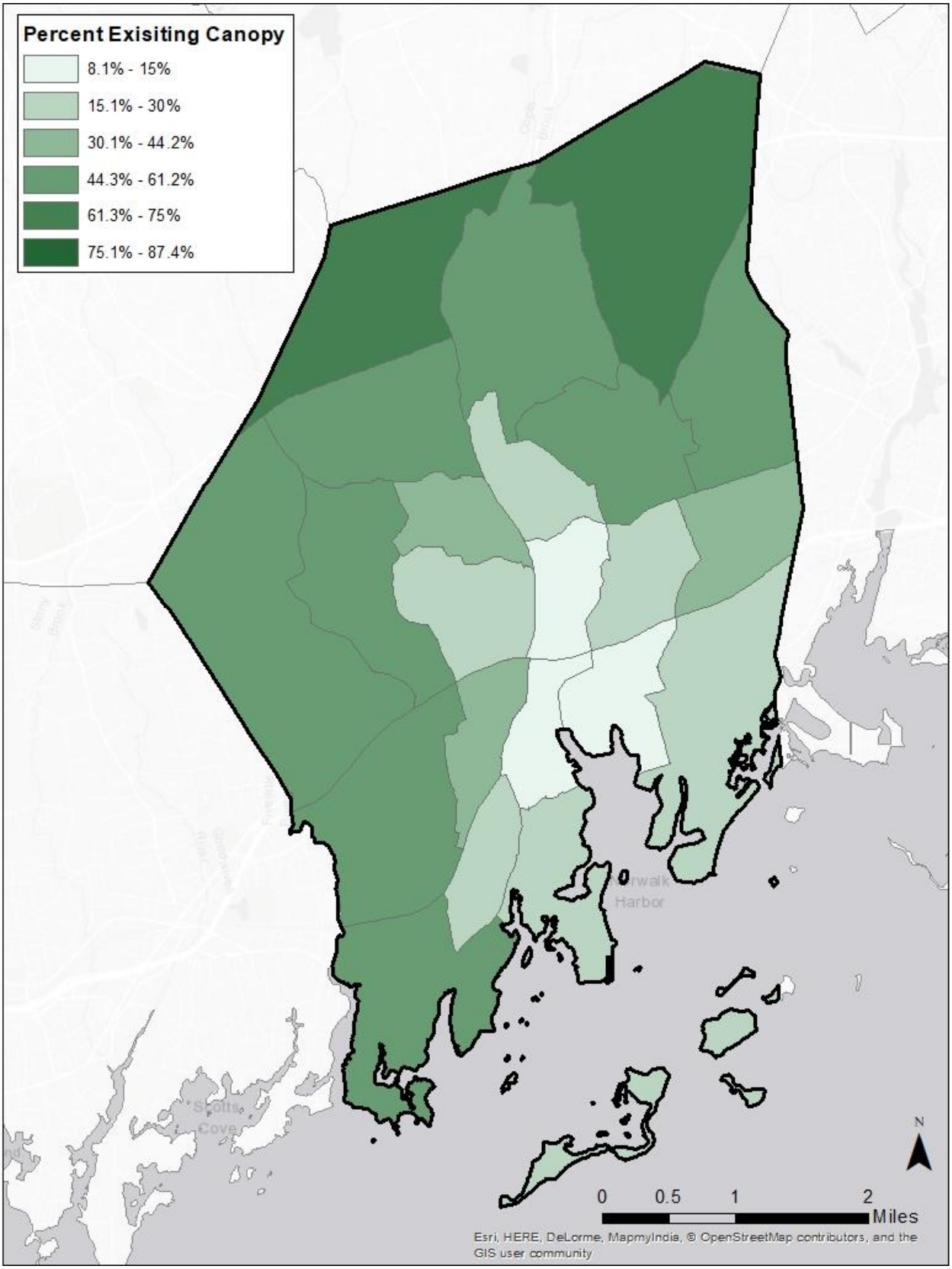
While vegetation is found throughout the City, certain areas have more vegetation, and thus canopy cover, than other areas. The City's canopy has a U-like shape, dense along the borders of the City, but sparser in the center of Norwalk, around the harbor, and Long Island Sound. Certain tracts have less than 15% coverage (Map 1).

Much of Norwalk's tree cover grows in parks and on the edges of the city. Cranberry Park, located in the northern part of the City, has swaths of forested land, and thus has particularly high tree canopy cover. The nearby residential areas north of the Merritt Parkway have the more canopy cover than those south of the route. The western side of the City bordering Darien has more canopy cover than Norwalk's area bordering Westport. The urban core, in particular, lacks canopy cover.

Map 1: Existing Tree Canopy in Norwalk

[1] It should be noted that this figure and subsequent analyses in this document were conducted with more finely tuned criteria than the Regional Analysis and are more accurate for Norwalk.

Map 1: Existing Tree Canopy in Norwalk 1



Impervious Surface

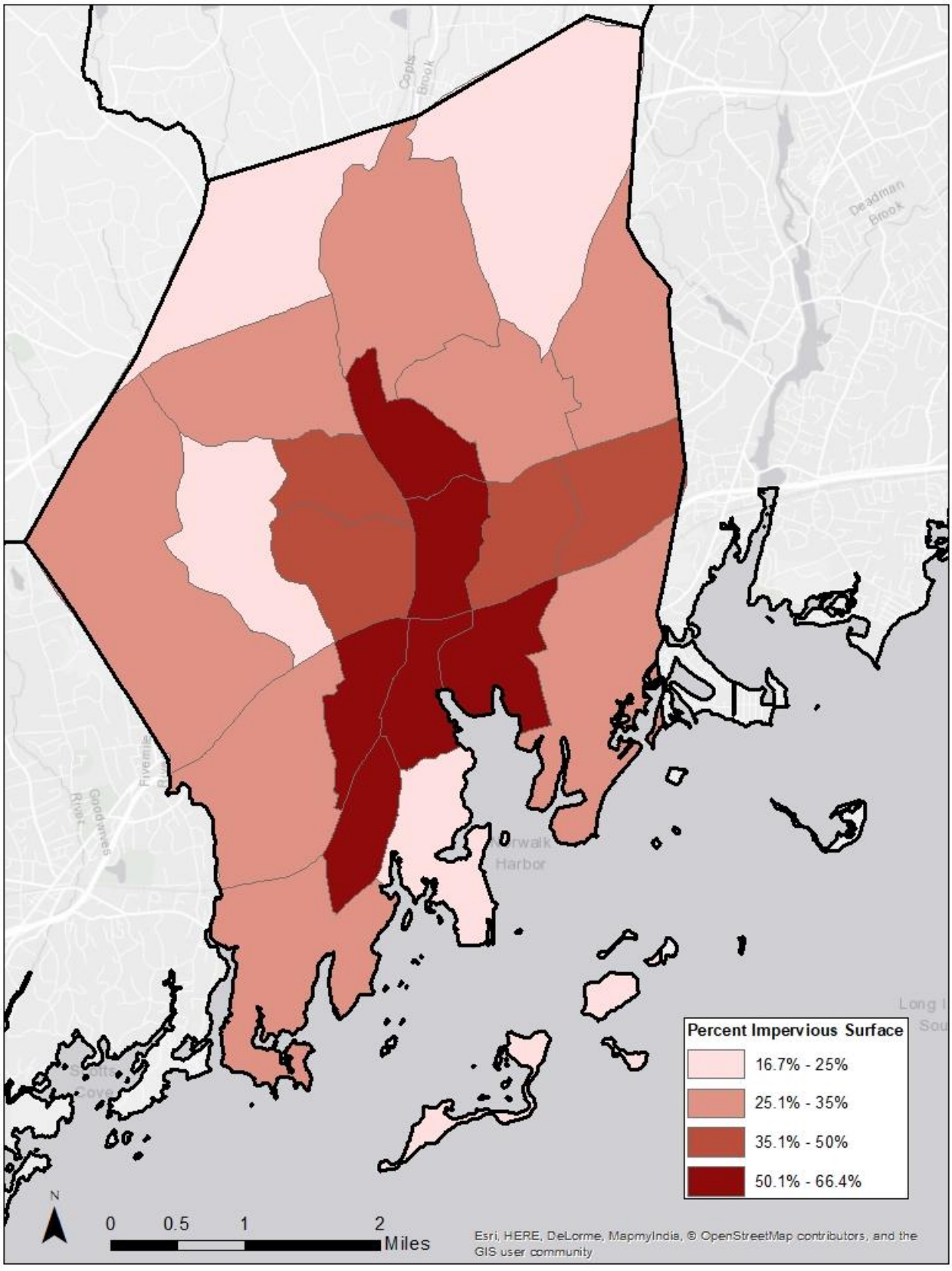
Impervious surface coverage plays a critical negative role in microclimates and stormwater. 32.2%, or 4,752.6 acres, of Norwalk is covered in impervious surfaces. This is the highest percentage of any municipality in the WestCOG Region (Table 2). However, this coverage is also unevenly distributed. While all of the City exceeds 10% impervious surface coverage the threshold for negative storm water impacts, tracts in the center of the City exceed 35% the threshold for increased urban heat island effect (Map 2). The tracts surrounding the harbor exceed 50%. Many of these tracts include major roadways.

Table 2: Canopy Coverage in the WestCOG Region

Percent Impervious Surface	
Norwalk	32.2%
Stamford	25.3%
Darien	21.7%
Westport	21.0%
Danbury	18.5%
Greenwich	17.0%
New Canaan	14.1%
Bethel	13.7%
Brookfield	13.2%
WestCOG	13.1%
Ridgefield	11.4%
Wilton	11.2%
Weston	8.9%
Newtown	8.1%
New Fairfield	7.1%
New Milford	6.9%
Redding	6.7%
Sherman	4.0%
Bridgewater	3.3%

Impervious Surfaces on North Water Street

Map 2: Existing Impervious Surface in Norwalk



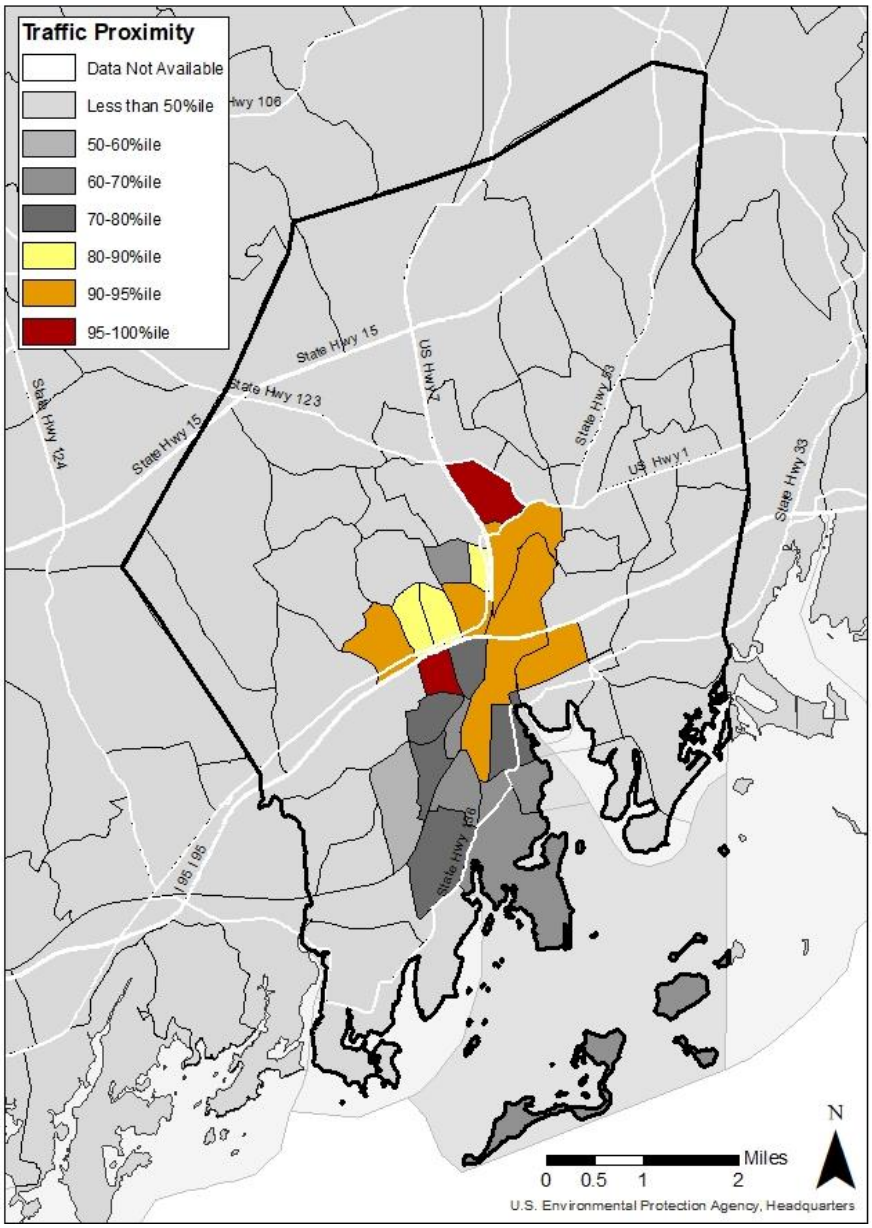
Air Quality

As mentioned previously, the presence or lack of trees can have a significant impact on air quality and health outcomes.

Traffic Proximity

Close proximity to high amounts of automobile traffic can have negative impacts on the land around it. Not only does the traffic necessitate considerable amounts of impervious surface for its use, but traffic also contributes to noise and air pollution. Map 3 displays areas of high traffic proximity compared to other areas in the United States. Some areas in the center of Norwalk are within the highest national percentiles. These areas have the highest average annual daily traffic at major roads within 500 meters, divided by distance in meters.

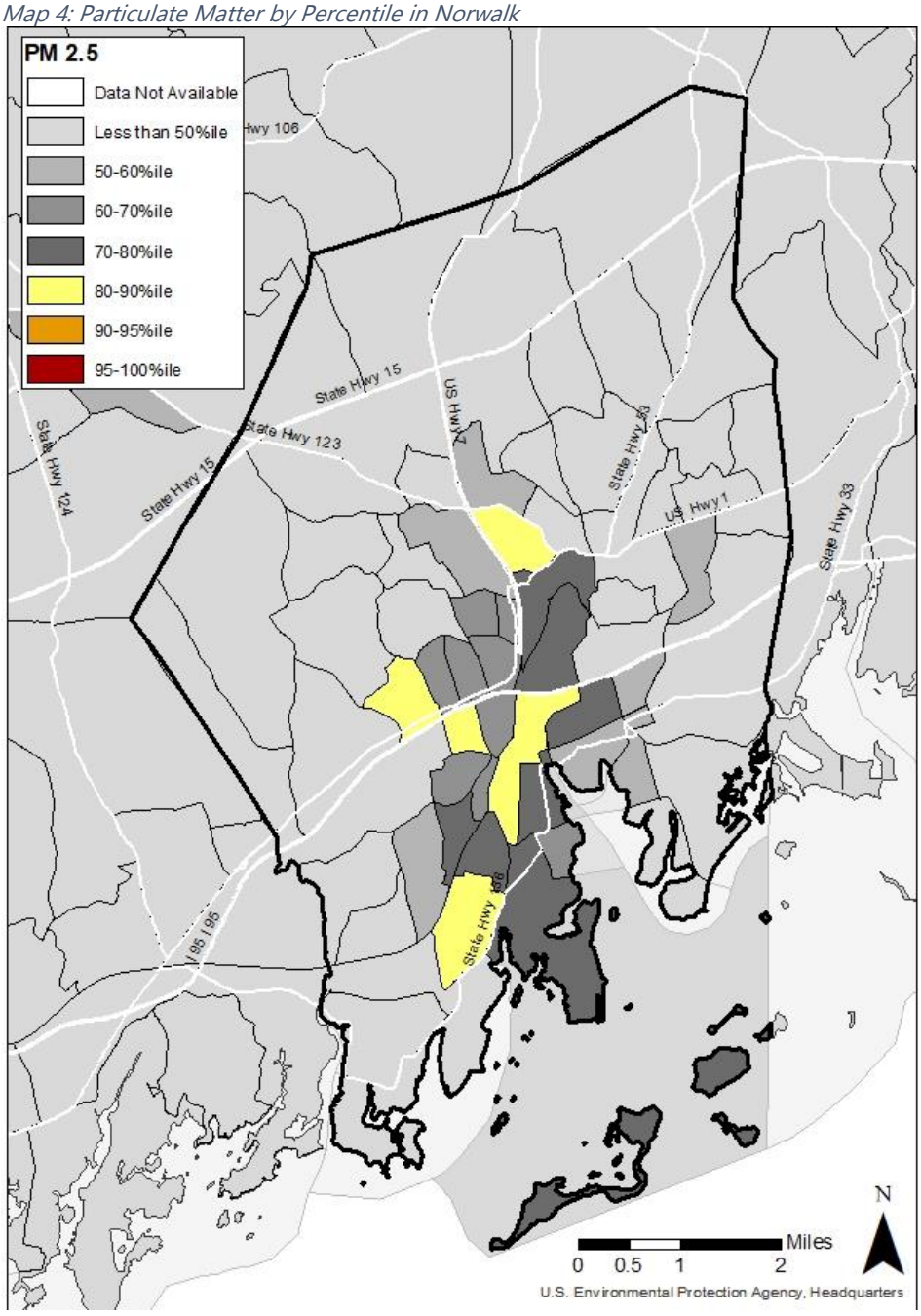
Map 3: Traffic Proximity by Percentile in Norwalk



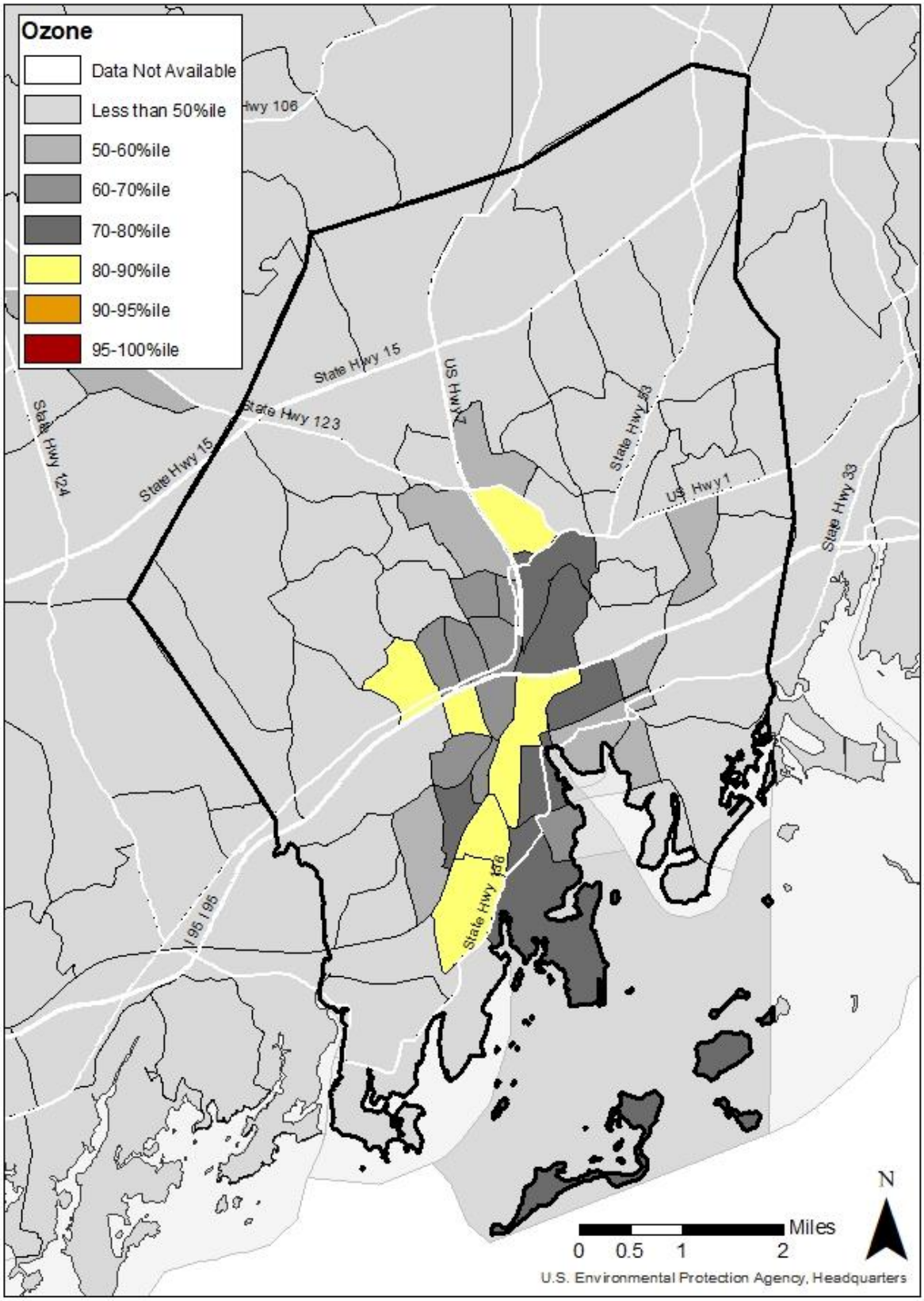
Particulate Matter & Ozone

Traffic, industry, and other sources can contribute to elevated levels of particulate matter and ozone in the air. These compounds exacerbate respiratory health conditions like asthma, and are key factors in warming climates and smog. Maps 4 and 5 display areas of high particulate matter and ozone compared to other areas in the United States. Some areas in the center of Norwalk are within the highest national percentiles. These areas have the highest annual average of PM 2.5 in the air, and highest summer seasonal average level of ozone in parts per billion.

Map 4: Particulate Matter by Percentile in Norwalk



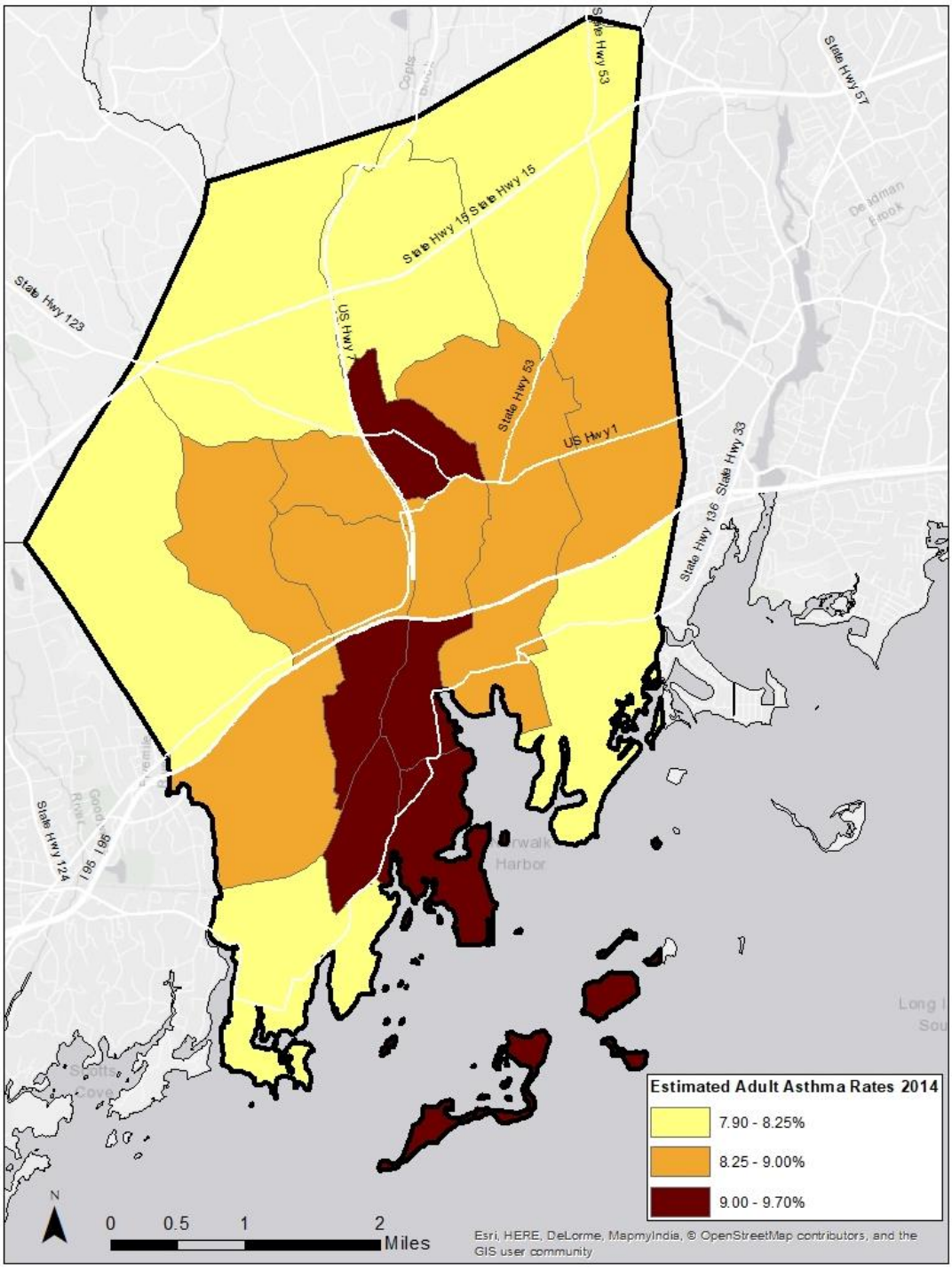
Map 5: Ozone by Percentile in Norwalk



Respiratory Health

Asthma rates are influenced by air quality and other environmental factors. Map 6 shows adult asthma rates in 2014. In the United States that year, 7.4% of adults had asthma, and in Connecticut 9.2% of adults had asthma. All of Norwalk had rates higher than the national rate, and many areas in the city met or exceeded the state-wide rate (CT Department of Public Health, 2014).

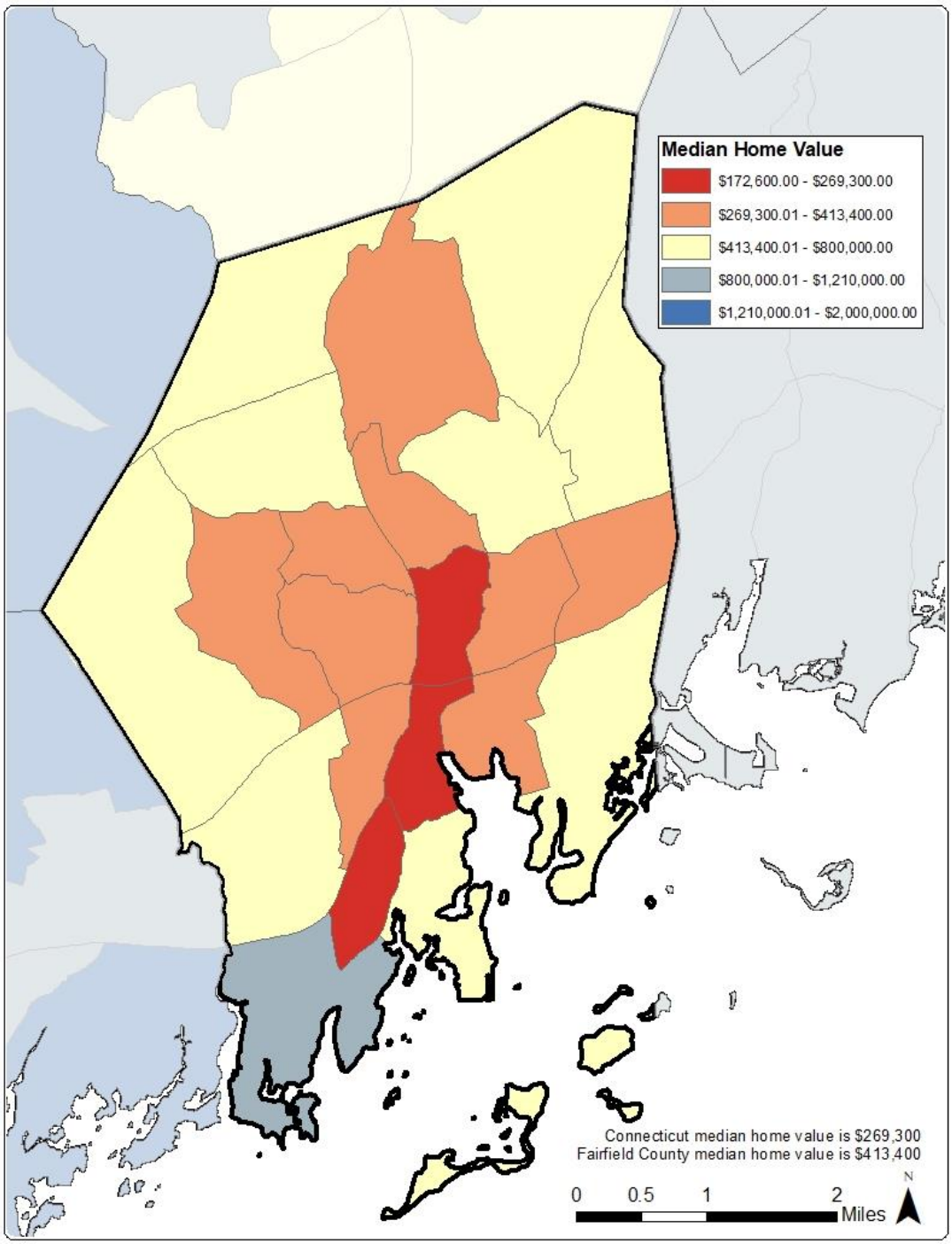
Map 6: Adult Asthma Rates in Norwalk, 2014



Property Values

Trees also contribute to property values. Most areas in Norwalk have a median home value below that of Fairfield County, $413,400. In the central areas of Norwalk, the median home value is below that of Connecticut, $269,300 (Map 7). As many families' largest source of equity, homes play a key role in socioeconomic mobility.

Map 7: Median Home Values, 2016



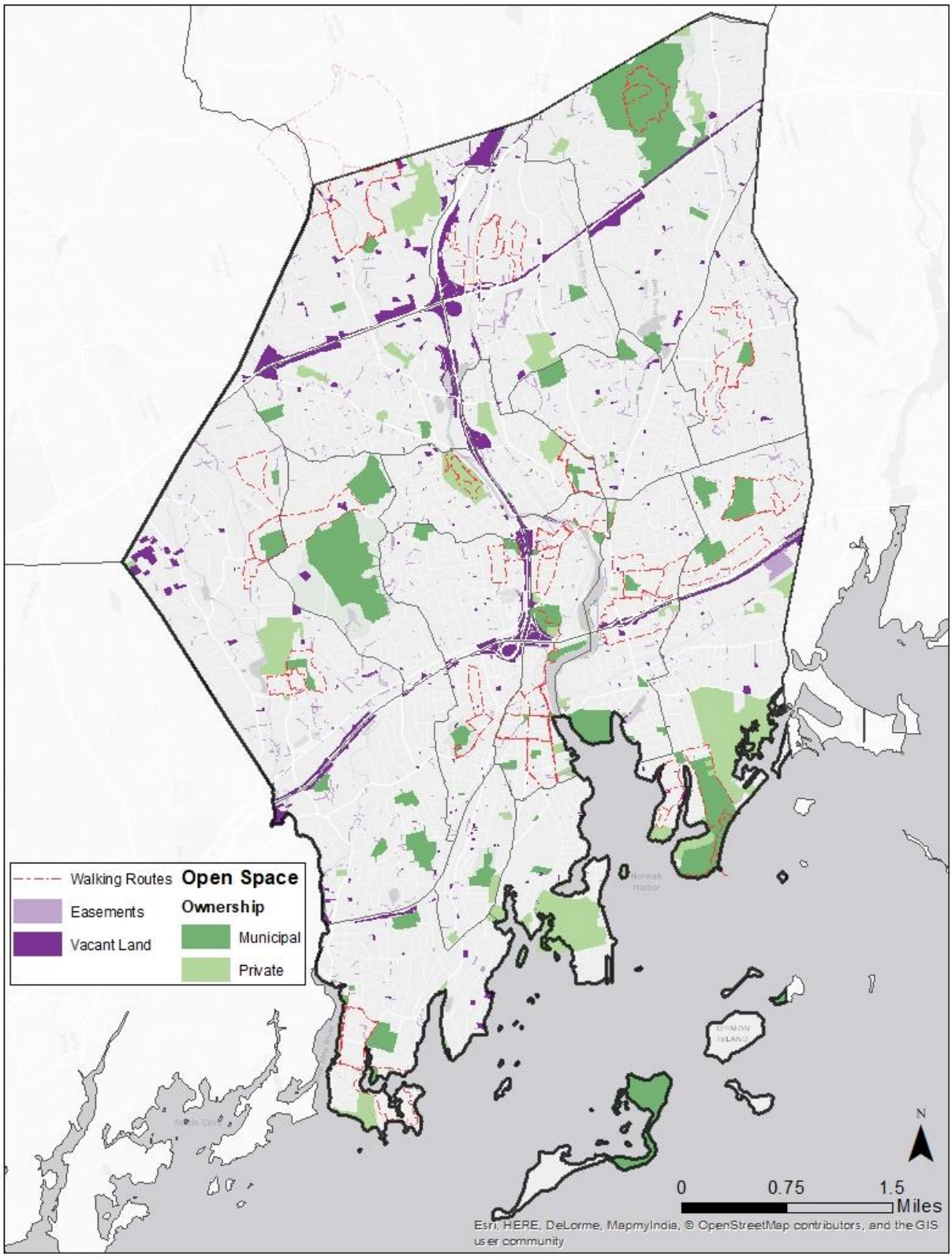
Source: American Community Survey, 2016

Open Spaces, Parks & Walkability

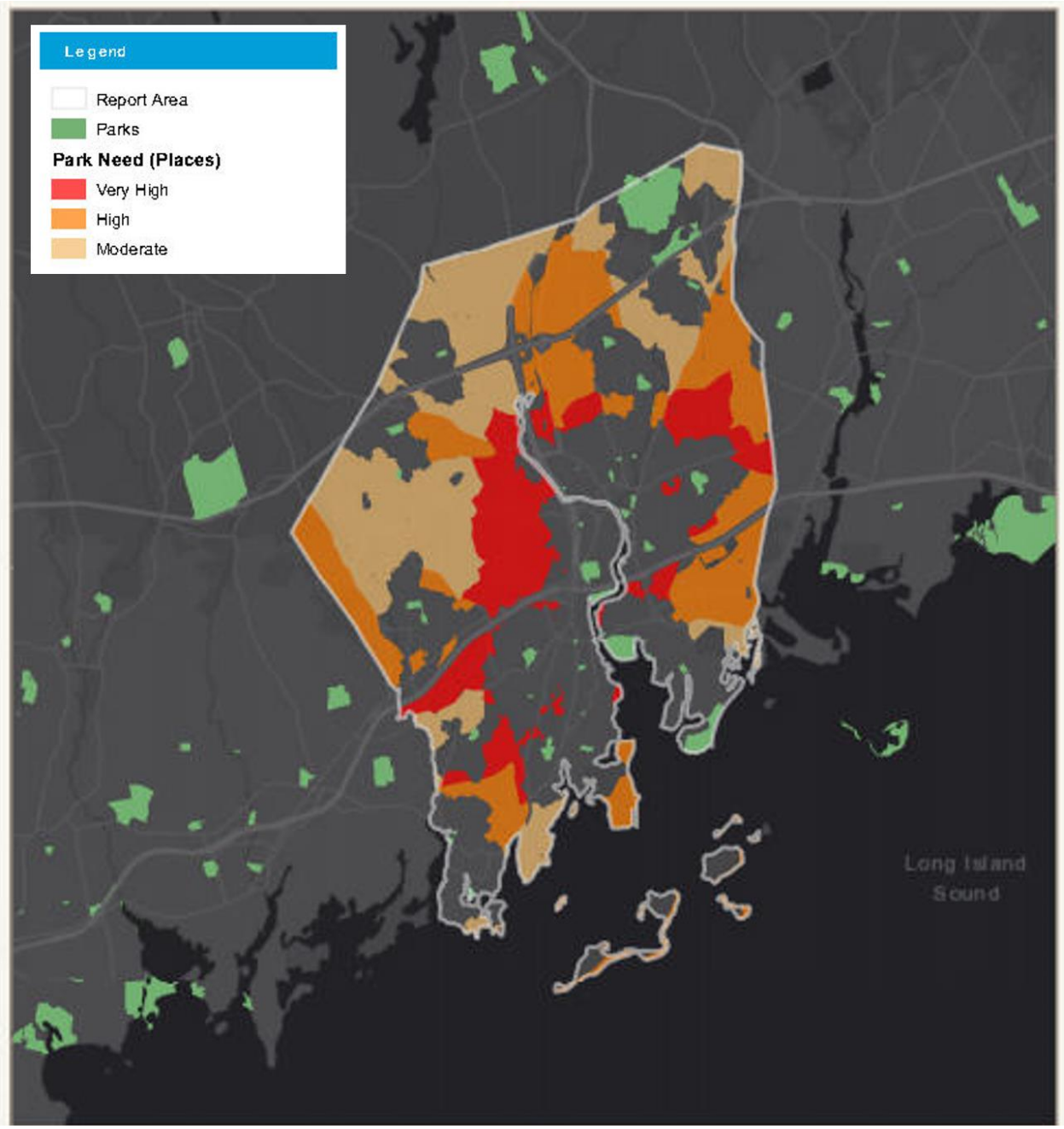
While private property and street trees play key roles in the urban canopy, parks and other open spaces are unique in their capacity to allow for dense urban forest habitat while also providing key neighborhood amenities. Map 8 shows existing open space, walking routes, and potential for new parks with vacant land and land with easements. The open space category in Map 8 includes schools, cemeteries, and private clubs that may not always be open to the public or may charge a fee.

Map 9 was created by the Trust for Public Land's ParkServe tool and shows which areas are more than a 10-minute walk (0.5 miles) from parks and are in the most need of one. By their estimate, there are 45 parks in Norwalk, totaling 477 acres. It should be noted that their map only includes municipal parks which are free to use, while Map 8 shows all open space. In the City 47,200 people live near a park while 43,772 people do not. This figure includes 4,501 low income households, 10,616 children, and 6,897 seniors. The national average for park access in a city is 54%; Norwalk is just below that figure at 52%. The national average of youth within a 10-minute walk of a park is 55%; Norwalk is under the average at 52%.

Map 8: Open Space & Walking Routes



Map 9: Park Needs, ParkServe



This report was created on May 24, 2018 using the ParkServe® interactive mapping site.
It is for informational purposes only. The providers of this report disclaim any and all warranties, express or implied, including fitness
for a particular purpose or merchantability, and make no representation that the report is complete, accurate, or error free.
Use and reliance on this report is at the sole risk of the party using same.

SPC Wilfredo Perez Jr. Trail

Analysis of the Current Tree Canopy

Benefits

Trees have proven their utility through the abundance of benefits they provide. These benefits can be quantified into monetary values to better understand the economic impact of planting trees. By removing compounds and particulates from the atmosphere, trees can save municipalities millions of dollars a year. Trees also add to property value, manage stormwater, and sequester carbon over their lifetimes.

Using the Northeast Community Tree Guide, WestCOG estimated the benefits that the trees in Norwalk provide. On average over their lifespans, trees produce between $30 and $147 in benefits per year depending on their size. These figures include energy savings, stormwater runoff reduction, aesthetic value, air quality improvement, and carbon dioxide sequestration. Each year, Norwalk's trees provide an estimated $36 million in benefits. This equates to $408.18 per resident annually.

Costs

Through the Norwalk Tree Planting Program, an average of $770.42 is spent to plant a tree and insure it for the first 2 years. In an average year, the Tree Advisory Committee plants 61 trees, costing $46,918.85.

Estimates from McPherson et al (2007) find that on average a small, medium, and large public tree needs $20, $27, and $34 worth of care per year over their lifetimes, respectively. This includes planting, pruning, removal, other maintenance, and infrastructure repair.

In Norwalk, this equates to an estimated $8.5 million per year. However, it should be noted that not all trees in Norwalk are intentionally planted or receive maintenance so this estimate may be higher than actual costs.

Net Analysis

The net benefits of Norwalk's tree canopy are estimated to be $26 million annually. Per resident it provides $294.63 in net benefits per year.

Using the estimates previously detailed, WestCOG found that for every dollar spent on tree care in Norwalk, the city receives $3.59 in benefits.

Table 3: Current Estimated Benefits of Trees in Norwalk

Tree Size	Number of Trees	Annual Benefits	Benefits per Capita
Small	12,428	$372,840.19	$4.22
Medium	175,391	$13,855,909.27	$156.67
Large	148,776	$21,870,003.93	$247.29
Total	336,595	$36,098,753.38	$408.18

Table 4: Current Estimated Costs of Trees in Norwalk

Tree Size	Number of Trees	Annual Costs	Costs Per Capita
Small	12,428	$248,560.13	$2.81
Medium	175,391	$4,735,563.93	$53.55
Large	148,776	$5,058,368.26	$57.20
Total	336,595	$10,042,492.31	$113.55

Table 5: Net Analysis of Trees in Norwalk

	Annual Value
Benefits	$36,098,753.38
Costs	$10,042,492.31
Net Benefits	$26,056,261.08
Ratio	3.59:1

Canopy Projections

As previously discussed, adding trees to the urban forest of Norwalk would result in benefits and savings. Resources that would otherwise be used for infrastructure, pollution control, and health care in the absence of trees could be reallocated to meet other needs. While there are costs associated with the planting of new trees and their maintenance, the benefits of trees are nearly quadruple the costs.

Canopy Decline

A 2012 study by Nowak and Greenfield found that city tree cover in the United States is lost at a rate of about 0.27% per year. Without proper maintenance and a concerted effort to increase canopy, Norwalk would lose 39.8 acres of tree canopy per year, this would be an estimated loss of between 1,380 and 5,519 trees annually. Without these trees, Norwalk could lose between $55,185 and $169,800 in net benefits per year.

Table 6: Potential Annual Canopy Decline

Trees	1,380 - 5,519
Net Benefits	$55,185 - $169,800
Per Capita Benefits	$6.54 - $20.12

Increasing the Canopy

Potential

Norwalk enjoys millions of dollars in savings annually from its current tree canopy. It is in the City's interest to populate available land with trees to thicken and expand the canopy. The tables below calculate the "plantable" land that could be used to increase canopy and how increasing canopy on this land would impact the City.

If canopy covered every bit of plantable land that did not have impervious surface, water, or current canopy, and that was not within 30 feet of a telephone pole, Norwalk could increase its canopy to a total of 10,265 acres and cover 70.4% of the City, nearly doubling its current canopy.[2]

If the City were just to target vacant land, municipal open space, and street trees, the canopy could be increased by 1,316.4 acres for a total canopy coverage of 53.8%. Only considering privately held land, the canopy could be increased by 2,429.3 acres for a total canopy coverage of 61.4%. These figures underscore the need to go beyond City Hall and encourage land owners to participate in canopy expansion efforts.

The estimated range of potential trees represents several scenarios. More trees typically represent more urban spaces where there is more competition and smaller species are planted. Fewer trees typically represent parks or lawn areas where trees may grow larger.

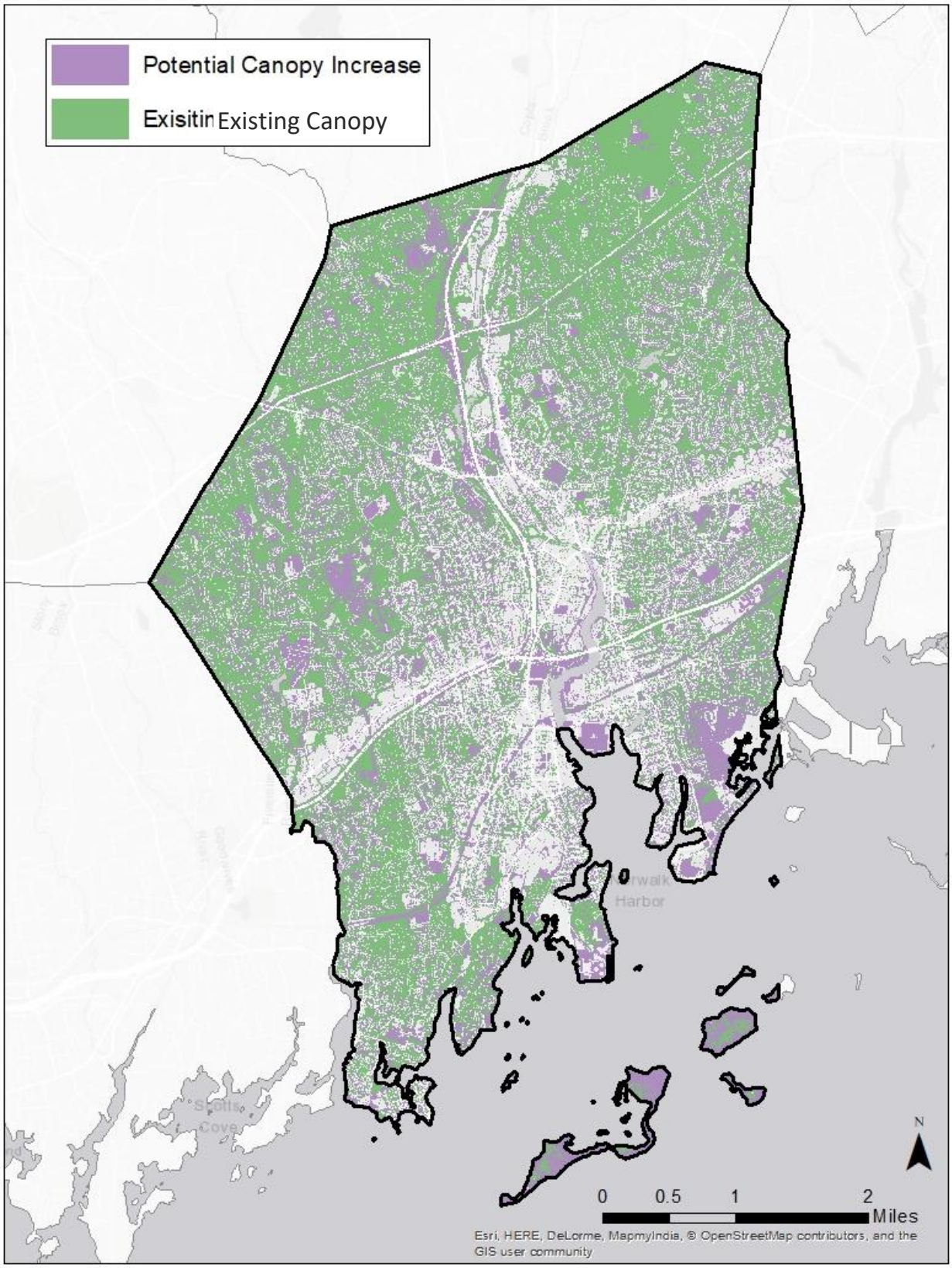
[2]Canopy can extend over plantable area, and over impervious surface, so this may be a low estimate.

Table 7: Potential Plantable Area in Norwalk

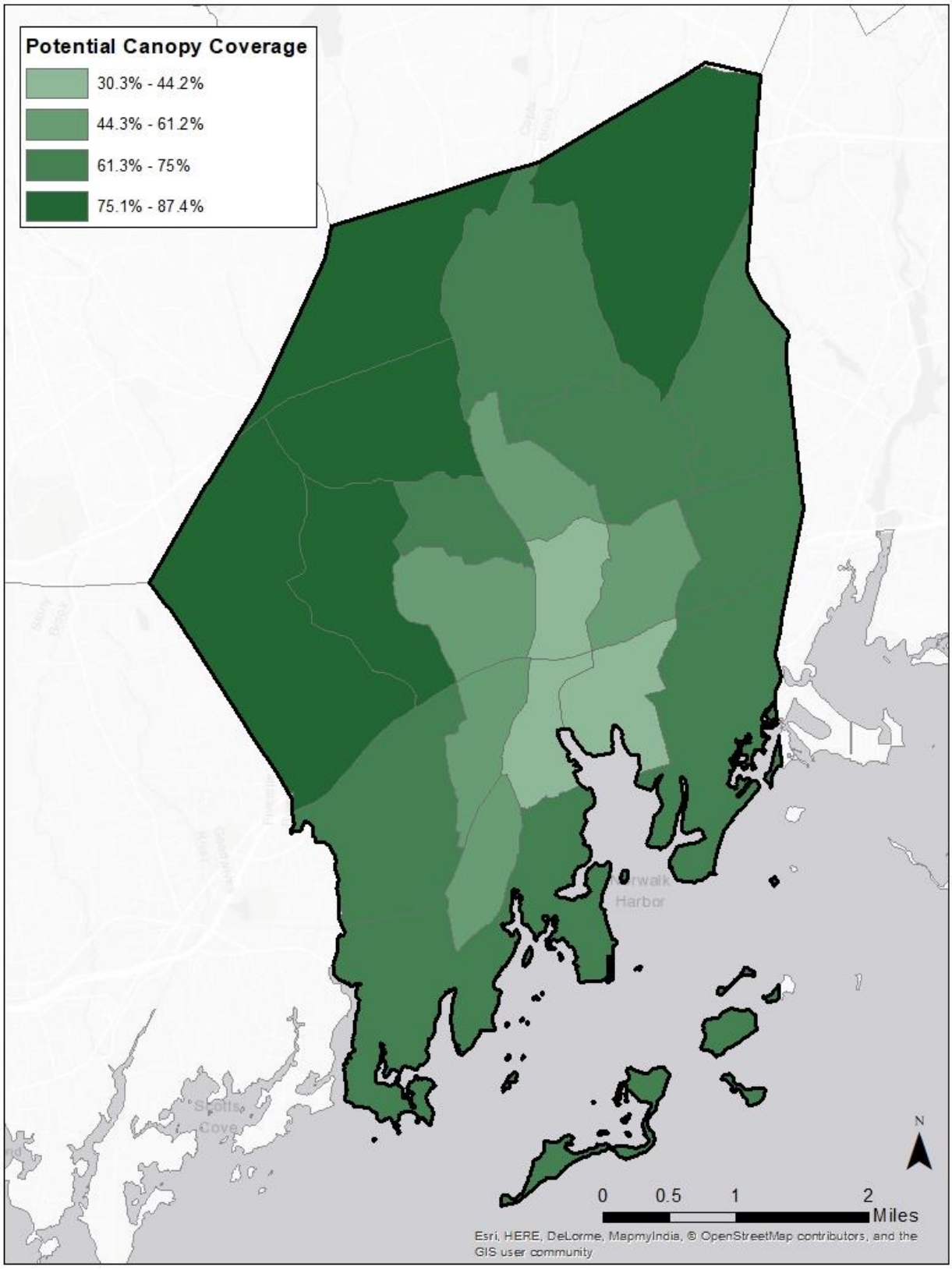
Type	Potential Acres	Percent of Norwalk Land	Potential Total Canopy Coverage	Potential Number of Trees
Within Vacant Land	174.8	1.2%	45.9%	6,059 – 24,237
Within Municipal Open Space	412.9	2.8%	47.6%	14,313 – 57,251
Street Trees	728.7	5.0%	49.7%	25,260 – 101,038
Within All Open Space	811.9	5.5%	50.3%	28,144 – 112,575
Within All of Norwalk	3745.7	25.4%	70.4%	129,841 - 519,363

Source: iTree

Map 10: Current & Maximum Potential Canopy Coverage



Map 11: Maximum Potential Canopy Coverage



Benefits

With 70.4% canopy coverage, Norwalk could nearly double the number of trees and could see an estimated $60 million in annual benefits, an increase of $24 million per year (Table 3). Residents could see $680 in benefits per year, an increase of $272.

Table 8: Maximum Potential Benefits (est.)

Tree Size	Number of Trees	Annual Benefits	Benefits per Capita
Small	7,752	$232,551.36	$2.63
Medium	466,910	$36,885,923.46	$417.08
Large	156,619	$23,022,992.54	$260.33
Total	631,281	$60,141,467.37	$680.04

Costs

If the City were to have 70.4% canopy coverage, costs would increase. This equates to $18 million per year, an increase of $8 million per year. Per resident this equates to $204 per capita per year, an increase of $91.

Table 9: Maximum Potential Costs (est.)

Tree Size	Number of Trees	Annual Costs	Costs Per Capita
Small	7,752	$155,034.24	$1.75
Medium	466,910	$12,606,581.44	$142.55
Large	156,619	$5,325,045.89	$60.21
Total	631,281	$18,086,661.57	$204.51

Net Analysis

The net benefits of Norwalk's maximum tree canopy are estimated to be $42 million annually. Per resident it provides $475.53 in net benefits per year.

For every dollar spent on tree care in the maximum canopy, the city would receive an estimated $3.33 in benefits.

Table 10: Net Analysis of Maximum Potential Canopy (est.)

	Annual Value
Benefits	$60,141,467.37
Costs	$18,086,661.57
Net Benefits	$42,054,805.80
Ratio	3.33:1

Intersection of Camp and North Streets

Intersection of Camp and North Streets Looking

Goals & Objectives

Pursuing an increase in canopy cover provides the opportunity to foster a healthy, vibrant community and may also cement Norwalk as a leader in environmental stewardship. When presented with the data, the Norwalk Tree Advisory Committee (NTAC) suggested goals for the City.

To bring Norwalk's canopy in line with the conditions of the Region, the NTAC aspires to see Norwalk's canopy increase coverage to 61.5%. This 17% increase would be equivalent to 2,509 acres of additional canopy, for a total of 9,074.2 acres of city wide canopy coverage. This is 67% of the available plantable area. It is estimated that this improved canopy would consist of 529,412 trees, nearly double the number of trees currently.

Benefits

61.5% canopy coverage would provide an estimated additional $16 million in benefits to the City each year, totaling $52.2 million annually. This would equal $590 in benefits per resident, an increase of $182 from the current canopy.

Table 11: Benefits of 61.5% Canopy Coverage (est.)

Tree Size	Number of Trees	Annual Benefits	Benefits per Capita
Small	10,179	$305,364.40	$3.45
Medium	358,948	$28,356,895.30	$320.64
Large	160,286	$23,561,980.19	$266.42
Total	529,412	$52,224,239.89	$590.52

Costs

If the City were to reach the goal of 61.5% canopy coverage, costs would increase by $5.3 million per year, totaling $15.3 million. Per resident, this increase would cost $173 annually, which is an increase of $60.

Table 12: Costs of 61.5% Canopy Coverage

Tree Size	Number of Trees	Annual Costs	Costs per Capita
Small	10,179	$203,576.26	$2.30
Medium	358,948	$9,691,597.13	$109.59
Large	160,286	$5,449,709.70	$61.62
Total	529,412	$15,344,883.10	$173.51

Net Analysis

The net benefits of Norwalk's maximum tree canopy are estimated to be $36.8 million annually. Per resident, it provides $417 in net benefits per year.

For every dollar spent on tree care in the maximum canopy, the city would receive an estimated $3.40 in benefits.

Table 13: Net Analysis of 61.5% Canopy(est.)

	Annual Value
Benefits	$52,224,239.89
Costs	$15,344,883.10
Net Benefits	$36,879,356.79
Ratio	3.4:1

Intersection Knight and

Intersection Knight and North with Street

Implementation

Compared to other cities in Connecticut, Norwalk has a robust and established tree policy infrastructure. It is designated a Tree City USA, giving the City an existing framework to carry out the goals of this document.

The Norwalk Tree Advisory Committee (NTAC) stated that they would like to see the City plant 250 trees a year until Norwalk's 400th anniversary in 2051, and that they would like to partner with homeowners and private investors to plant an additional 250 trees annually. This would total 16,500 trees over 33 years.

This is a lofty goal that will take decades to complete. To receive the largest return on investment and capitalize on the benefits of trees, this document recommends focusing on Strategic Implementation Areas first.

Map 13: Strategic Implementation Areas

Strategic Implementation Areas

After meetings with stakeholders in Norwalk, six neighborhoods (Census Tracts) were selected as areas of focus for new canopy coverage. These neighborhoods have low canopy coverage, high impervious surface coverage, high asthma rates, traffic volume, particulate matter, and ozone. These neighborhoods also have median home values lower than that of the State of Connecticut and Fairfield County.

The plantable area in these neighborhoods could be utilized to increase canopy between 18.4% and 29% for each neighborhood.

Sustaining Current Efforts

The Norwalk Tree Planting Program has contributed significantly to the City's current canopy and aesthetic appeal. From 2005 to 2017, this program has been instrumental in the planting of approximately 669 trees. This program must continue to be funded and supported to maintain current canopy coverage and prevent decline. More information on the Norwalk Tree Planting Program can be found in Appendix A.

Tree Conservation & Protection

To ensure trees continue to be a priority of the City of Norwalk, it is important to include them in the City's core documents. In the 2008 Plan of Conservation and Development (POCD), trees were frequently mentioned and prioritized for their environmental benefits. As Norwalk continues to update and revise the plan, the prominence of trees should be maintained and expanded.

Protecting existing trees is important because more established trees provide more environmental, health, and social benefits and store more carbon dioxide. Indiscriminate, uncontrolled and excessive destruction, removal, and cutting of trees can cause increased drainage control costs, increased soil erosion and sedimentation, decreased fertility of the soil, degradation of water resources, decreased groundwater recharge, increased buildup of atmospheric carbon, and increased dust.

Norwalk can also take additional measures to ensure trees are conserved and protected. Tree Protection Ordinances are designed to provide municipalities with the ability to protect natural resources within the community from possible harmful effects caused by development.

For Norwalk to adopt a Tree Protection Ordinance, there needs to be a clear connection to the POCD. The POCD should identify areas in need of protection. These areas should be included as part of the Norwalk's overall vision and land use goals.

Clustering, easements, identification of trees of significance, and open space acquisition, among other tools, can be a part of a Norwalk's plan to protect trees. Whenever possible, Norwalk should aim to protect large, contiguous areas of wooded areas as much as possible, as these unbroken areas provide the largest benefit to the environment and society.

The Association of New Jersey Environmental Commissions has a guide for creating such ordinances.

Zoning

Zoning can be a powerful tool for shaping a city. Through amendments, the zoning code can be changed to place a greater emphasis on retaining and protecting existing trees, and requiring the planting of new ones for new developments. The neighboring Town of Darien, Connecticut, which is also urbanized in nature, has placed such specifications throughout their zoning regulations. For example, "To the extent possible, existing trees, vegetation and unique site features such as stone walls shall be retained and protected during construction. Existing healthy, mature trees, if properly located, shall be considered in meeting the requirements of these Regulations."

In their zoning code, The City of New Rochelle, New York, considers trees when expanding impervious surface in an effort to reduce its harmful effects.

"Mitigation for creating or increasing impervious surface.

To mitigate the negative environmental impacts associated with the creation or expansion of impervious surfaces, for every 200 square feet of impervious surface created or expanded or part thereof in excess of the first 200 square feet, the property owner shall plant one tree with a minimum DBH [diameter at breast height] of two inches. Trees with a greater DBH may satisfy this requirement in a mathematically proportionate manner, so that, for example, a tree with four-inch DBH

may be planted for 400 square feet of newly created or expanded impervious surface beyond the first 200 square feet. In the event trees are proposed to be removed and replaced under Chapter 301, Trees and Shrubs, of the City Code, the greater required total DBH of new trees between this chapter and Chapter 301 shall control. In lieu of planting trees on site and only when technically impractical or impossible, a fee shall be paid to the City Tree Fund to defray the City's costs for acquisition maintenance and planting of trees elsewhere on City properties, in accordance with Chapter 133 (Fees) of the City Code." – City of New Rochelle

Bucking the tradition of mandating parking minimums, the City of Hartford, Connecticut is capping a leading cause of impervious surface coverage by mandating parking maximums. For example, for all retail uses other than auto sales, a "maximum 3 [off-street] spaces per 1,000 square feet net floor area devoted to retail space." They also encourage different uses to share parking. Through these changes, Hartford can reduce overall impervious surface thereby creating space for potential tree plantings.

These are just a few examples of the many ways the zoning code and be used to prioritize trees and improve outcomes for the City.

Tree Canopy Maintenance

"Given a limited budget, the most effective expenditure of funds to improve a street would probably be trees. … Moreover, for many people trees are the most important single characteristic of a good street."

– Allan Jacobs, Great Streets

Tree maintenance will be critical to ensure the trees planted survive to maturity, and for the City sees maximum benefits from them. While City departments may shoulder many of the tree maintenance tasks, private property owners and residents should also be involved as stewards of the environment. Tips on tree maintenance can be found in Appendix A.

Performance Measures

To tackle a goal of canopy coverage this ambitious, it is necessary to keep continuous records of how the tree canopy is changing. Each time satellite imagery of the City is updated, the tree canopy coverage should be analyzed, to monitor its status.

City departments, non-profits, and private property owners must all contribute to planting efforts if 16,500 trees are to be planted by 2051. To keep a central record of the progress, a web portal could be created to allow all parties to map where the new plantings are. This webpage could allow the user to input varying levels of detail including but not limited to; species, diameter at breast height (DBH), and drip line measurements. This portal could also be

used to record tree loss and assist in replacement efforts.

Funding Possibilities

The City of Norwalk provides a budget to the NTAC to plant a small number of trees each year. To reach the goal of 61.5% canopy cover, other funding sources may be needed to support this effort.

There are many financial resources that can be used to fund an urban tree planting project.

Potential City Funding Programs

- **Capital Improvement Project Budgets:** tree planting and maintenance are valid expenditures of large road, utility, or facility improvement projects. Trees can be included as a part of right-of-way improvement projects.
- **Stormwater Utility Fees:** Trees help mitigate stormwater runoff. Stormwater fees are assessed to all property owners, including those that would be exempt from taxes.
- **Tree Work and Land Development Permit and Inspection Fees:** To the extent permitted under state and municipal codes, permit and inspection fees can be a significant source of funding. The urban forestry program could be reimbursed for the administrative time to review development permits applications, review plans, and make site inspections.
- **Compensatory Payment, Land Development Mitigation, and Environmental Fines:** When trees are damaged or removed (whether by an accident or a planned economic development project), municipalities should be compensated. Generally, this requirement and the compensation method should be codified, and should be clear about its applicability to public and/or private trees. Many cities across the U.S. have ordinances that stipulate this, and as a result have tree funds where compensatory payments, mitigation, or "in lieu of" fees and environmental fines are deposited for a variety of uses and urban forest management projects.

Grants

Sources for grants include the US Department of Agriculture's Urban & Community Forestry Challenge Cost Share Grants, US Department of Transportation's grant program, US Department of Housing and Urban Development's Community Development Block Grant, The Foundation Center, and the Alliance for Community Trees. Additionally, U. S. EPA's Urban Waters Small Grants, Environmental Justice, and 319 grants, and the U.S. Department of Transportation's Better Utilizing Investments to Leverage Development (BUILD) program may prove fruitful. The business community and private foundations can be a potential source of funding. Foundationcenter.org maintains a list of private funding sources.

Creative Solutions

In addition to city funding and grants, some cities have created innovative programs to support tree planting. The Chicago Park District has a Green Deed Tree Dedication Program. This program allows donors to select the type of tree planted and planting location. Once planted, donors receive a certificate detailing the person or event being honored, the tree type planted, and

the location. The Green Deed Tree Dedication Program has proven to be an innovative way of planting additional trees as part of the Chicago Trees Initiative. Other potential sources could include Adopt-A-Street programs; wood product sales; utility bill donations; community or organizational fund-raising events; revenues from municipally-owned concessions and recreational facilities; and cash and in-kind donations.

Conclusion

Trees are essential to health and vibrancy of the City of Norwalk. They provide a host of valuable economic, social, and environmental benefits. These benefits include cleaner air and water, lower stormwater infrastructure costs, lower summer temperatures and lower cooling costs, higher property values and higher business revenues, and better physical and mental health. However, these benefits are often underappreciated or ignored.

This report quantified both existing and potential tree canopy cover in Norwalk. It estimated both the costs and the benefits trees currently do and could provide the City. The current tree canopy provides an estimated $36 million in benefits annually, at a cost of $10 million annually. If the City reaches its goal of 61.5% canopy cover, the expanded tree canopy would provide an estimated $52.2 million in benefits annually. When the goal canopy coverage is reached, the net benefits of the canopy would increase from $26 million to $36 million annually.

While the report assesses available locations for tree planting and outlines suggested tasks to include in a tree planting program, the report is not a planting plan, rather it is guidance for providing the best return on investment. This report demonstrates that tree planting is economically feasible and, indeed, will generate far more value than it demands in city resources.

Planting 16,500 trees in Norwalk is a long-term initiative, and trees are a long-term investment, creating value as they grow. In return for the time, effort, and funds required for planting and care, trees will contribute to a healthier, more vibrant community for years to come.

About the NTAC

Members of the NTAC are appointed by the Mayor and approved by the Common Council. Their goals are to:

- Establish and maintain optimum tree cover in the City.
- Secure stable funding and management resources to maintain and enhance the urban forest.
- Maintain public trees in a healthy condition through good cultural practices.
- Establish and maintain an optimal level of age and species diversity within the urban forest.
- Promote conservation of tree resources both public and private.
- Select, situate and maintain street trees appropriately to maximize benefits and minimize hazard, nuisance damage and maintenance costs.
- Promote efficient and cost-effective management of the urban forest.
- Ensure that the urban forest is sustainable.
- Foster community support for the local urban forestry program and encourage good tree management on private properties.
- Maintain a standing list of Urban Tree Canopy Restoration projects with specific planting locations based upon input from the Tree Advisory Committee members, Neighborhood Tree Liaisons, WestCOG, and residents.

New Plantings at Woodward Avenue

WestCOG Project Team

- Elizabeth Esposito, Associate Planner
- Michael Towle, Senior Planner

Other WestCOG Staff

- Francis Pickering, Executive Director
- Patricia Payne, Senior Financial Manager
- Josephine Harvey, Financial Manager
- Kristin Hadjstylianos, Associate Planner
- Jamie Bastian, Associate Planner
- Kristin Floberg, Associate Planner
- Carl Zimmerman, Senior GIS Manager
- William Kenny, Associate Planner
- Nicole Sullivan, Associate Planner
- Ariana Vera, Associate Planner

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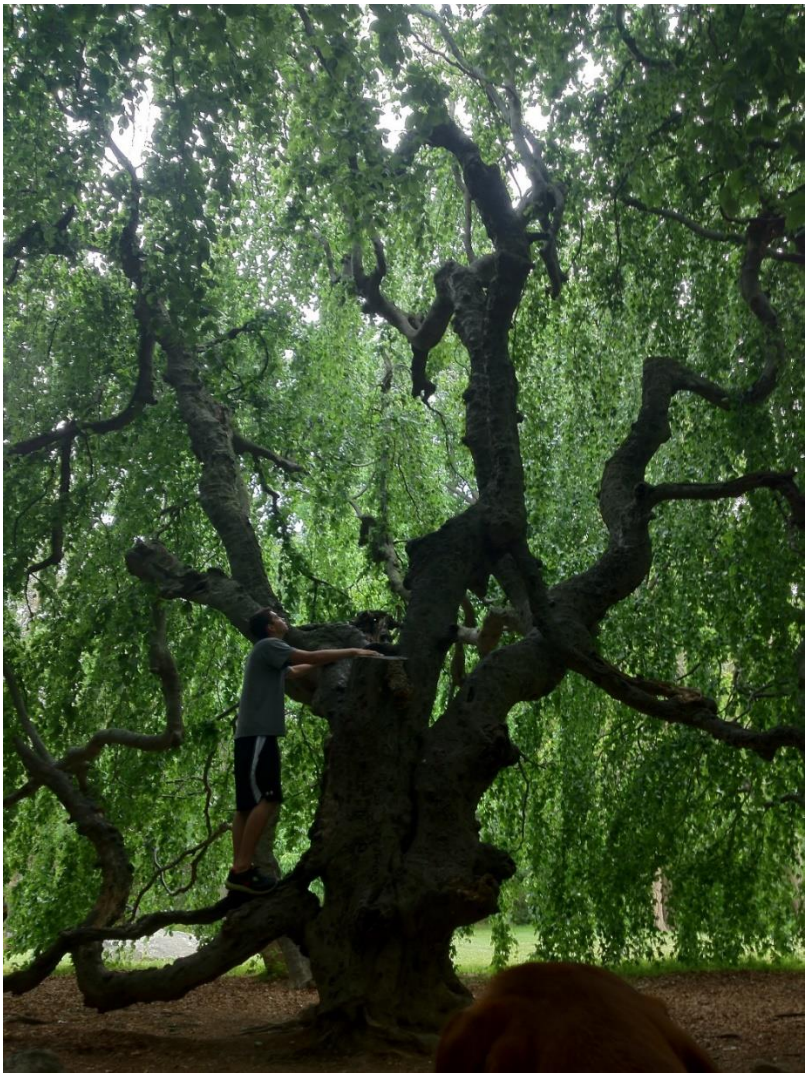


Weeping European Beech, Cranbury Park, Norwalk, CT

Source: Norwalk Tree Alliance

Appendix A: Tree Guidance

Recommended Trees

The following lists were compiled using the University of Connecticut's Plant Database. The recommendations are listed by size and separated by suggested location based on tolerance to salt and sea spray. Planting areas south of US Route 1 may be more susceptible to ocean flooding and sea level rise over time and should be planted with trees that can accommodate increases in salinity. Tree listed in the salt tolerant list are also recommended for planting north of Route 1. All trees listed are native to Connecticut, hardy to Zone 6, and tolerant of urban environments so they may be used both as street trees and lawn trees. Native trees may require less maintenance and replacement, they also provide more ecosystem services to native animal species. This list does not restrict the City of Norwalk or property owners from planting other species of trees.

CT Native, Hardy to Zone 6, Urban Tolerant, Salt/Sea Spray Tolerant (South of Route 1)

Tree 80' +

1. Acer saccharinum, Silver Maple
2. Fraxinus Americana, White Ash
3. Quercus rubra, Red Oak, Northern Red Oak

Tree 50' – 80'

1. Fraxinus pennsylvanica, Green Ash, Red Ash
2. Juniperus virginiana, Eastern Redcedar
3. Liquidambar styraciflua, American Sweetgum
4. Nyssa sylvatica, Black Tupelo, Black Gum

Tree 30' - 50'

1. Acer negundo, Boxelder, Ash-leaved Maple
2. Celtis occidentalis, Common Hackberry

Tree 15' – 30'

1. Crataegus crusgalli, Cockspur Hawthorn
2. Juniperus communis, Common Juniper
3. Rhus glabra, Smooth Sumac
4. Rhus typhina, Staghorn Sumac
5. Salix discolor, True Pussy Willow

Shrub 8'+

1. Amelanchier canadensis, Shadblow Serviceberry, Thicket Serviceberry
2. Myrica pensylvanica, Northern Bayberry, Candleberry

Shrub 4' -8'

1. Clethra alnifolia, Summersweet, Sweet Pepperbush

Shrub < 4'

1. Juniperus horizontalis, Creeping Juniper
2. Potentilla fruticose, Bush Cinquefoil

Other

1. Arctostaphylos uva-ursi, Bearberry, Kinnikinick
2. Parthenocissus quinquefolia, Virginia Creeper, Woodbine

CT Native, Hardy to Zone 6, Urban Tolerant, Not previously listed (North of Route 1)

Tree 50′ – 80′

1. Acer rubrum, Red Maple, Swamp Maple
2. Betula nigra, River Birch
3. Quercus macrocarpa, Bur Oak, Mossycup Oak
4. Quercus palustris, Pin Oak, Swamp Oak
5. Quercus prinus, Chestnut Oak, Basket Oak
6. Tilia Americana, American Linden, Basswood

Tree 30′ - 50′

1. Acer negundo, Boxelder, Ash-leaved Maple
2. Ostrya virginiana, American Hophornbeam, Ironwood
3. Quercus bicolor, Swamp White Oak

Tree 15′ - 30′

1. Amelanchier arborea, Downy Serviceberry, Shadbush
2. Amelanchier canadensis, Shadblow Serviceberry, Thicket Serviceberry
3. Crataegus mollis, Downy Hawthorn
4. Juniperus horizontalis, Creeping Juniper
5. Rhus copallina, Flameleaf Sumac, Shining Sumac
6. Viburnum prunifolium, Blackhaw Viburnum

Shrub 8′+

1. Cornus racemose, Gray Dogwood
2. Cornus sericea, Redosier Dogwood
3. Myrica pensylvanica, Northern Bayberry, Candleberry
4. Physocarpus opulifolius, Common Ninebark, Eastern Ninebark

Shrub 4′ - 8′

1. Aronia arbutifolia, Red Chokeberry
2. Comptonia peregrine, Sweetfern
3. Ilex glabra, Inkberry
4. Rhus aromatic, Fragrant Sumac

Shrub < 4′

1. Aronia melanocarpa, Black Chokeberry
2. Potentilla fruticose, Bush Cinquefoil

Norwalk Tree Planting Program

Urban Forest Improvement Program: Goals & Objectives

The City of Norwalk conducts a tree planting program with goals of:

- Enhancing parklands and open spaces
- Expanding the environmental benefit of trees in the urban landscape
- Improving the aesthetics of streetscapes
- Restoring tree canopy along city streets

Each tree planted is added to the city's tree inventory and entered in the tree layer of the City's Geographic Information System.

How the Program Works

The Department of Public Works typically plants trees on City property or in the City's right-of-way (ROW). Where City property or ROW is not adequate to support health and unrestricted growth, trees will be planted on private property when the property owner agrees to care for the tree(s), although the program is not intended to provide free landscaping for residents or businesses.

In parklands, City-controlled open space, and the grounds of public buildings, plantings are accomplished by the Recreation and Parks Department.

Neighborhood Treescapes

As opposed to scattered individual plantings, trees are planted along a contiguous street or on a neighborhood basis. Planting plans are developed by neighborhood associations, usually through their volunteer tree liaisons. Planting plans are approved by the tree wardens and the Tree Advisory Committee following a walk-through of the street or neighborhood to confirm that the plan conforms to the goals of the program.

The neighborhood association and the adjoining property owners participate in the selection of the species of tree(s) to be planted. Following a successful walk-through, the Department of Public Works then orders the tree(s). Provision and planting of the trees is done through contract.

Benefits of the Neighborhood Approach

The neighborhood approach to implementing plantings contributes to a sense of accomplishment within the neighborhood, ensures a sense of ownership for the tree(s), provides group oversight for the healthy development of the tree(s), and reduces vandalism and pilferage.

Tree Liaisons

Tree liaisons are provided with training, a staking kit, and a volunteer guidebook that provides photographs and key information on each species of tree and shrub that are available through the tree planting program and contract.

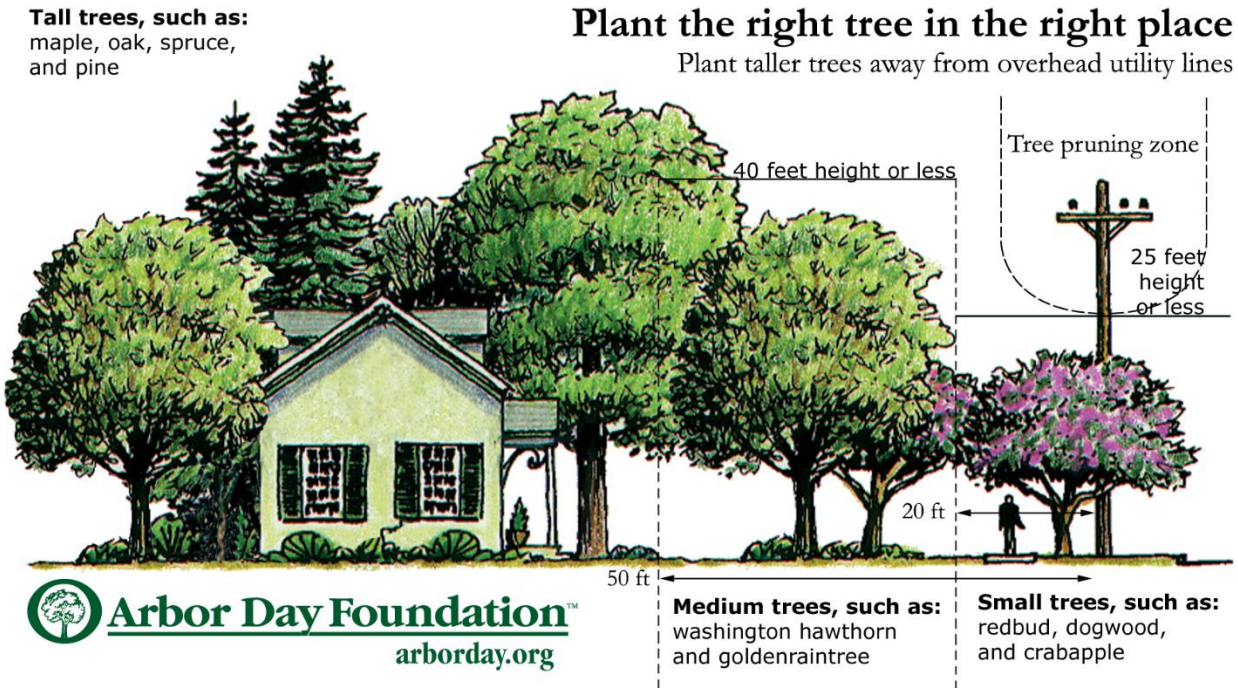
Source: norwalkct.org/196/Tree-Planting-Program

Right Tree, Right Place

Adding trees to a property can increase home value and reduce energy cost. When selecting trees for planting, it is important to take into account not only the requirements the tree will need to thrive, (soil, sun, moisture, and climate) but also the landscape around the planting site and the tree species. While the full size of the tree may not be apparent for several seasons, trees can create conflicts due to their height and canopy spread as they grow. Well intentioned trees can damage utility lines, roofs, and infrastructure like sidewalks and sewer drains if not properly sited. These conflicts are easily avoided if the right species tree is selected for the right place.

Eversource Tree Planting Guidance

Eversource has put together a list of recommended native species for plantings that have appropriate tree heights but are also aesthetically pleasing. The program is called "Plan before you Plant" and a handout of recommended species are provided, the planting list can be found here:
https://www.eversource.com/content/ct-c/residential/outages/avoiding-an-outage/tree-trimming/plan-before-you-plant



Tree Maintenance

Pruning

Each year thousands of trees are killed by homeowners and non-professional landscapers who try to prune a tree without knowledge of what keeps a tree alive, healthy, and beneficial to the environment. A licensed arborist is your best choice for pruning a tree.

Trees need to be pruned correctly. If not, this damage can be compounded as the tree struggles to stay alive. In many cases, it may take years before a tree dies from incorrect pruning. Cutting a tree is not like trimming and designing a hedge. One cannot just cut it to the desired height and shape, regardless of the height and spread the tree needs to survive. Incorrect pruning shortens the life of the tree by disfiguring the natural form, causing wounds that the tree cannot heal, and creating sites for infection and invasion for fungus, pests, and pathogens.

How to Correctly Prune a Tree

Allow a tree to grow as much as possible naturally. However, when trimming is necessary, there are proper guidelines to manage the growth and not cause death and disease to the tree.

1. Make a small wedge-shaped cut on the underside of the branch, on the branch side of the stem collar. This will break the bark and prevent a tear along the bark.
2. Farther along the branch, starting at the top, cut all the way through the branch, leaving a stub end.
3. Finally, make a third cut parallel to and just on the branch side of the stem collar to reduce the stub length.

Tree Benefits from Pruning

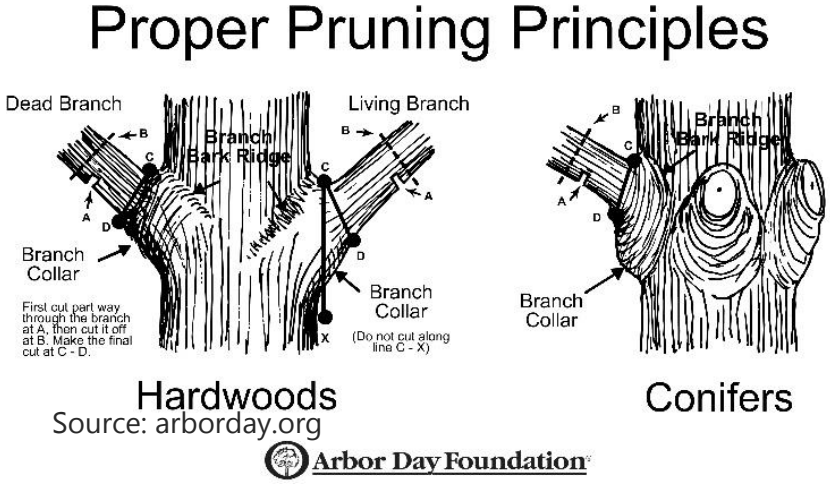
After pruning, new foliage is fresh and vibrant. The tree has new vigor as the nutrients flood into the remaining branches. Young tree pruning strengthens the growth and flowering ability of the plant. The best time to remove low-lying branches, disproportionate trunk or limbs is when they are young.

Season to Prune

The dormant season, late fall or winter, is the best time to prune. Although dead branches can be removed anytime. Pruning during the dormant period minimizes sap loss, and reduces the risk of insect invasion and fungus infection.

How Much to Prune

Prune as little as possible. No more than 10% - 15% of the crown should be removed, and it is best to ensure that the living branches compose at least 2/3 of the height of the tree.



Mulching

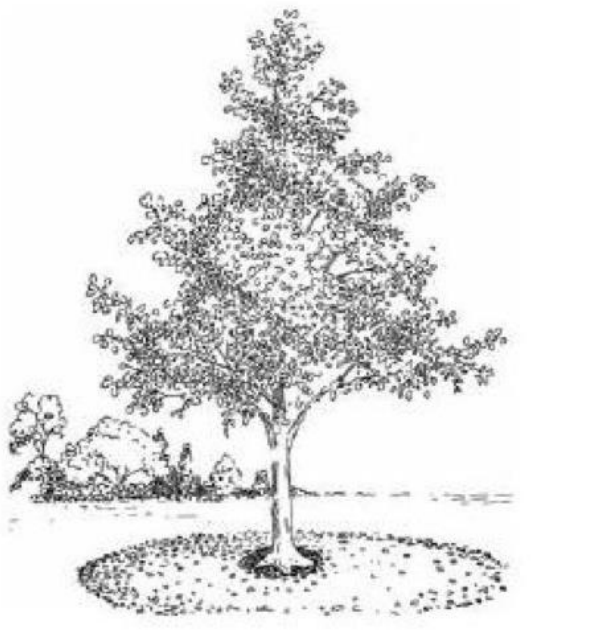
Wood mulch can be an excellent tool to retain moisture and suppress weeds around the trunk of a tree. However, improper mulching can have negative impacts on tree health. If mulch is piled too high around a tree trunk, it smothers the roots and trunk. The moisture it retains can cause rot and become a home for fungus. Borrowing insects are also attracted to deep mulch piles and may harm the tree.

Tips for mulching

- Never build a "mulch volcano" around a tree trunk.
- Keep mulch away from the tree trunk.
- The mulch should be no more than 3 inches deep.

Source: arborday.org

Improper Mulch
Root flare buried &
Mulch piled high up against the trunk



Proper Mulch
Root flare visible at the base of the tree &
Mulch extends to dripline of canopy

Source: treefolks.org

Appendix B: Methodology

The Norwalk Tree Analysis was structured around four components, existing tree canopy classification, potential tree canopy classification, tree census, tree canopy costs and benefits. These component methodologies are presented below.

Existing Tree Canopy Classification

WestCOG had access to planimetrics, high resolution imagery, NAIP 2016 Leaf on imagery and LiDAR data. The planimetrics data provided a vegetation line, and location of street trees but did not provide a canopy polygon. A tree canopy polygon was generated using esri image segmentation tools along with imagery, and lidar derived data as outlined below.

A digital elevation model (DEM) and surface elevation model (SEM)[3] were derived from the lidar data. By use of the raster calculator these features were utilized to derive the difference between the two to create a feature elevation model (FEM), that is raster of the heights of tree, structures, and objects upon the surface.

A segmented "leaf-on" NAIP image was created to assist with the tree canopy classification. Bands 4 (NIR), 2 (green), 3 (blue) were used in the ArcGIS Pro's "segment mean shift" tool with spectral and spatial detail set to 20 (the max detail).

Training sites were then created for 4 classes: Canopy, Impervious, Turf, and Water. Training sites were developed to capture the exact pixels of interest. Training site Polygons attempted to capture around 100 pixels per site. The goal was to stay under 10,000 pixels for training sites, and above 500.

Tree Canopy = [conifer, deciduous, bright deciduous, swamp Trees, tree shadow]

Turf = [golf turf, lawn, bright lawn, dull lawn, shadowed turf]

Impervious = [Buildings gray, buildings white, buildings black, sand, imperviosu shadow, cars]

Water = [sound, murky, shallow, deep, shadow]

Sites were trained with Support Vector Machine Classifier, which included FEM layer into its calculations. Segment attributes reviewed included: converged color, mean digital number, standard deviation, compactness, rectangularity. These were chosen as they are associated with tree features.

With the classifier definition file created from above, the land cover could be classified with a focus on canopy. Again the FEM is included as an additional raster during the classification process. The output raster displays the classes. This raster output is overlayed with a grid covering the region made up of 1km squares. The resulting raster is exported to polygon, split up by the grid and including all four classes. using

[3] The Surface Elevation Model (SEM) had an instrument banding error causing thin lines of lower surface elevation values to band across. This was attempted to be resolved through interpolation. However, because the segmentation process did not seem heavily influence by the banding, the issue was overlooked.

definition query WestCOG could isolate the canopy feature. The polygon is incredibly detailed an intensive, which is why the grid was overlayed in the raster processing level. The grid allows for easier processing.

An accuracy assessment was created using 500 random points, to identify if features were marked as "canopy" or "other". As we were only concerned with Canopy, the error with other classes landing in other classes was not of concern. Omission and commission error were calculated with a total accuracy of 90% for the canopy class alone[4].

Potential Tree Canopy Classification

Potential canopy represented areas where tree could be planted and was built upon the previously developed canopy layer. All areas in the WestCOG study area that do not fall under impervious cover, roads, buildings, or within excluded areas around 30 feet of utility poles. The erase tool was applied to the shape of Norwalk's land features and street pavement, building footprints, impervious areas and utility pole 30ft buffers were removed from the layer. The resulting layer was then ran through the union tool with the existing canopy layer to develop the Potential Canopy Polygon Layer.

Tree Census

A count of trees was needed to calculate costs and benefits of trees, both existing and potential canopy. Utilizing a method applied in a previous tree study done in New Britain CT, WestCOG classed the canopy polygon into three classes: Street, Park, and Inner Canopy

Street Canopy was any canopy polygon 0.007 acres or less in size with a canopy diameter of 20ft. Park Canopy represented canopy on the fringe of canopy polygon, extending 20 ft in and an estimated diameter of 40ft. The remaining canopy was classed as inner with an estimated canopy diameter of 26ft. With research based assumptions on canopy diameters, the area of canopy per tree can be calculated, which is then used to calculate the total amount of trees for the given amount of area for each class. This process was performed for both the existing canopy and the potential canopy.

Cost Benefit Analysis

I tree eco was considered for this study, but it was realized the effort was beyond the scope of this analysis. I-tree is able to provide detailed benefits, and is useful for monitoring an urban canopy, but it requires substantial field work to sample tree plots, with labor that would far exceed the budget of this analysis. Cost benefits were instead based on peer reviewed research, using an assumption for the cost and benefits, associated with full life of a tree annualized. These values were applied to small medium and large trees, which we match into our street, inner, and park canopy classes respectively. With a count of trees for each class, used to estimate financial impact.

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[4] Canopy cover accuracy while 90% is largely thanks to the correct classification of large swaths of forest. Fringe and street trees are, likely represent most of the error which occurred.