



CENTER FOR ENVIRONMENTAL STUDIES, BROWN UNIVERSITY

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# TREES AND THE URBAN HEAT ISLAND EFFECT:

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A CASE STUDY FOR PROVIDENCE RHODE ISLAND

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**BENEFITS OF URBAN TREES**

summer cooling & winter warmth

stormwater & flood reduction

air & water pollution capture

higher property values

greater biodiversity

improved quality of life

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# TREES AND THE URBAN HEAT ISLAND EFFECT:

## A CASE STUDY FOR PROVIDENCE RHODE ISLAND

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Why are cities so much hotter on summer days and evenings than surrounding woodlands and fields? The urban heat island effect refers to developed areas that are hotter than surrounding rural areas due to the abundance of man-made materials there. These materials, such as concrete, brick, and asphalt, absorb the sun's energy much more than trees or other plants, and in turn warm the air around them. In addition, vehicles and buildings in urban areas generate heat from burning energy.

The urban heat island effect has proven to be deadly in heat waves in Chicago in 1995 and Paris in 2003, where thousands of people died of heat-related illness. While no event this severe has occurred in Providence, temperature records since 1970 show that the city has been steadily warming. Now computer models based on the best science predict that summers here may be 6-14 degrees warmer on average by 2100. What does that mean for us? Instead of the average 5-6 days a year over 90°F, we will be experiencing around two months a year (60 days) over 90°F by 2070. Even more startling is that if emissions of greenhouse gases continue to grow, there are likely to be 2-4 weeks (14-28 days) in average summers when the city is over 100°F near the end of the century.<sup>1</sup> Heat at this level taxes human bodies and the physical infrastructure that we depend on.



## ONE STRAIGHTFORWARD AND COST-EFFECTIVE WAY FOR THE CITY TO BUFFER ITSELF FROM HEAT WAVES STOOD OUT AMONG ALL THE REST: TO PLANT AND CARE FOR TREES

In our investigation of this problem, one straightforward and cost-effective way for the city to buffer itself from heat waves stood out among all the rest: to plant and care for trees. This report reviews the benefits Providence residents gain from their trees and discusses how we can improve our performance in planting and caring for them. We set out to bring together the hard science of satellite imagery public health data with interviews in a Providence neighborhood to understand from residents why there aren't more trees around their houses. The report describes efforts in other cities and identifies a fairly long list of possible funding sources for increasing tree planting in Providence. We conclude by proposing some concrete policy steps the city and state can take to reach and exceed existing goals to green the city with trees.

Rhode Island is one of the most urbanized states in the country, with 23.2% of our land area covered in cities.<sup>2</sup> A recent study found that Providence had about 25,000 street trees and an overall canopy cover of 23%. Greenprint: Providence put forward a goal of 30% coverage by 2020, which would require planting 40,000 trees total, or about 3,333 more trees per year.

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Why bother to plant so many trees? Trees bring a series of benefits at relatively low cost: they cool the city, lower energy costs, reduce the amount of flooding, erosion, and pollution in the bay, raise property values, and make people feel more positive towards their neighborhoods. One cost of not having trees is that air quality is adversely impacted by the urban heat island effect. Poor air quality in turn creates waves of asthma and other illnesses. Increasing temperatures accelerate the formation of smog, which proliferates as daily temperature go above 72°F.<sup>3</sup> Trees can reduce air temperature by transpiring water, which consumes heat energy in the surrounding air. Trees also reduce air pollution by filtering surrounding air: they absorb pollutants in their pores and collect soot on their leaves.<sup>4</sup>

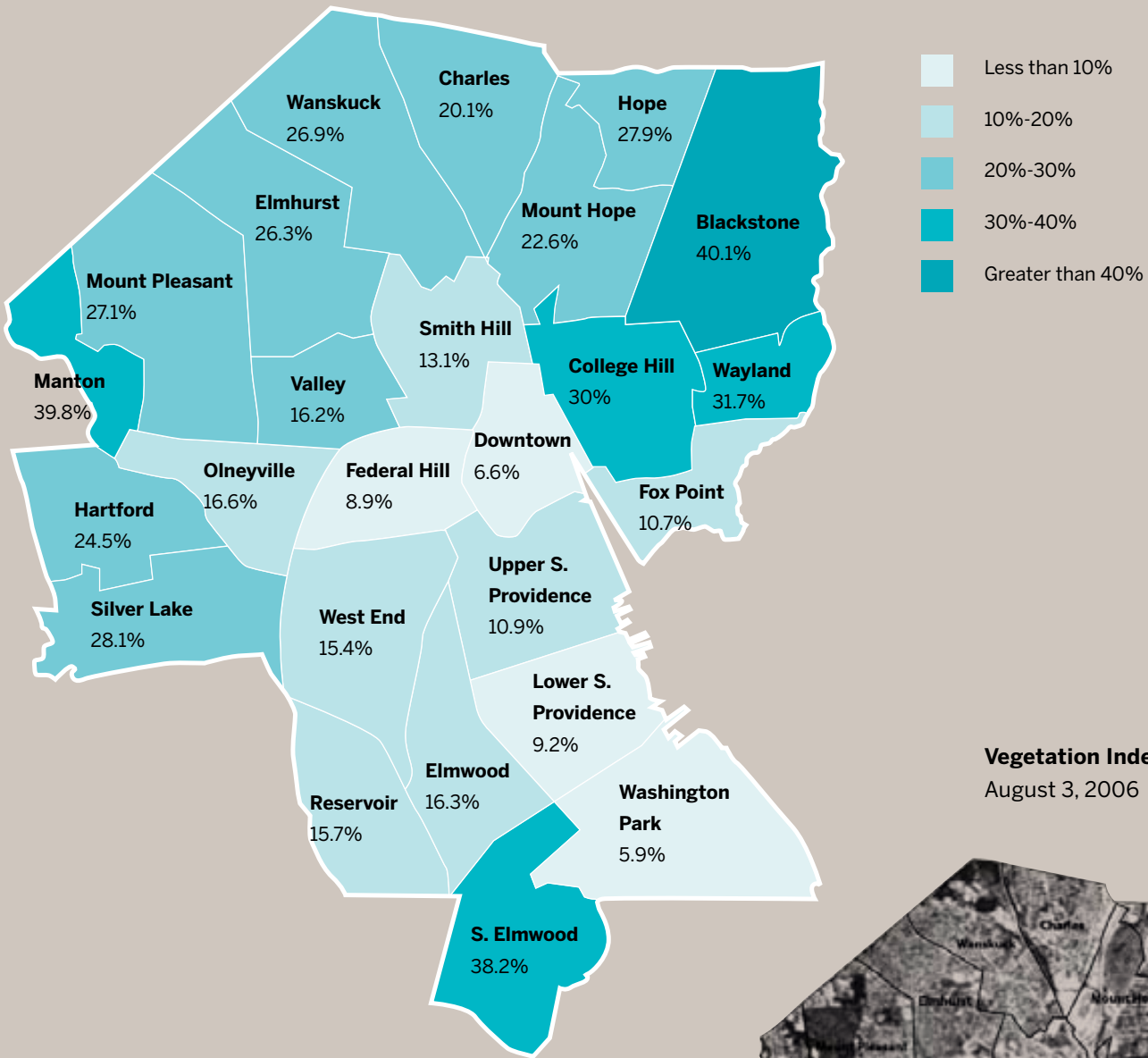


On reducing the urban heat island effect, the numbers are illuminating. One study suggests that a well-placed 25-foot tree can reduce heating and cooling costs for a typical residence by 8 to 10%, or \$10 to \$25 a month.<sup>5</sup> A national tree planting initiative could save the country \$1 billion per year from heating and cooling expenses, which means less fossil fuels burned, less carbon dioxide emitted and less dependence on foreign oil. It has been shown that the value of decreased energy use and reduced smog can amount to as much as \$200 per tree planted.<sup>6</sup> There are estimates that trees can increase property values from 3.5%-20% on unobservable factors alone.<sup>7</sup> To summarize the net benefits and costs, the Providence city government calculates that for every dollar spent on tree planting and maintenance, the city reaps \$3.33 in benefits.<sup>8</sup> Community involvement could decrease costs, but using the current model, costs are largely fixed. To maximize the benefits of tree-planting, Providence should conduct a few intensive case studies in different neighborhoods to understand how benefits vary, and focus on engaging residents to reduce their maintenance costs.

In summary, a determined and sustained tree planting effort in Providence and other parts of Rhode Island can be a central part of how we cope with a hotter and more unpredictable climate. Regardless of one's views on climate science, planting trees makes sense for a series of very immediate reasons. The next section documents how trees are making a difference in cooling certain neighborhoods and where trees are needed most.

## Providence Urban Tree Canopy

Figure from the State of Providence's Urban Forest Report, April 2008.



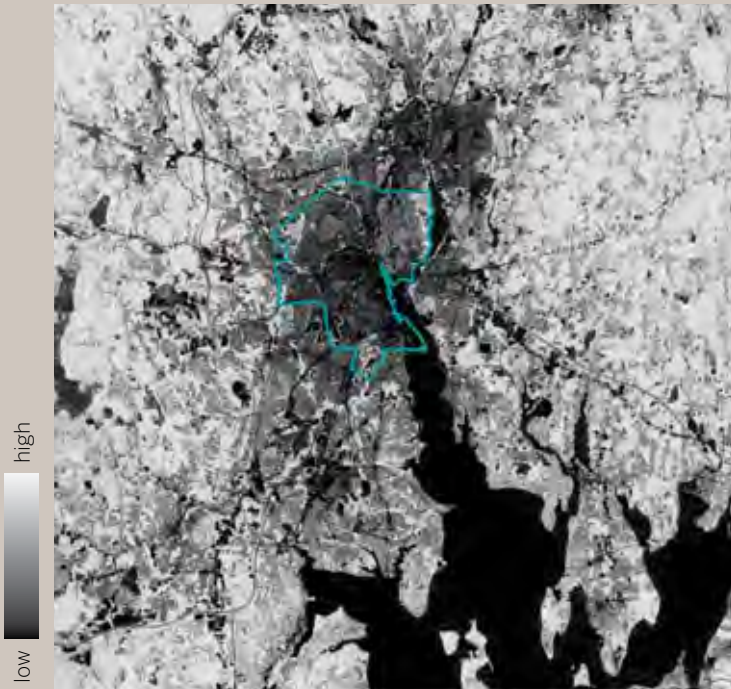
**Vegetation Index**  
August 3, 2006



## Imagery Acknowledgements

Daytime surface temperature and vegetation index images derived from Landsat 5 TM satellite data, available at <http://glovis.usgs.gov>.

Nighttime surface temperature image derived from ASTER satellite data, available at the USGS Land Processes Distributed Active Archive Center (LP-DAAC) at <https://lpdaac.usgs.gov>.



**Vegetation Cover**

Greater Providence area.  
 Calculated using the NDVI  
 vegetation Index. Image  
 taken August 3, 2006.

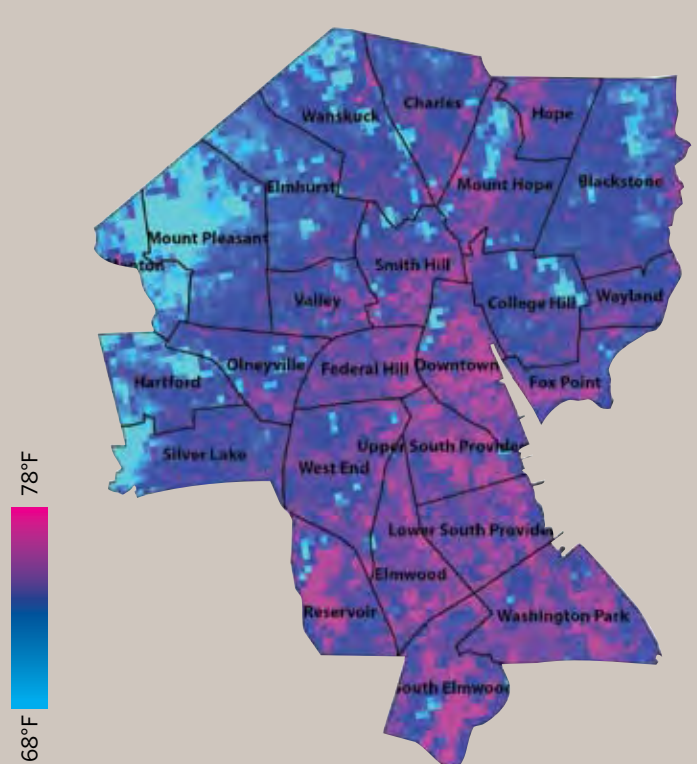
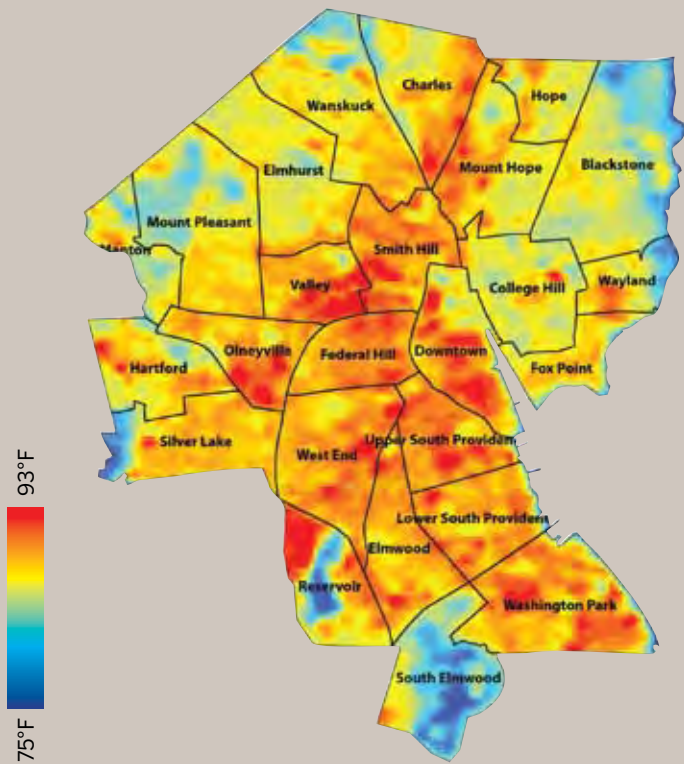


**Daytime Surface  
 Temperature**

Greater Providence area. Image  
 taken August 3, 2006 at 11:20am.

**Daytime Surface Temperature**  
 August 3, 2006, 11:20am

**Nighttime Surface Temperature**  
 July 24, 2005, 10:49pm



# MEASURING PROVIDENCE'S URBAN HEAT ISLAND

## AN ANALYSIS OF VEGETATION AND TEMPERATURE USING SATELLITE AND WEATHER DATA



In order to understand how to increase tree-planting efforts, it is important to determine the scope of the urban heat island effect in Providence and where it is most severe. Satellite imagery, Geographic Information Systems (GIS) data, and weather data are useful tools for describing the effects of trees on Providence's heat island because of their ability to visually communicate information. In addition, much of this data is readily available to the public through the USGS Glovis website (<http://glovis.usgs.gov/>) and the Rhode Island Geographic Information Systems website (<http://www.edc.uri.edu/rigis/>). In this study, we used Landsat and ASTER satellite imagery in combination with weather data to understand the intensity of Providence's urban heat island and identify the areas of the city that can benefit most from additional tree planting.

### METHODS

In our analysis, we used two sets of satellite data (Landsat 5 TM and ASTER) along with weather station data to understand the relationship between vegetation cover, surface temperatures, and air temperatures. To measure vegetation cover and surface temperatures, we performed calculations using ENVI, a computer program used to analyze satellite imagery. Using this data, we created day and nighttime images of surface temperatures in Providence, as well as a map of vegetation using a vegetation

index. The following section discusses how we performed these calculations and describes the characteristics and limitations of these datasets.

The Normalized Difference Vegetation Index (NDVI) is a calculation that provides a measure of vegetation cover for a satellite image. This index takes advantage of the unique spectral character of green vegetation; live green plants strongly absorb incoming radiation at wavelengths within the visible spectral range, but are highly reflective at near-infrared spectra. This calculation is completed for each pixel in the image, such that the whole image represents the distribution and density of vegetation cover. Specifically, NDVI is calculated with the following formula:

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

where NIR and RED represent reflectance measurements in the near-infrared (NIR) and red (RED) regions of light. NDVI is measured on a 0-1 scale, where 1 indicates high vegetation cover and 0 represents negligible vegetation. It is important to note that NDVI does not distinguish tree cover from other types of




vegetation cover. The easiest way to understand tree distribution is to look at a Google Maps satellite image of Providence, where trees are clearly distinguishable from grass due to their texture and shadows. However, all types of vegetation may contribute to mitigating the urban heat island, and NDVI allows us to isolate vegetation from other types of land cover and directly compare it to surface temperatures.

To measure surface temperature, we used two sets of satellite imagery: Landsat 5 TM's Band 6 and data from the Terra Satellite's ASTER instrument. Both satellites measure thermal infrared light, which is carefully calibrated and can be mathematically converted to surface temperature. It is useful to use both Landsat and ASTER data because each has specific strengths and limitations. Landsat 5 passes over the Providence area every 16 days at approximately 11:00am, and therefore does not capture early afternoon temperature peaks. Like Landsat, ASTER passes over Providence in late morning, but also captures images around 11:00pm. This nighttime imagery is useful for tracking the urban heat island when it is most pronounced. In addition, ASTER uses five discrete thermal bands while Landsat uses a single thermal band, which ultimately allows for more accurate temperature data. ASTER's spatial resolution is slightly better, with 90m/pixel

resolution, versus Band 6 Landsat 5 TM's 120m/pixel resolution. However, ASTER data has smaller image swaths, is available less frequently, and has irregular coverage. In contrast, Landsat 5 scenes cover standardized areas and are easily downloadable from the USGS Glovis website.

While many studies have used surface temperature to measure the urban heat island effect, a fundamental flaw with this analysis is that we actually want to understand patterns in air temperature. In order to understand the relationship between surface and air temperatures, we analyzed weather data from over a dozen automatic weather stations (AWS) in the greater Providence area, provided by the National Climatic Data Center (NCDC) and AWS/Weatherbug. Each station measures air temperature, dew point, wind speed, wind direction, cloud cover, and precipitation, and has data available at least every hour. The NCDC site is located at T.F.Green Airport in Warwick, RI, and has weather records from as far back as 1932. This AWS site is well calibrated and located in a grassy field away from airport tarmac and pavement. Therefore, we can be very confident in its temperature measurements. However, even if surface and air temperatures match up at this site, this does not mean that they will match accurately at other sites within the city where pavement and man-made materials are widespread.



## REGIONS WITH ESPECIALLY HIGH TEMPERATURE ANOMALIES, INCLUDING DOWNTOWN PROVIDENCE, LOWER OLNEYVILLE AND VALLEY, FEDERAL HILL, AND UPPER SOUTH PROVIDENCE ARE ALSO THE LEAST VEGETATED.

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The AWS/Weatherbug program works with schools nationwide to install rooftop AWS instruments and develop weather-related educational programs. We acquired this weather data for each Landsat satellite image date, for a total of seven days across 14 years. This data was available for 15-29 AWS sites within a 15-mile radius of the Providence area, depending on the date. AWS/Weatherbug has a number of specifications for AWS installation, including requirements that temperature sensors be a minimum of 8ft from a rooftop, 50ft from ventilation and heat sources, and away from large, asphalt parking lots. One potential problem in correlating this data to surface temperature is that roof temperatures are typically hotter than surrounding areas, so the discrepancy between surface and air temperatures may be misleadingly large. Another problem with this data is that none of these weather stations are located in the hottest parts of Providence; all are sited in cooler regions of the city or outside Providence itself. Nevertheless, this information is very useful for understanding how surface temperatures correspond to air temperatures and how air temperatures vary throughout the region.



### RESULTS AND DISCUSSION

We found a significant correlation between hotter surface temperatures and low vegetation. Regions with especially high temperature anomalies, including Downtown Providence, Lower Olneyville and Valley, Federal Hill, and Upper South Providence are also the least vegetated. Conversely, neighborhoods with higher vegetation cover, such as Blackstone and Mt. Pleasant, had lower average surface temperatures. These trends occur both during the day and night.

One discrepancy between day and nighttime temperatures occurs in Lower Reservoir and Elmwood, both of which appear relatively cool during the day and warm at night. This may seem odd, since most other locations have either relatively cool temperatures both day and night or relatively warm temperatures. These neighborhoods, however, contain a number of water bodies that affect local climate due to the heat-retaining properties of water. Because water takes more energy to heat and cool than land does, water bodies warm up very gradually during the day and retain stored daytime heat at night. This results in cooler daytime temperatures and warmer nighttime temperatures.



Although the correlation between surface temperatures and vegetation is clear, the weather data suggests that the relationship between surface and air temperatures is more complex. In general, there was an approximately 10°F range in temperatures between all sites in the greater Providence area at any given date and time. T. F. Green Airport had consistently lower temperatures, while stations within the city generally had warmer temperatures. Temperatures at the three Providence schools (Ocean Tides, Moses Brown, and Lincoln School) were reliably at the low end of the temperature range, while Cranston East often experienced higher temperatures. These findings suggest that local factors such as vegetation and proximity to water are important in determining air temperature at a given site. However, it may be inaccurate to generalize about a neighborhood or town based on one specific site. In order to better understand these trends, future studies could analyze weather data for a greater range of dates across multiple seasons and work with weather specialists to interpret this data.

In our analysis, we identified a few specific policy recommendations related to tree planting. Downtown Providence, Lower Olneyville and Valley, Federal Hill, and Upper South Providence have especially high surface temperatures and could greatly benefit from higher vegetation cover. Tree planting in Federal Hill, Downtown Providence, and Upper South Providence would be especially beneficial. These areas are mostly residential or commercial, and trees could directly impact the people that inhabit, work, or travel in these areas. In contrast, Lower

Olneyville and Valley are largely industrial, so there may be less interest in tree planting. These results match a 2008 urban tree cover analysis that found Federal Hill, Downtown Providence, and Upper South Providence to have the greatest potential for increasing canopy cover.<sup>1</sup>

[Please see page 4 for day and nighttime images of surface temperature, as well as NDVI for the City of Providence.](#)

# THE HUMAN HEALTH BENEFITS OF TREES



## HOW TREES MITIGATE AIR POLLUTANTS AND HEAT

Not only do trees mitigate urban heat, but they also remove air pollutants commonly found in cities. Both of these processes in turn produce important benefits to human health. In this section, we will discuss how trees remove pollutants and alleviate heat, as well as the effects of excessive heat on human health. A summary of common pollutants and their health effects is shown on page 13.

### COMMON AIR POLLUTANTS AND HOW TREES REMOVE THEM

There are four major pollutants that trees help to reduce: ground-level ozone, nitrogen dioxide, sulfur dioxide, and particulate matter.<sup>1</sup> Each of these substances has negative human health impacts and may aggravate asthma and other respiratory conditions (see chart on page 13). While it is important to curb emissions from factories and vehicles, tree planting is a valuable strategy for removing contaminants from the atmosphere. Trees remove these pollutants by absorbing them through leaf stomata and collecting them on leaf surfaces.<sup>2</sup>

Stomata are the pores on the stems and leaves of most plants, which act as a respiration mechanism by absorbing atmospheric gases and releasing  $O_2$ . Because the absorption mechanism operates by diffusion, higher concentrations of pollutants cause more uptake. Trees draw in many major pollutants through their stomata, including nitrogen dioxide, sulfur dioxide, and carbon monoxide, among others.

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## EXCESSIVE HEAT STRESSES PHYSIOLOGICAL SYSTEMS IN THE HUMAN BODY AND AT WORST, CAN LEAD TO HEAT STROKE AND DEATH.

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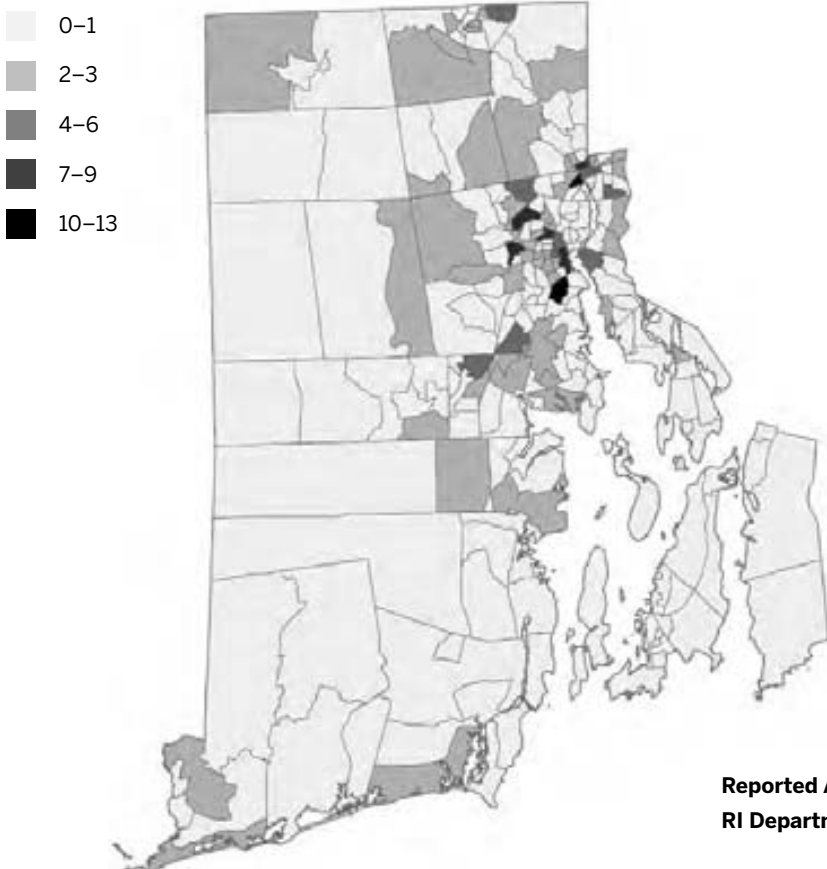
Particulate matter, composed of dirt, soot, and other particles that float in the air, is removed by settling on leaf surfaces. The more leaf area and the longer the growing season (the amount of time in which trees have leaves), the higher the removal rate. It is important that there are shrubs and smaller plants growing beneath trees, because the denser the vegetation cover, the more particulate matter will be removed.

Ground-level ozone is produced by the reaction between nitrous oxides, carbon monoxide, and volatile organic compounds (VOCs), all of which are released in automobile combustion. Production of ground-level ozone increases with temperature, so tree-related cooling can decrease ozone formation. Trees also absorb ozone in their leaf stomata as described, further reducing atmospheric concentrations.

Although trees are good at absorbing air pollutants on the local level, they do not remove a significant amount of the total pollutants in the troposphere (<1%).<sup>3</sup> Therefore, more trees on a national scale may not do much to mitigate air pollution and climate change. However, on a local scale, trees are crucial to keeping the air clean and citizens healthy.

# AIR POLLUTANTS AND THEIR HEALTH EFFECTS

POLLUTANT & SOURCES	COMMON HEALTH EFFECTS	NOTES
<b>GROUND-LEVEL OZONE<sup>1</sup> (O<sub>3</sub>)</b> <ul style="list-style-type: none"><li>• Vehicle emissions</li><li>• Industrial emissions</li><li>• Chemical solvents</li><li>• Natural sources</li></ul>	Coughing, wheezing, shortness of breath, chest pain, congestion, aggravation of pre-existing respiratory conditions (asthma, pneumonia, bronchitis, emphysema), reduced lung function, inflammation of lining of the lungs, permanent scarring of lung tissue	<ul style="list-style-type: none"><li>— Created by reaction between nitrogen oxides (NO<sub>2</sub>) and volatile organic compounds (VOCs)</li><li>— Trees capture in their stomata and reduce conditions for O<sub>3</sub> formation</li></ul>
<b>NITROGEN DIOXIDE<sup>2</sup> (NO<sub>2</sub>)</b> <ul style="list-style-type: none"><li>• Vehicle emissions</li><li>• Industrial emissions</li></ul>	Irritation of eyes, nose, throat, and respiratory tract, accumulation of fluid in the lungs, lung injury, respiratory failure, bronchitis, aggravation of pre-existing respiratory conditions (asthma, obstructive pulmonary disease)	<ul style="list-style-type: none"><li>— Aggravation of respiratory conditions can occur even at low levels of exposure</li><li>— Trees absorb measurable quantities</li><li>— Also contributes to the formation of ground-level ozone</li></ul>
<b>SULFUR DIOXIDE<sup>3</sup> (SO<sub>2</sub>)</b> <ul style="list-style-type: none"><li>• Power plant emissions</li><li>• Industrial emissions</li><li>• Vehicle, train and ship emissions</li></ul>	Coughing, wheezing, shortness of breath, aggravation of pre-existing respiratory conditions (namely asthma), especially among children and elderly	<ul style="list-style-type: none"><li>— Also contributes to the formation of particulate matter</li><li>— Trees absorb measurable amounts</li></ul>
<b>PARTICULATE MATTER<sup>4</sup> (PM)</b> <ul style="list-style-type: none"><li>• Construction sites</li><li>• Dirt roads</li><li>• Fires</li><li>• Power plant emissions</li><li>• Industrial emissions</li><li>• Vehicle emissions, especially diesel</li></ul>	Decreased lung function, aggravation of pre-existing respiratory conditions (bronchitis, asthma), airway irritation, increased cardiovascular and respiratory disease-related mortality among elderly, coughing, difficulty breathing, heartbeat irregularity, heart attacks	<ul style="list-style-type: none"><li>— Mixture of liquid droplets and solid particles</li><li>— PM10: "coarse" PM; 2.5-10 microns in diameter; inhalable</li><li>— PM2.5: "fine" PM; &lt;2.5 microns in diameter; inhalable; penetrates deep into lungs</li><li>— PMs settle on leaves and are washed away with rains</li></ul>



**Reported Asthma Cases per 1000 People,  
RI Department of Health**

### How Trees Mitigate Heat

Trees reduce heat in two ways: by providing shade and releasing water vapor. Shade is one of the most important services that trees offer, created when the leaves of full-canopied trees block sunlight from the ground. Their placement beside buildings dramatically decreases material surface temperatures and reduces the need for air-conditioning. The EPA reports that tree shading can reduce surface temperatures 20–45°F in the summer.<sup>4</sup>

Trees also reduce heat by releasing water vapor in a process called evapotranspiration. Trees absorb water through their roots and transport it to their branches and leaves. Some of the water not used in photosynthesis is released into the air through leaf stomata, creating a cooling effect. Water that collects on leaves during rainfall evaporates and cools the surrounding air. This water vapor coupled with direct shading can provide cool relief in the midst of urban heat.

### Heat and Human Health

Heat reduction by trees and other vegetation can have a direct effect on human health. This is because excessive heat stresses physiological systems in the human body and at worst, can lead to heat stroke and death. Heat stress, or hyperthermia, is especially dangerous for children, the elderly, and those with existing cardiovascular problems.<sup>5</sup>

High temperatures cause stress by inducing the body's homeostatic functions, such as body temperature and blood pressure. Heat causes the blood vessels near the skin to dilate, and in order to maintain blood pressure, the heart pumps faster. This increases the risk of cardiovascular complications and can decrease blood flow to the brain.<sup>6</sup> In addition, excessive sweating can cause salt and fluid loss, leading to dehydration. Symptoms of heat stress include rash, fainting, cramps, and exhaustion. The most severe and dangerous risk is heat stroke, which can potentially cause seizures, coma, and death.

The effects of heat on human health can be measured on a larger scale. Many studies have shown increases in mortality during extreme heat events, especially in urban areas among the elderly. The July 1995 Chicago heat wave is often cited to establish a link between increased heat and elevated mortality.<sup>7</sup> During this event, 485 residents died from confirmed heat-related symptoms, while thousands were hospitalized. Many of those that died were poor, elderly and impoverished. Cases like this highlight the need for heat-mitigating strategies in cities, and tree-planting is a highly effective option.

# DISPARITIES IN ACCESS TO TREES

## ENVIRONMENTAL JUSTICE, THE OVERNIGHT PARKING BAN, AND POTENTIAL MODELS FOR PROVIDENCE'S TREE PLANTING PROGRAMS



Trees provide substantial health, social and economic benefits to individuals and communities across Providence. However, as with many public amenities, access to trees is not equal across all demographics. Nationwide, proximity to street trees and urban green spaces consistently favors homeowners to tenants and the wealthy to the poor.<sup>1</sup> This is one of the most difficult problems to overcome in promoting equitable and widespread access to trees, but also one of the most important. Therefore, it is vital that Providence considers this environmental justice issue when designing tree-planting policy.

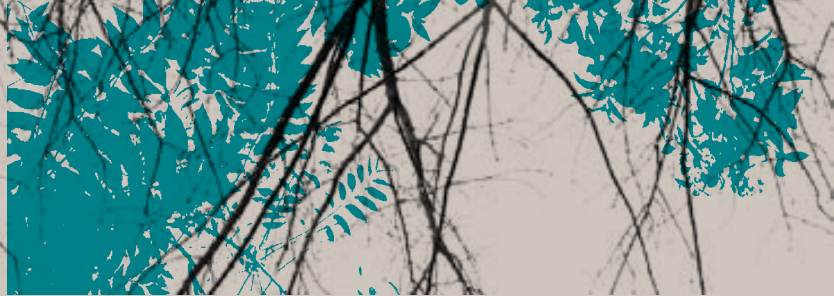
Environmental justice advocates have historically focused on how environmental hazards disproportionately affect certain populations based on race, income, education level, land tenure status, and other factors.<sup>2</sup> In 1991, delegates to the First National People of Color Environmental Leadership Summit drafted and adopted 17 principles of environmental justice. These principles have since become standard guidelines for justice advocates. However, they focus primarily on environmental risk, such as exposure to toxic waste and poisons, and give less attention to equitable access to environmental amenities.<sup>3</sup> A growing body of literature suggests that lack of access to these amenities is as serious a problem as unequal exposure to environmental hazards.<sup>4</sup> The reasons for fewer trees in poor neighborhoods are varied and

complex. Some obstacles include inadequate resources to purchase and care for trees, logistical barriers to obtaining trees, and insufficient funds for street trees and public green spaces.<sup>5</sup>

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**PATTERNS SUGGEST THAT HIGH-TENANT AND LOW-INCOME AREAS SHOULD RECEIVE SPECIAL ATTENTION IN PROVIDENCE'S TREE-PLANTING INITIATIVES.**

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In designing a tree-planting program for Providence, it is useful to examine similar efforts launched in other cities. One such program is “Greening Milwaukee,” created by the city in 2002. This program aimed to increase the city’s canopy cover from 16% to 40% through collaboration with residents and community groups. It provided participants with free or heavily discounted trees in exchange for their agreement to maintain the trees, similar to the Providence Neighborhood Planting Program.<sup>6</sup> Ultimately, the program highlighted the disparity between tenants and homeowners. Although “Greening Milwaukee” reached out equally to both groups, homeowners planted and maintained trees in much greater numbers than tenants.<sup>7</sup> This tenure-based disparity is not limited to Milwaukee tree-planting projects. Instead, it represents a nationwide environmental justice problem that largely not being addressed.<sup>8</sup>

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## NATIONWIDE, PROXIMITY TO STREET TREES AND URBAN GREEN SPACES DISPROPORTIONATELY FAVORS HOMEOWNERS TO TENANTS AND THE WEALTHY TO THE POOR.

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Unlike homeowners, tenants have little incentive to make long-term investments that may increase property values. In fact, higher property values from tree planting may lead to higher rents. Although tenants may enjoy the benefits of trees, these effects may be less tangible than an increase in rent. Additionally, there is a tendency for low owner-occupancy and low-income areas to experience neighborhood-wide disinvestment. This occurs when property owners and tenants allow their properties to fall into disrepair, giving neighbors a lack of incentive

to maintain their properties.<sup>9</sup> As a result, neighborhoods can become barren of trees, leaving residents little motivation to start planting from scratch.

These patterns suggest that high-tenant and low-income areas should receive special attention in Providence’s tree-planting initiatives. Policy makers should not only aim to increase total tree cover in municipalities, but also focus on residential areas where trees are needed most.<sup>10</sup> These programs should consider the specific needs of tenants and the poor in setting tree-planting goals and outreach initiatives. In Providence, this could mean setting goals for both individual neighborhoods and the city to ensure an equitable, cost-effective outcome.

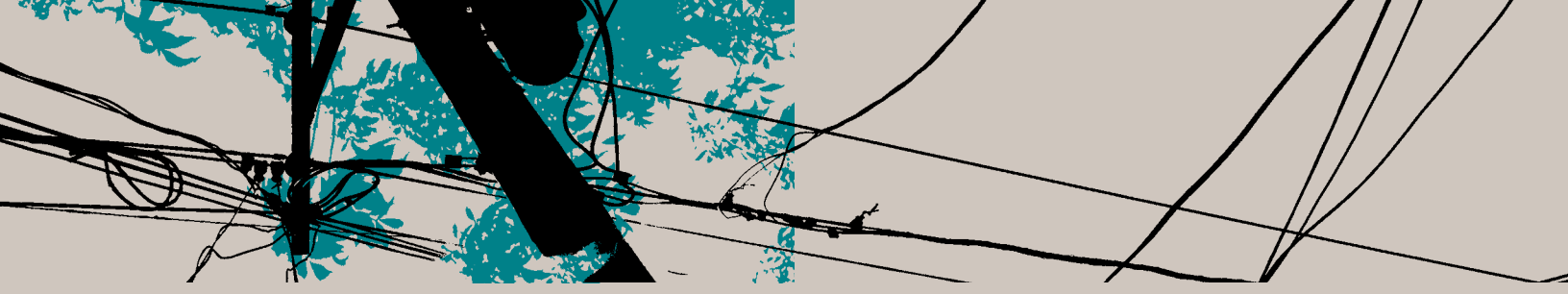
### THE OVERNIGHT PARKING BAN

“It shall be unlawful for the operator of any vehicle to park the same on any street between the hours of two o’clock a.m. and five o’clock a.m. of any day, unless such parking is permitted through a program under the direction of the Traffic Engineer.”

— Traffic Regulation #57

The Providence Traffic Engineer authorized this overnight parking regulation in 1935. While little is known of its original purpose, one thing is for certain: the ban has sparked controversy for many years. Supporters of the ban include single-family homeowners who do not want cars parked in front of their properties, firefighters and public works employees who worry that overnight parking will make maneuvering fire trucks, street sweepers, snow plows, and garbage trucks through the streets of Providence more challenging, and police officers who assert overnight parking would lead to increased cover for potential muggers and encourage dumping of stolen vehicles throughout Providence. Opponents of the ban cite the inconvenience and inequity of the regulation, and numerous residents and community groups have rallied around repealing the ban.

This parking regulation has significant implications for the fate of tree cover and other vegetation when coupled with a zoning ordinance that requires a minimum one and a half parking spaces per residence, whether it be a single-family home or multi-family apartment. Many two- and three-story homes in Providence have been converted to multi-family rental units,



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## SOME HOMEOWNERS SAY THEY WOULD DIG UP THEIR DRIVEWAYS TO CREATE LARGER YARDS IF GIVEN THE OPPORTUNITY TO LEAVE THEIR VEHICLES ELSEWHERE.

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where landlords must provide upwards of three or four parking spaces. Left with no street option, many landlords pave over front, side, and rear lawns to accommodate the parking needs of their tenants.

Some view this requirement as the root of the impervious surface problem in Providence, but Director of Current Planning Bob Azar offers a different perspective. He says that parking demand will always outpace this minimum requirement, and most landlords want a space for every bedroom of their properties. “There are some who would turn this whole city into black-top if they could,” says Azar. It is for this reason that the current street parking pilot programs in Providence might not actually lead to less lawn paving, but this largely depends on the tenancy rates in these neighborhoods. According to Yvonne J. Graf, Manager of Policy and Research at the Providence City Council, some homeowners say they would dig up their driveways to create larger yards if given the opportunity to leave their vehicles elsewhere.

In an effort to address the issue of impervious surfaces, the Providence Planning Department has imposed stricter zoning laws. These regulations include:

**1** No more than one third of a front lawn may be paved for the purposes of parking.

**2** No more than one half of a back yard may be paved for parking.

**3** No more than one side yard may be paved for parking.

**4** 30% of any lot of land must be a pervious (i.e. permeable) surface.

**5** 30% of any lot must be covered by tree canopy.

**6** Residents may not park on a portion of a lot that is not paved and property owners must install barriers between these paved and unpaved surfaces to ensure this is followed.

According to Azar, these zoning laws have improved the state of Providence properties dramatically, but there’s a catch – they only have authority over new development. All pavement already in place has been grandfathered in until a decision is made on what to do about it. “In many ways the damage has already been done,” Azar says.

These regulations are also very difficult to enforce. Though the Department of Inspection and Standards can cite violations that must be reviewed by the Zoning Board of Review, nothing can stop a property owner from paving their lawn in the short-term. When this happens, it’s up to the Zoning Board to figure out what to do, which often proves complicated.

The overnight parking ban and the zoning ordinances discussed above are topics that require further analysis from all levels of government and input from the communities and residents they affect. Some possible solutions include increasing fines and penalties for violating these zoning ordinances, imposing a maximum number of parking spaces per residence in addition to the minimum already in place, and lifting the overnight parking ban in combination with incentives for property owners to break up existing pavement and plant trees, shrubs, and grass. In addition, parking could be prohibited for three hours a week to allow for street cleaning and removal of abandoned vehicles. These and other innovative strategies may be the keys to reclaiming lawns long lost beneath the asphalt.

# COMMUNITY ATTITUDES TOWARDS TREES

## A SURVEY OF ELMWOOD RESIDENTS



A critical aspect of understanding the role of trees in Providence is assessing the attitudes and beliefs residents have about trees. To accomplish this, we drafted a formal survey with questions relating to individuals' feelings towards trees. These questions addressed opinions about both the benefits and negative aspects of trees. We distributed the survey in person to residents of the Elmwood neighborhood while carrying out informal interviews with participants. A central aim of the survey was to assess participants' desire (or lack thereof) to have more trees in their neighborhood. As such, we framed part of the survey to gauge residents' awareness of the Providence Neighborhood Planting Program, as well as their willingness to participate in a community tree planting event. What follows is a breakdown of our approach and methodology, followed by our results, conclusions, and recommendations.

### APPROACH

In order to study community attitudes about the role of trees in Providence, we narrowed the focus of this project to a single neighborhood. After consulting with Doug Still, the Providence City Forester, and assessing where trees are needed most, the team settled on the Elmwood district of Providence, an area with low tree canopy cover: 16.3% (see figure on page 13). A fundamental goal was to determine the factors that had resulted in this low tree cover and the barriers to its increase. In the process, we spoke to residents about the Providence Neighborhood Planting Program, a tree-planting partnership supported by the Providence Forestry Division and the Sharpe Street Tree Endowment. This program gives residents the opportunity to plant street trees free of charge, provided that they will help plant and care for the trees. These interviews and surveys were conducted during the first weekend of May, 2010.

### METHODS

**Participants:** Residents of the Elmwood district of Providence, RI, who answered their doors and were available and willing to be surveyed. Participation was limited to English and Spanish speaking residents.

**Materials:** A survey was developed based on similar projects done in the past,<sup>1</sup> as well as community input and recommendations. Survey questions varied in type and included yes-or-no, ranked, and open-ended questions. The survey was available in both English and Spanish.

**Procedure:** Researchers spent two weekend days surveying the district of Elmwood in a door-to-door fashion. Surveys were read aloud to respondents (unless the respondent was more comfortable filling it out) and served to initiate a guided conversation with residents. In addition to the survey itself, researchers noted prominent quotations by residents, as well as their own observations. Limitations of the survey include the small sample size of residents—only those who were available and interested in taking time to be surveyed—and the inability to speak with residents who did not speak either English or Spanish. The warm weather on the survey days could have potentially biased the results in regard to residents' perceptions of the cooling benefit of trees. In addition, opinions may vary by region of the city, and we only conducted the survey in one of Providence's 25 neighborhoods.



## MANY RESPONDENTS REMARKED THAT THEIR NEIGHBORHOOD USED TO LOOK NICER YEARS AGO BECAUSE IT HAD MORE TREES ALONG THE STREETS.

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### RESULTS

Cooling (from shade) and the aesthetic value of trees were the two benefits most commonly cited in our conversations with Elmwood residents. Most participants who had trees on or near their property mentioned the shade they provide as a key reason for keeping them. When asked about the benefits of trees, the most common first response was that “they make the neighborhood look better.”

In these discussions with Elmwood residents, a large proportion of respondents expressed unhappiness with the area in which they live. Much of this dissatisfaction seemed to stem from feelings that their neighborhood is unsafe and that residents of the same community don’t always know one another well. Many respondents remarked that their neighborhood used to look nicer years ago because it had more trees along the streets. One woman described her street when she first moved in as “an archway of trees. [The] street was like driving in the country.” When asked to identify the reasons for the loss of street trees in recent years, common responses were vandalism, disease (likely Dutch Elm Disease, which has plagued Providence for years), and a lack of upkeep by residents and by the city. One

respondent cited the area’s low revenues as a likely reason for the inaction of the city to replace these damaged and diseased trees. In her words, “the city doesn’t value poor neighborhoods like Elmwood.”

In the survey portion of the interview, residents responded that improving air quality and reducing pollution was the most important benefit of trees. Twenty of the 33 respondents cited air quality as a key benefit. Shade cover and cooling came in a close second. Rainwater absorption/reduction of flooding and increased privacy were also of interest to Elmwood residents. Most residents seemed to understand and appreciate other benefits of trees that we described, such as blocking wind, aesthetic value, and buffering noise.

Interestingly, very few people in Elmwood cited increased property values as a benefit of trees. Residents felt that this did not apply to their neighborhood. “Maybe somewhere else,” said one older woman, “but not around here.” In addition, residents raised aesthetic value as a key benefit of trees in our informal conversations, but did not rate this as important in the survey.

Through the survey we found that only 8 out of 33 respondents had heard of the Providence Neighborhood Planting Program. However, when we described the program to them briefly, many residents seemed interested, and 26 out of 33 responded that they would be interested in participating in a “one-time community tree planting event.”



Despite a general enthusiasm about trees and their benefits, a few residents were not excited about the prospect of more trees in the neighborhood. One person even shouted from the background, “No trees! Keep them in the forest!” However, residents more commonly showed general support for trees, while highlighting obstacles and problems they create. Several respondents cited the cost of trees to utilities, especially plumbing, as prohibitive. Another resident was very enthusiastic about trees, but noted that she had recently paid over \$6,000 to replace a sewer line damaged by tree roots.

Though few people seemed know the concrete cost of planting a tree, we perceived that cost would be prohibitive and that residents would not be interested in paying several hundred dollars for one tree. One respondent noted, “I think the city should take care of them, it shouldn’t be left to homeowners.”

In answer to the survey question, “Why do you think there aren’t more trees in your neighborhood?”, several said that even though they themselves wouldn’t mind them, other people wouldn’t be interested. General impressions of the neighborhood seemed to be linked to the idea that people wouldn’t want or take care of trees: “No one takes care of the neighborhood around here.”

## CONCLUSION

Overall, survey participants indicated strong interest in increasing the number of trees in Elmwood. Although the sample size was small, the surveys showed the potential of outreach initiatives to increase awareness of tree benefits. This suggests that it would be valuable to conduct similar surveys in other neighborhoods. The surveys may also help establish an initial relationship between Elmwood residents and the Providence Neighborhood Planting Program (PNPP). Lacking community awareness of the program highlighted the disconnect between the PNPP and Elmwood.

To be successful, it appears that the PNPP must overcome a number of obstacles in order to strengthen its relationship with Elmwood and other neighborhoods in Providence. As discussed in the previous section, trees and other urban amenities are often less common in lower-income and renter-dominated areas. The reasons for this are complex and related to a lack of incentive and inadequate resources to invest in these services. Planting new trees alone may not be successful in the long-term; the City of Providence and PNPP must also address social justice problems that underlay the inequality in tree cover. It was apparent from our surveys that participants feel the city pays insufficient attention to them. This shows that Providence has a long way to go in addressing the needs of Elmwood residents, but also that there is a lot of room for positive growth. We found the residents to be very open to greater tree planting, and we believe the potential benefits for Elmwood and other neighborhoods are great.

# URBAN FOREST POLICY IN PROVIDENCE

## AN EVALUATION OF THE CURRENT TREE-PLANTING PROGRAM AND POTENTIAL FUNDING SOURCES



Urban trees provide a number of public services including reducing the heat island effect, improving air and water quality, carbon sequestration, lowering energy bills, increasing property values, and decreasing storm water runoff. These services not only improve the quality of life for Providence residents — they are valued at \$2.9 million annually and represent a vital economic asset to the city. The City of Providence currently has two programs it uses to promote tree-planting: the Providence Neighborhood Planting Program (PNPP) and *Trees 2020*. Established in 1988, the PNPP is an ongoing program to plant and maintain street trees, funded by the Mary Elizabeth Sharpe Street Endowment and the City of Providence. This program grants street trees to Providence residents free of charge, provided that they help to plant and care for them. The *Trees 2020* program also supports tree planting in Providence, but focuses on yards and private property. This initiative was launched in 2008 by the City of Providence and Groundwork Providence and aims to achieve 30% tree canopy cover by 2020. This will require planting 40,000 trees in total, approximately 3,333 per year or 2.5 times the former planting rate. This section will review these programs in more detail, describe similar initiatives in other cities, and offer promising policy strategies to make the goals of *Trees 2020* a reality.

### CURRENT PLANTING STRATEGIES

The PNPP and *Trees 2020* use somewhat different approaches to promote tree-planting in Providence. The PNPP assists residents in planting street trees — the trees on the city-owned space between the sidewalk and the street. Residents or neighborhood groups can apply for these trees through the program at no cost. At least five property owners must participate in a request, and they must jointly ask for a minimum of five trees. Participants agree to care for the trees, but in turn the PNPP covers the cost of tree installation, which includes cutting the sidewalk concrete, removing the existing soil, and replacing it with fresh soil. The PNPP plants an average of 400-450 trees per year.

In contrast, *Trees 2020* encourages planting by offering heavily discounted trees to homeowners to plant on private property. The city does this by buying trees in bulk from nurseries, then further subsidizing the price for Providence residents with the help of grants. Residents can choose from a selection of dozens of trees with costs ranging from \$45 to \$85 per tree. As part of the purchase, the *Trees 2020* Tree Team will visit the homeowner's property to help them choose an appropriate tree and teach them to plant it correctly. In return for the up-front price reduction, residents commit to maintaining the trees so that their full environmental and social benefits can be realized. Unfortunately, funding constraints have limited the city to planting only 1,100 trees per year, which falls significantly under the program's goal of 3,333 trees per year. Later in the section, we discuss external funding sources that can help Providence achieve this goal.

# FUNDING CONSTRAINTS HAVE LIMITED THE CITY TO PLANTING ONLY 1,100 TREES PER YEAR, WHICH FALLS SIGNIFICANTLY UNDER THE 3,333 TREES PER YEAR GOAL LISTED IN *TREES 2020*.



## CASE STUDIES

Case studies of successful policies implemented in other cities around the United States can inform policy recommendations for Providence. The following examples include interesting management tools and policies that could be applied here.

In 2007, New York City unveiled PlaNYC, a plan to create “a greener, greater New York,” that contains a number of tree-related strategies. Under this plan, the city aims to fill every possible street tree spot by 2030 by planting a total of one million trees. To put this goal in perspective, only 74% of existing spots are currently filled.<sup>1</sup> In order to make this happen, the municipal government will revise current zoning codes to require new construction and major redevelopment projects to plant one street tree for every 25 feet of street frontage.<sup>2</sup> Through this zoning law, PlaNYC expects private development and major capital construction projects to plant a total of approximately 7,000 new trees each year.<sup>3</sup> To supplement this, the city government will plant 12,500 trees at an annual cost of \$17 million dollars, prioritizing neighborhoods with poorer air quality and lower stocking levels.<sup>4</sup> In addition to increased street trees, PlaNYC plans to reforest approximately 2,000 acres of parkland by 2017 as a part of their goal to achieve better air quality within the city.<sup>5</sup> They will also increase tree plantings in unused lots, a recommendation that the following case study used as well.

Another relevant study took place nearby in Brooklyn. David Nowak, Project Leader/Research Forester for the United States Department of Agriculture Forest Service, conducted a study of Brooklyn’s Urban Forest. After an in-depth analysis of the trees themselves, he presented a set of management recommendations that could also apply to Providence’s urban forest. For instance, he pointed out that the more fossil fuel-intensive the initial planting and maintenance of a tree is, the longer that individual tree must survive in order to offset its greenhouse gas emissions.<sup>6</sup> As it stands, tree maintenance requires extensive use of shredders, chippers, chain saws, leaf blowers, and vehicles to transport new trees. For this reason, new urban forest management policies in Providence should emphasize a reduction of fossil fuel use in maintenance. In addition, Nowak recommends planting trees strategically around buildings in order to increase energy conservation, another strategy that could be implemented in Providence. Nowak also explained the important potential of vacant lots and unused spaces in the urban environment for cost-efficient increases in tree cover. Policies such as limiting the mowing of unused lots could increase tree cover over large areas at very little expense.

Washington D.C. provides another example of tree policy reform. In 1999, a nonprofit conservation group called American Forests released a report that indicated a 64% loss of tree cover in Washington D.C since 1973.<sup>7</sup> In response to this information, the D.C. Council established the Urban Forest Preservation Act (UFPA) in 2001. The UFPA protects city trees by making it illegal for any person to cut down, remove, girdle, break, top, or destroy any tree over a diameter of 17.5 inches on either public or private property.<sup>8</sup> If someone violates the UFPA, they are



subject to a fine no less than \$5,500 at \$100 per inch of circumference.<sup>9</sup> However, individuals may apply for a permit to remove a tree if they can prove it is a hazard or a pest. The person must then agree to plant a replacement or pay money into the “Tree Fund”, which is used to maintain D.C.’s urban forest. The UFPA presents a solid piece of legislation that Providence could potentially draw from to develop its urban tree canopy.

### POTENTIAL POLICY TRACKS

We are aware of the severe financial challenges that Providence and the State of Rhode Island face, and have therefore sought to identify funding sources for tree-planting projects. There are a variety of potential funding opportunities available to the city, state, or private entities that could help Providence meet its goal of planting 3,333 trees per year. The most promising option for the city may be to apply for funds under the Cooperative Forestry Assistance Act of 1978, Title 16, Part 2105, Section 9, Public Law 95-313, 92 Stat. 365. This act established the Department of Agriculture’s Urban and Community Forestry Program, which coordinates local initiatives and provides resources for community planting efforts. This program allocates approximately one million dollars annually to State Foresters or equivalent State agencies, NGOs, interested members of the public, and others. Another direct option may be the general funds available for “Green Projects” under the 2009 American Recovery and Reinvestment Act. Tree planting may qualify for funding under the following ARRA categories: “Energy Efficiency Projects,” “Green Design Projects,” or potentially “Environmentally Innovative Projects.” In addition, if a program can create or improve wildlife habitats, it may qualify for federal assistance through the Wildlife Habitat Incentive Program under USDA’s Natural Resource Conservation Service (NRCS).

## A SURPRISING NUMBER OF FUNDING SOURCES COULD BOOST TREE PLANTING:

Cooperative Forestry Act of 1978

American Recovery and Reinvestment Act of 2009

Wildlife Habitat Incentive Program

USDA Natural Resource Conservation Service

Clean Water State Revolving Fund

Clean Water Act & 1987 Amendments

CWA Section 320: National Estuary Program

NRCS Emergency Watershed Protection Program

American Heritage Rivers Initiative

Carbon Offset Programs

Compliance with EPA implemented standards

Home Depot “Building Healthy Communities Grant Program”

Office of Energy Efficiency and Renewable Energy financial assistance programs

Enterprise Green Communities

“Local Government Commission” related to Green Building



## WE ARE AWARE OF THE SEVERE FINANCIAL DIFFICULTIES IN PROVIDENCE AND RHODE ISLAND, AND SO HAVE SOUGHT TO IDENTIFY FEDERAL AND OTHER FUNDING SOURCES.

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### WATER QUALITY

Many of the rivers and streams running through Providence are bound by cement banks. Removing cement walls and establishing thriving greenways through tree installation may help to curb non-point source pollution, decrease flooding, and provide erosion control in riparian zones. Providence has already started this process through in the Woonasquatucket River Greenway Project. The city may choose to fund additional tree-planting projects related to waterways by tapping into the Clean Water State Revolving Fund (CWSRF), created under Title VI in the 1987 Amendments to the Clean Water Act. One important option under this fund is the Implementation of Non-Point Source Projects, Clean Water Act Section 319 (h) Grants program, which allocates over \$100 million for watershed-based projects that curb non-point source pollutants from entering impaired river systems. Either the Rhode Island State Government or a private entity may apply to this program to receive funding for tree planting project along Providence waterways.

In addition, the city may borrow funds from the National Estuary Program if it seeks to plant trees along its coastline. If trees bordering a watershed are damaged during an emergency, such as in the devastating Rhode Island floods of March 2010, the city may apply for restoration funding

through the NRCS Emergency Watershed Protection Program. This program offers to cover up to 75% of projects such as tree-planting that prevent erosion and runoff on public and private lands. In addition, there are funds available for bank restoration under the American Heritage Rivers initiative, which Bill Clinton created under Executive Order 13061. The Blackstone and Woonasquatucket rivers, which run through Providence, are designated as two of the nation's fourteen American Heritage Rivers and therefore qualify for funding for environmental remediation projects that involve tree planting. The Woonasquatucket River Watershed Council and the Blackstone River Watershed Council have been working on restoration projects along the banks for years, yet more funds may be available to them through Clinton's Executive Order for stretches of the river that are currently underutilized.

### AIR QUALITY

According to the 2008 State of Providence's Urban Forest Report, street trees absorb 29 tons of pollution and prevent 12 tons of pollution each year, producing a net \$194,334 in yearly air quality benefits. Planting trees in Providence will improve the health of its citizens while bringing the city closer to meeting federal Clean Air Act standards for hazardous air pollutants. In addition, planting urban street trees can also be part of a



carbon-offset program to reduce green house gas (GHG) emissions when federal climate policy is established. However, this may not be the most efficient solution because it requires proving that trees planted are “new and additional,” which is a difficult process that will require monitoring and accurate record-keeping. The Massachusetts vs. EPA (2007) decision gives the EPA the authority to regulate GHG’s as hazardous air pollutants. Therefore, planting trees will help Providence comply with GHG standards if implemented by the EPA. Additionally, Rhode Island has committed to the Regional Greenhouse Gas Initiative for which 10 mid-Atlantic and northeast states have agreed to cap CO<sub>2</sub> emissions and reduce them 10% by 2018, a goal that planting trees will help to reach.

### **ENERGY AND GREEN BUILDINGS**

Because trees help reduce energy use in buildings, there are a number of funding options related to building efficiency available to the city. First, the Home Depot “Building Healthy Communities Grant Program” offers 501(c)(3) organizations, public schools, and tax-exempt public service agencies grants of \$2,500 towards the purchase of Home Depot tools and materials for green community improvement projects, which includes planting of native trees. Second, if a Government agency, non-governmental organization or busi-

ness is able to show significant energy reductions through tree planting, competitive grants and cooperative agreements may be available through the Office of Energy Efficiency and Renewable Energy (EERE) financial assistance programs. Third, in the context of Providence’s low-income housing projects, developers may apply for grants, tax-credit equity, and technical assistance from the private-venture Enterprise Green Communities if the project incorporates energy-reducing technologies such as tree planting in the building design. Lastly, there are a variety of funds available for planting through the “Local Government Commission” related to Green Building.

# RECOMMENDATIONS FOR THE CITY

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## 1 PRIORITIZE TREE-PLANTING IN STRATEGIC AREAS

- Focus efforts in low-income communities that lack trees and green space
- Plant trees around buildings to increase energy conservation
- Redevelop vacant lots and unused land into greenways
- Promote vegetation and wetlands along key waterways

## 2 CREATE A CITIZEN EDUCATION CAMPAIGN

- Spread awareness of the Providence Neighborhood Planting Program Trees 2020, and other tree-planting resources available to residents
- Develop and distribute educational materials about the benefits of trees for Providence communities

## 3 EMPLOY COST-REDUCING STRATEGIES FOR PLANTING

- Establish a Providence volunteer tree-planting corps
- Expand school programs for planting trees
- Select species to minimize risk of tree roots damaging sewer lines.

## 4 INCREASE THE LAND AREA AVAILABLE FOR TREE PLANTING

- Remove the nighttime parking ban to promote redevelopment of parking areas to yards and green space

## 5 TAKE ADVANTAGE OF POTENTIAL FUNDING OPPORTUNITIES

(see previous section for list and descriptions of funding sources)

## 6 INVEST IN SOCIAL JUSTICE INITIATIVES IN PROVIDENCE COMMUNITIES

- Support programs that address the social inequities at the root of disparities in tree-cover

## 7 INCENTIVIZE PLANTING AND TREE-MAINTENANCE PRACTICES

- Limit mowing of unused lots to allow for increased natural tree cover
- Prohibit cutting down or destroying trees of a particular size on public or private property
- Explore cost-sharing options for damage caused by public trees
- Reduce fossil fuel emissions associated with tree-planting and maintenance by using more efficient machinery and hand labor

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**TREES AND THE  
URBAN HEAT ISLAND EFFECT:**

**A CASE STUDY FOR PROVIDENCE RHODE ISLAND**

Brown University Center for  
Environmental Studies

Analysis and Resolution of  
Environmental Problems  
& Case Studies

Design by Cameron Neat

Photograph page 19:  
by Lindsay Kinkade,  
Neighbors dig a hole for a new  
street tree near Broadway in  
spring of 2009 as part of the  
Providence Neighborhood  
Planting Program.