oUR Air:

Determining Ideal Locations for Tree Planting in Richmond, VA in Order to Deter Inequalities in Temperature

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Abstract

With the ever increasing effects of climate change, it is pertinent that an effective, efficient, and economic solution be reached in order to mitigate the extremity of urban heat islands. Since heat can contribute to a variety of health problems, it is very important that the unequal distribution of heat be minimized in order to promote the equal well-being within a city. One substantial and popular method of doing so is through the planting of trees, as there is research done to show that they reduce air pollution on top of reducing overall surface temperatures. This paper explores how and where tree planting will be most productive at limiting temperature inequalities within the city of Richmond by looking at various factors such as tree coverage, population density, and various social factors such as average income and race. I will also conduct research into how tree planting endeavors currently proceed in the city. Ultimately, this paper concludes that Census Tract 204 in the East End and Census Tract 608 in the West End would most benefit from an increased number of trees. At the end of the paper, I will also discuss various recommendations for how tree planting might be improved within the city of Richmond, including increased maintenance, education, and privatization of tree planting.

1. Introduction

Within urban areas throughout the world, extreme differences in temperature are prevalent. The neighborhoods that the upper-middle class and wealthy individuals live in are oftentimes tens of degrees cooler than the more urban, industrialized, areas where less privileged communities live (Jin et al, 2020). This is particularly concerning, as heat can contribute to a variety of health related issues, such as hypertension which can lead to serious heart problems (Wright et al, 2019). These issues are also the most severe for individuals 85 years and older, which is especially concerning as these groups already suffer from other health issues (Benmarhnia et al, 2015). Research has also shown that heat can result in an overall increase in mortality rates with 12,000 deaths being attributed to heat related issues in the decade with a 95% confidence interval (Shindell et. al, 2020). Another significant issue to consider is that heat can exacerbate the effects of air pollution, making the problem especially concerning in urban areas which tend to have worse pollution than more rural or suburban areas (Lai et al, 2010). In this study, researchers concluded that the convergence of air pollutants and the urban heat island effect results in higher hospital admissions for respiratory issues. Excessive heat can also have extremely negative effects on mental health, therefore disrupting the optimism and productivity of a given community (Lohmus, 2018).

There are also social issues associated with heat. According to a study conducted by Taelaei et al, incidences of rage and psychiatric admission increase with increased levels of heat (Talaei et al, 2014). Further, in the United States, urban heat islands often exist in neighborhoods where the majority of the residents are minorities, which is largely due to historical redlining in the areas (Hoffman et al., 2020). Redlining is the practice of refusing a service to an individual strictly based on whether they reside in an area that is classified a certain way (Squires et al, 2017). This is particularly concerning as these groups already suffer the most from low-incomes and lack of opportunity. Consequently, these urban heat-island's serve to exacerbate social and economic inequalities that already persist in cities.

Given the health and well-being disparities which can persist in cities due to urban heat islands, it is crucial that city governments and communities develop strategies to minimize heat differences. Not only does no individual deserve to suffer more than another for something that is out of their control, but also equality within cities serves to strengthen the community. Further, it is worthy of note that this issue is pertinent, as climate change and a general global heating will result in increased inequalities in cities (Sharma et al., 2018).

One of the most commonly used methods of reducing this heat effect in cities is through tree planting. Not only do trees serve to cool areas through evapotranspiration and reducing the light radiation, but they also can help limit air pollution and lower the prevalence of asthma (Lovasi et al. 2008). This is because urban trees work to facilitate the deposition of gasses and particulates (Grote et al, 2016). Additionally, there are certain types of trees with smaller leaves, such as the Juniperus chinensis L., which are best equipped to deter air pollution in a city (Weerakkody et al. 2018). Greenspaces and trees can also lower stress levels in a given area (Roe et al, 2013). Trees promote the beauty of an area. This is largely the reason why wealthy neighborhoods often are in the neighborhoods with greater tree coverage. Lastly, trees are an ideal method of deterring the urban heat island effect, as their planting benefits everybody, making it an easy endeavor to be government funded.

However, when planting trees within vulnerable areas, it is important to assess the community opinion on the project to ensure that the plantings are not merely performative, but rather an act that will be appreciated and approved by those that will benefit from the plantings. Past tree plantings in the past have demonstrated that a lack of communication with communities can result in a distaste for future plantings. Community members often complain about maintenance, as they are forced to deal with tree planting issues, such as fallen branches that may cause power outages and other problems which are expensive and tedious to deal with (Carmichael et al., 2018). Lastly, increased number of trees and greenspaces can oftentimes result in accelerated gentrification within neighborhoods. This can displace already vulnerable populations and make way for millennials who want to live in “historic” areas (Rigilon et al, 2018). Therefore, an intensive look into the specific community is pertinent in determining where trees should be planted.

An additional issue with planting trees, is that oftentimes the areas that are in the most need of trees are in areas where there is no room to plant due to large areas of paved and impermeable surfaces. Additionally, there are often not open public spaces to plant trees, as parks are often limited in urban areas. Given these issues, scholars and urban planners often argue for the implementation of living walls as an alternative to planting whole trees.

The city of Richmond, VA suffers considerably from the urban heat island effect. This has been demonstrated through numerous studies conducted throughout the city mapping the temperature differences (Saverino et al. 2021). These maps show that there can be up to a 16 degree temperature difference in different parts of the city at the exact same time of day (Hoffman et al., 2021). These temperature differences are visualized on Figure 1 (Figure 1). This is particularly

concerning, as Richmond, Virginia is a very hot city and can experience about 43 days per year with temperatures that are at least 90 degrees throughout the city (Griggs, 2018).

Additionally, Richmond is one of the worst cities in the country for individuals who suffer from asthma, and increased heat serves to aggravate these issues (Everhart et al., 2020). Additionally, the areas in the city which are reported to have the highest temperatures, are in the historically redlined districts, making the issue especially pertinent to address in order to establish greater equality within the city. Therefore, in order to reduce health and racial inequities in the city, there must be concrete efforts made to lower temperatures in vulnerable parts of the city.

In this paper, I will specifically address the urban heat island effect in Richmond, VA. I will use map data and research into the population, race, and income of communities in order to determine the ideal places to plant trees within the city. I hypothesize that the areas in most need of tree plantings will be in the neighborhoods which have high population densities, high minority population, and very low income in comparison to the rest of the city.

2. Methodology

2.1 Further Background on the City of Richmond

Richmond is the capital of Virginia and the fourth largest city in the commonwealth. Since it was incorporated in 1871, the city has come to be known for its beautiful views of the James River, and rich history. However, Richmond suffers considerably from racial inequality and segregation, largely influenced by former redlining in the city. This redlining resulted in blocked investment to Black neighborhoods (Broady, 2021). Figure 1 represents how the city was originally redlined. Due to this lack of investment, these areas of the city struggled from serious environmental justice issues, including increased levels of air pollutants and, as stated earlier, hotter temperatures. These areas also have a lot of asphalt and often have highways running through them, which increases the albedo effect.

Another troubling fact to note about the city of Richmond is that according to RVAgreen, the city's climate action plan, only 6% of the City's land is used for parks and recreation, as opposed to the national average of 15% (Dean, 2020). This is particularly concerning given the natural beauty that the city possesses and the fact that children and families should be able to have access to a safe and comfortable environment to play and explore.

2.2 Commentary on Geospatial Analysis of the city of Richmond

The inequalities that persist in Richmond are easily identifiable through spatial data. In addition to the heat map that I included in the introduction, it is also beneficial to analyze a tree coverage map in order to confirm that there is a correlation between tree density and temperature. The tree data that I am using comes from the NLCD canopy cover, which is a 30 m raster dataset.
I also looked at a "real-time" inventory of trees within the city of Richmond that was supposedly last updated March 9, 2022. It accounts for the address and species of each tree. However, it is worth noting that this data is merely an estimate of tree coverage in specific areas. Some of the tree maps that I looked at appeared to have entire neighborhoods in which there were no trees. When I went on Google Maps, I found that there were less trees in these areas, but still a decent number of trees that remained unaccounted for. This inaccuracy in the data demonstrates a notable flaw for determining tree plantings, but can be resolved by directly looking at specific neighborhoods.

2.3 Current Community Planting Endeavors

There are various tree-planting programs throughout the city of Richmond. These organizations provide volunteers to plant trees in designated parts of the city. Some of these organizations are ReForest Richmond, Richmond Trees, and Friends of James River. These organizations work with city officials and to receive funds for buying necessary tools for planting the trees, as well as purchasing the trees themselves. There is currently a grant program where up to $15,000 worth of funds can be given toward a specific planting project. Some of the locations where trees have been planted recently include the Jackson Ward neighborhood, Battery Park, and the property surrounding the Science Museum of Virginia. These tree plantings typically occur between early spring and late fall as this is the ideal time to plant trees. The majority of these tree planting projects occur on public property, as the process of planting on private property serves to be substantially more complicated, as volunteers would have to work together with landowners.

However, there are also ways that individuals can plant their own trees if they apply for a permit by filling out the address of where you would like to plant the tree, as well as the proposed species. There is also a map available online which demonstrates the locations where wells exist so that residents know where they are eligible to plant. Lastly, there are "Adopt-A-Tree" programs which allow an individual to pay $50 to have a tree planted for them. The rest of the funding to plant the rich is provided by the government. However, for both of these programs, the planter of the tree must agree to water the tree twice a day for the first two years and do all of the diligence to ensure that it has the tree survives being a sapling (Tree Resources-Enrichmond).

Since these programs require the planter or the sponsor to return to the area continuously after the first planting, it is implied that most of the people who want to plant trees through this process are living very close to where the tree is being planted.

Lastly, Richmond has worked to implement community gardens in the Southside of Richmond which currently struggles with urban heat issues. This garden has allowed not only for a general cooling of the area, but also increased the general wellbeing of residents as they have a safe area to interact and get in touch with nature. In 2020, projects such as this one were set to increase, as the Mayor announced that he will be putting in intensive efforts into ensuring that all residents of Richmond live within 10 minutes of a public park (*Announcing the City of Richmond's Green Team*, 2020)

3. Results

Upon looking at the heat, tree coverage, and social dynamics within the city of Richmond, I concluded that there are three census tracts that are in the most need of tree planting. Table 1 represents these areas and their respective average temperature on a given day in Richmond and average percent tree cover (Table 1).

In each of these areas, there are specific public areas that are most in need of tree planting. Census Tract 204 has a population density of 6,520.5 and 50.5% of people living below the poverty line, which is more than double the rate in the entirety of Richmond (Census Profile: Census Tract 204). Additionally, this area has a percent white population that is less than 20%. The area surrounding Luck Field and Martin Luther King Jr. Middle School are identified as the ideal places to plant trees. This census tract poses to be an especially important place to plant trees, as it is the location of Mosby Court, a housing project which is home to a high population of children and families that would benefit from increased tree coverage. Further, the areas between the various apartments that make up the housing projects would also serve as a good place to plant trees. Figure 2 spatially demonstrates the low tree coverage in the area (Figure 2). In the future, these areas could be recommended to the Heat Watch grant program, so that heat might be reduced in these parts of the city. Additionally, volunteers could aid tree planting activities in this area, as there are open tree wells.

The other census tract that I decided to look at is Census Tract 608. According to 2020 census data, this part of the city has 1,281.5 people per square mile and a per capita income of $13,013 which is about one-third of that of the entirety of the Richmond community. The area that I

found would be most beneficial for planting trees is along Interstate 95. Planting trees here would not only serve to lower temperatures in the areas, but also shield the neighborhood from the harsh sounds, pollution, and make the area prettier for its residents. There are also many large vacant tree wells in this area of the city. Further, since these trees would be beneficial for reducing air pollution from the interstate, it would be best if they were small-leafed pine trees, as I discussed in the intro that these trees are the best at limiting the dispersion of air pollutants.

Given the temperatures and tree coverages of the worst-off neighborhoods, it is interesting to note the contrast that exists between these and the cities that suffer the least from the urban heat island effect. This is demonstrated through Table 2. While the temperatures may not seem that different on the surface, it is significant to note that the risk of dying increases by 2.5 percent with every one degree increase in temperature (Brook et al, 2011).

In addition to being less hot due to increased tree coverage, these parts of the city also have significantly higher average incomes, with the median household income being $250,001 and a white population of 92.7%. Overall, analysis of the various census tracts demonstrates that there is a correlation between income level and canopy cover.

4. Discussion & Conclusions

4.1: Recommendations

Upon analyzing the urban heat islands and community efforts to minimize it, there are some recommendations that I would like to propose regarding its execution in order to make the efforts more effective and efficient.

First, upon looking at the various programs available to help plant trees, I found that most of them required some sort of additional cost, whether it be the actual buying of the tree, or the donation of $50 to have the tree planted for you. Given the fact that the areas most in need of trees are in the lower income areas, it is unlikely that they will have the extra money available to plant a tree. Additionally, if one wanted to have a tree planted, they had to complete regular maintenance and checking up on trees in order to ensure that there are no flaws in the growing process. The individuals living in these communities probably also lack the spare time, or motivation, to spend any substantial amount of time watering and monitoring the progress of a tree’s growth.

Due to the financial and time constraints of planting their own trees, the individuals in these neighborhoods rely upon the tree plantings that are carried out by federal grant programs and volunteers. However, the issue with these plantings is that they often do not take into account the preferences of the people that actually live in the communities. Furthermore, if these individuals do not want the trees planted in their backyards, then it will be exceptionally frustrating and difficult for them to have to deal with the maintenance and dealing with damages that might occur after the trees are fully grown. While tree trimming does not necessarily occur on a very regular basis, it still costs on average $460 per tree (Lovely, 2022). Given these costs, and the inability for communities to afford or keep up with them, a large portion of tree planting grants should go toward ensuring that the trees planted are properly maintained. This will allow for the communities to better appreciate the trees being planted in their areas, as well as ensure that the tree plantings are not merely performative.

Additionally, there needs to be efforts to educate community members, particularly youth, on the importance of tree planting. I believe teaching youth, particularly those in late elementary school and middle school, is the best way to make sure tree planting is successful. This is because this age group likely has the most time on their hands and optimism toward improving their community. Also, they will have the most time with the newly planted trees, as adults might be less invested in tree planting since they on average take around 10 years to grow and make any substantial improvements to the communities heat or beauty (*How Long Does it Take for a Tree to Grow*). The importance of tree planting could be taught in the local public schools or through government funded summer camps. Additionally, these classes could also involve hands-on learning where students actually go out into their neighborhoods to plant trees. This would help people both to be more motivated to plant trees, as well as develop a deeper connection with them. These educational programs could even provide extra credit for students who document the planting of their trees.

My final education recommendation is that students at the University of Richmond and Virginia Commonwealth University could work with these programs as volunteers. In addition to these universities establishing closer communal relationships, college students would be good role models for children in underprivileged communities. At the University of Richmond, these programs could be run through a collaboration of the Bonner Center for Civic Engagement and the Office of Sustainability. Since the University of Richmond in particular serves to be representative as both a mecca for the rich and privileged in the Richmond area, as well as exists in one of the areas with the highest tree coverage, it would be fitting for Richmond students to engage in communities that exist in urban heat islands.

I also think that tree planting would be improved if there were increased privatization of the plantings. Currently, the majority of tree planting endeavors are merely for public property. However, there is definitely space in people's front and backyards that would benefit from tree planting. This might be done by starting a program where employees from the Department of Forestry or nonprofit organizations might check out people's private land to see if it might be suitable for tree planting and what species would be most beneficial. Additionally, there might be certain stipends granted by the government if private property owners choose to plant trees on their property. This would inspire those who do have the funds to have more motivation to plant trees.

4.2: Concluding Remarks

In conclusion, while tree planting endeavors have demonstrated a lot of success within Richmond, there is always room for improvement to ensure that efforts are carried out the most efficiently and effectively. Ultimately, tree planting has the potential to at least provide some way of decreasing the inequality within the city and bringing communities closer together. With the community and local government's interest and involvement in tree planting endeavors in the city of Richmond, there is no doubt that the planting of trees will progress throughout the coming years.

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Figures and Tables
(Listed in Order of Appearance)

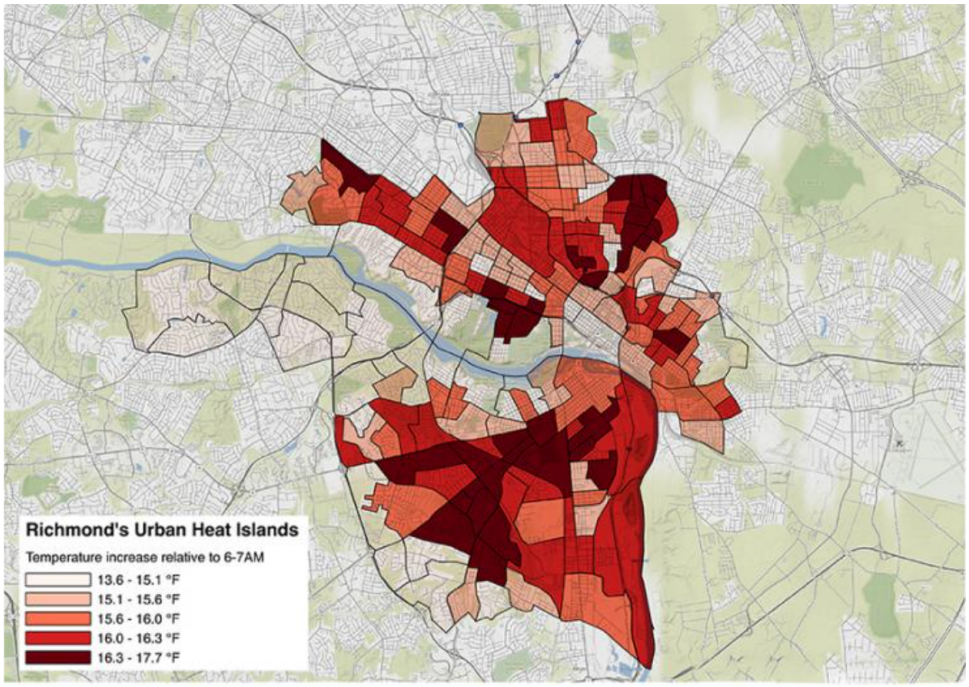

Figure 1: Spatial representation of temperature differences between different census tracts in the city of Richmond

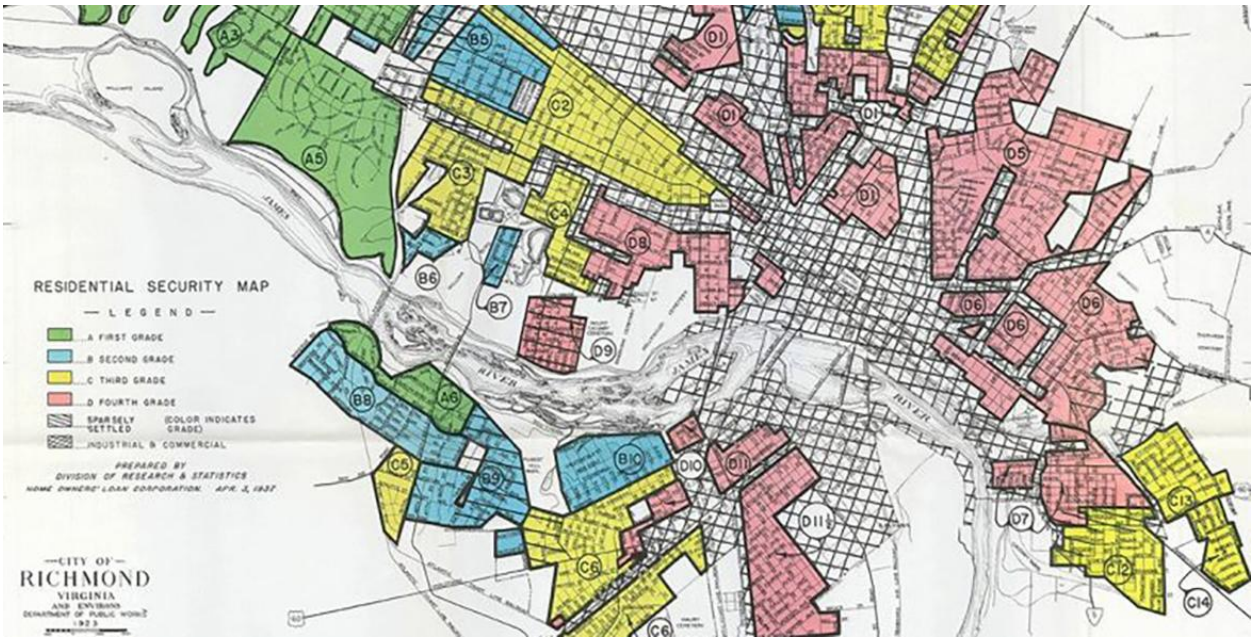

Figure 2: This map depicts the census supposed risks of various Richmond neighborhoods, with the green neighborhoods being the least risky and the red neighborhoods being the most (Long, 2021).

Table 1: Represents census tracts within the city of Richmond which exhibit the most need for tree planting given the average afternoon temperature and the Average % Tree Canopy Cover

Census Tract	Region/ Neighborhood	Avg Afternoon Temp (F)	Avg % Tree Canopy Cover
204	Mosby Court, Whitcomb	91.24	10.51
608	US Route 1/301 Corridor	91.37	10.41

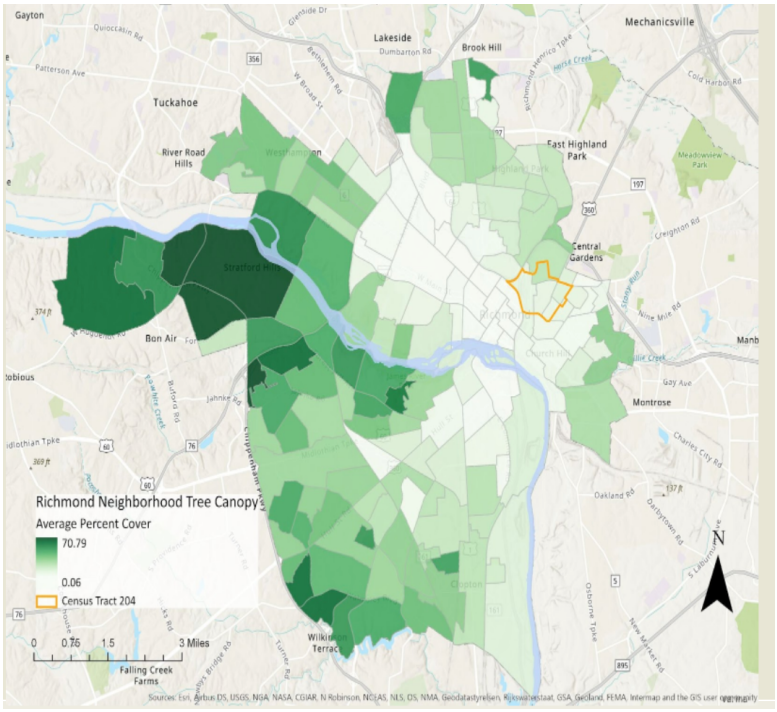

Figure 2: Richmond neighborhood tree canopy cover, with Richmond census tract 204 highlighted.

Table 2: Temperature and tree cover in the more cool areas of Richmond.

Census Tract	Region/Neighborhood	Avg Afternoon Temp	Avg % Tree Canopy Cover
506	Near West End	89.76	43.40
416	Maymont	89.79	20.08