

# To Combat Gun Violence, Green the Neighborhood

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## Objective

The impact of green spaces on community safety remains a topic of debate. While some studies suggest that green spaces can lead to reduced crime rates by fostering community connections and positive sentiments, others argue that green spaces may also become sites of conflicts and potential safety concerns.

Washington D.C. presents a conundrum along the debate of green spaces and community safety. As shown in [figure 1](#), which displays distributions of tree equity scores across U.S. states, D.C. exhibits comparatively high levels of tree equity. Moreover, urban parks in D.C. are of exceptional quality as demonstrated in [figure 2](#), which highlights the positive feedback received from visitors.

Despite the government's commendable efforts in ensuring equitable access to green space, DC still has the highest homicide rate among all states. This raises questions about the extent to which and how provision of green spaces has improved public safety in the city.

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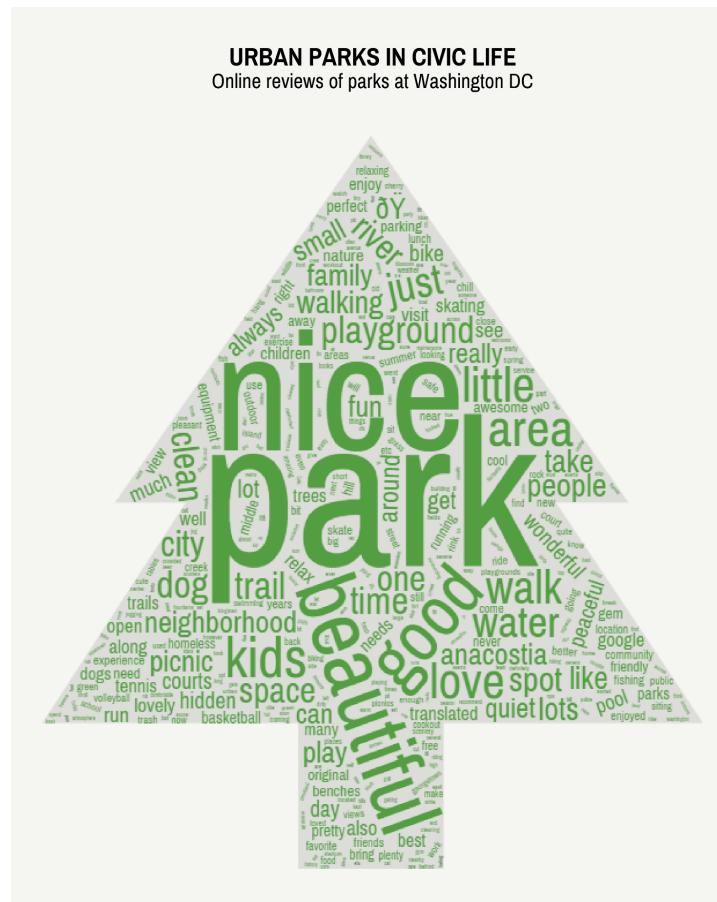
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## ACCESS TO GREEN SPACE

Distribution of tree equity scores across census blocks in the US



**Figure 1:** Distribution of Tree Equity Scores across Census Blocks for each U.S. State



**Figure 2:** Word cloud of online reviews of urban Parks in Washington D.C.

## Research Questions

This project aims to address the following questions.

- How does green space affect gun violence in Washington DC, especially on subgroups of the population who have been historically marginalized?
  - What attributes of green space matter in reducing gun violence?

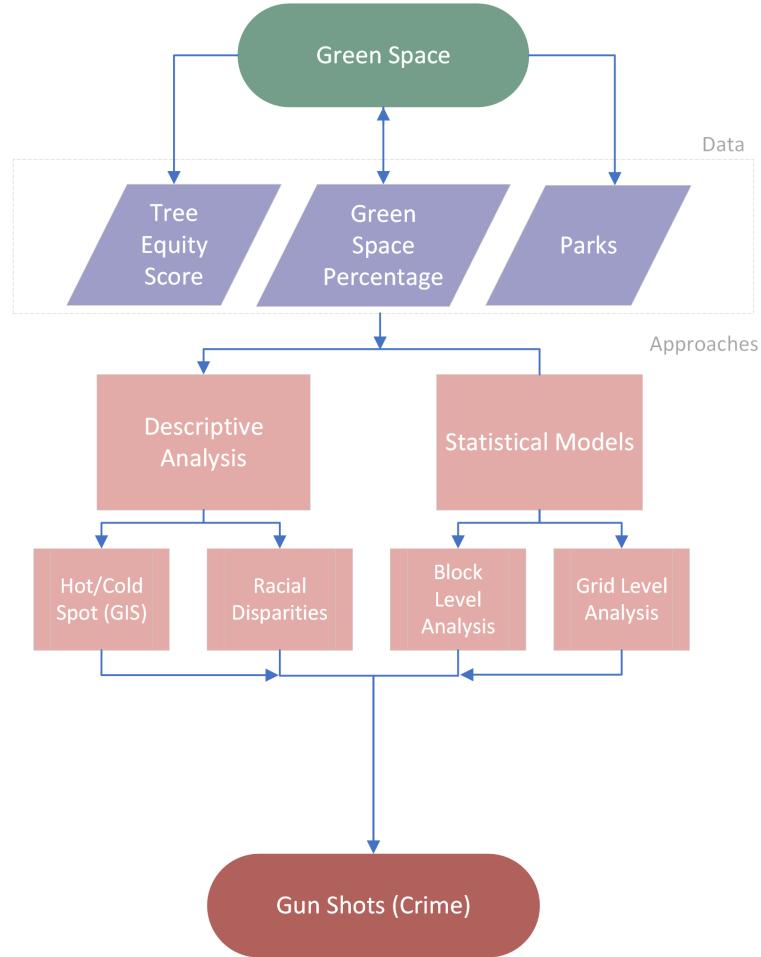
The following sections will discuss our [analytical approaches](#), [key findings](#), and [conclusion](#).

For a more interactive reading experience, we encourage readers to visit

<https://arcg.is/1evv1yo> to explore our story map.

## Analytic Approach

We operationalized the key variable of interest, green space, into three metrics: tree equity score, the percentage of green space, and attributes of parks. Our analysis was organized into two phases: descriptive analysis and statistical modeling, as illustrated in the chart below.



**Figure 3:** Data Processing Flow Chart

To visually display the distribution of gunshots in DC, we adopted the Hot/Cold Spot Analysis in ArcGIS which identifies spatial clusters of high values (hot spots) and low values (cold spots) to help uncover point distribution patterns. Next, we compared potential differences in gun violence exposure across different racial communities to decide whether

communities of color are affected disproportionately and inform us of the following statistical models.

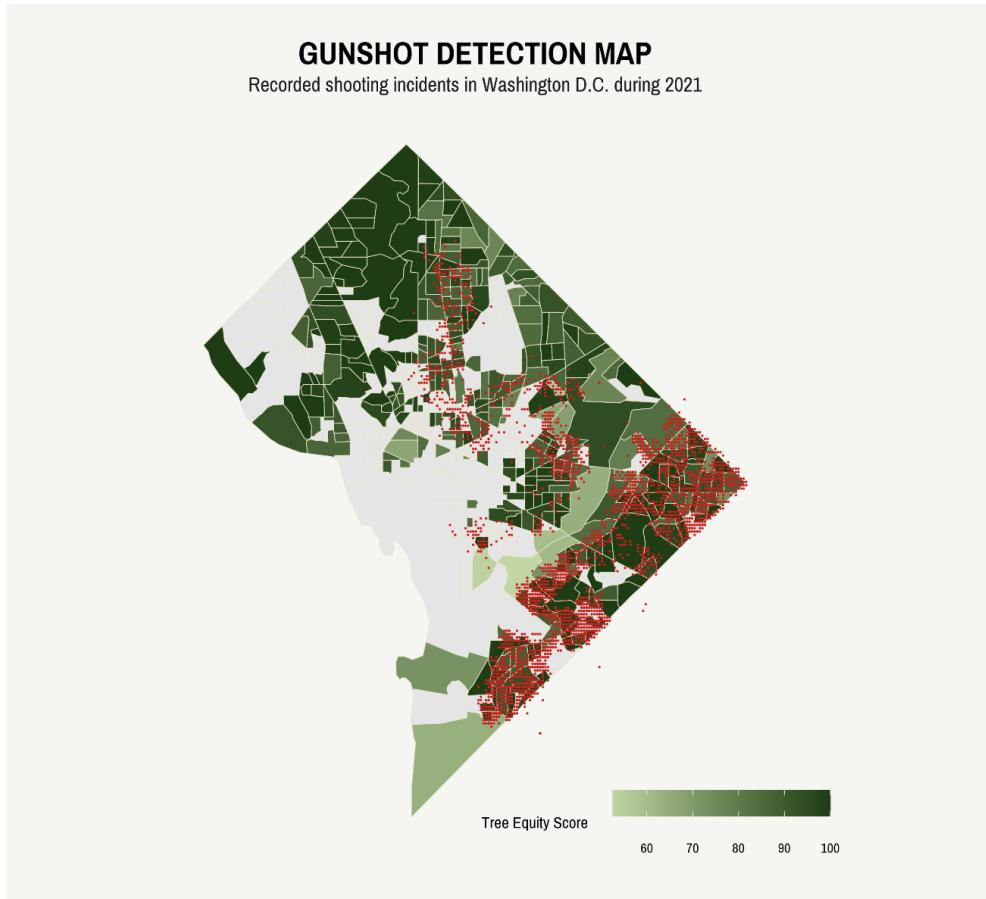
Building upon the descriptive patterns, we conducted block-level logistic regressions to explore further the relationship between green space and gun violence exposure across different census block groups. This allowed us to rigorously assess the impact of green space on community safety across communities, while controlling other influencing factors. Block-level regressions were further augmented with grid-level Poisson regressions to delve deeper into how specific attributes of green spaces, such as the size of parks and streetlights in parks, affect community safety.

## Key Findings

- Despite high levels of tree equity, Washington D.C. experiences high levels of gun violence. Communities of color are disproportionately exposed to gun violence, with over 70% of affected communities being of African-American descent. [→](#)
- Gunshots are concentrated on the south and southeast sides, while streetlights are clustered on the center and north sides. [→](#)
- Installing streetlights may reduce the risk of gun violence, especially in areas adjacent to parks. [→](#)
- Expanding green space may lead to a reduction in gun violence, but the mitigation effect is much smaller for communities of color. [→](#)
- Easier access to small parks would lead to a greater decline in gun violence for communities of color compared with large parks. Neighborhoods closest to parks experience higher risks of gun exposure. [→](#)

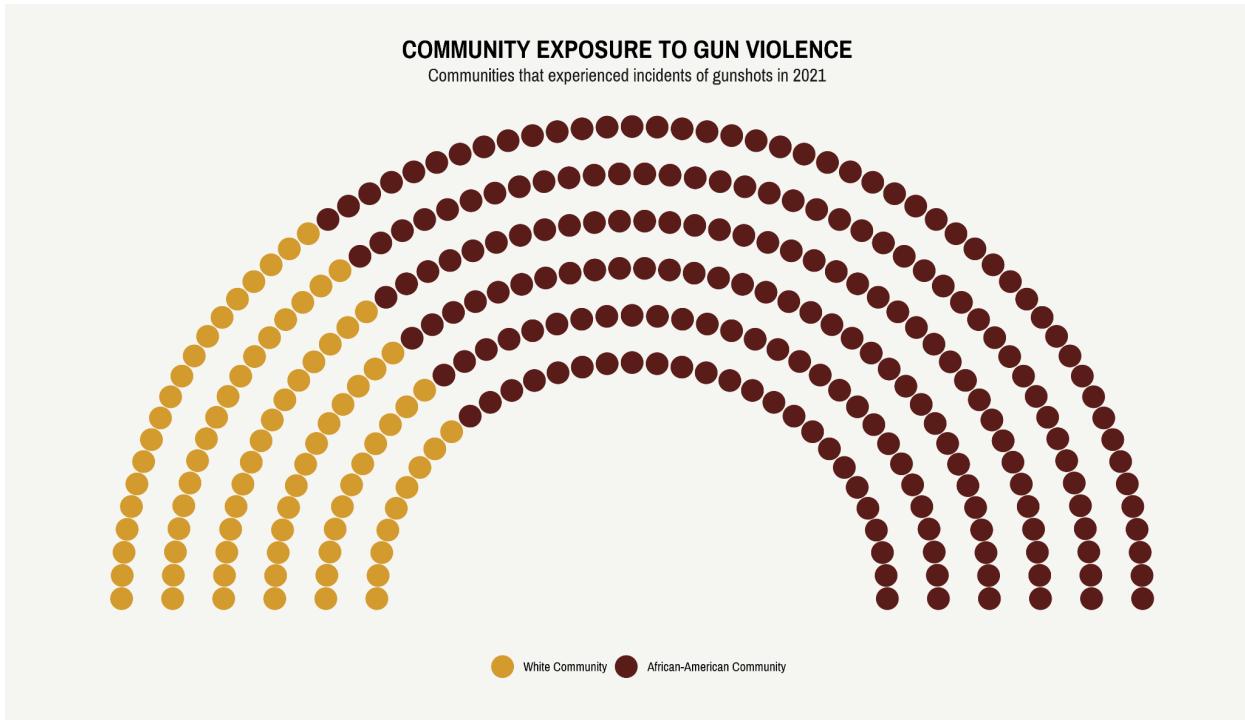
### *Descriptive patterns of green space provision and gun violence in Washington D.C.*

After analyzing the spatial distribution of both tree equity scores and gunshots, we discovered that the city boasts relatively high levels of tree equity while exhibiting an unequal spread of gunshots. Our graph shows that gunshots are concentrated in Southeastern areas, while Northwestern areas experience fewer incidents.



**Figure 4:** Gun Shot Detection Map

We next examined the issue of racial disparity in gun violence exposure. A staggering 70% of communities exposed to violence in 2021 were African-American. Additionally, 80% of Hispanic or Latino communities experienced gun violence, while only 53% of non-Hispanic communities were exposed to such incidents. These results indicate a significant racial disparity in gun violence exposure and underscore the need for targeted interventions to address this issue.



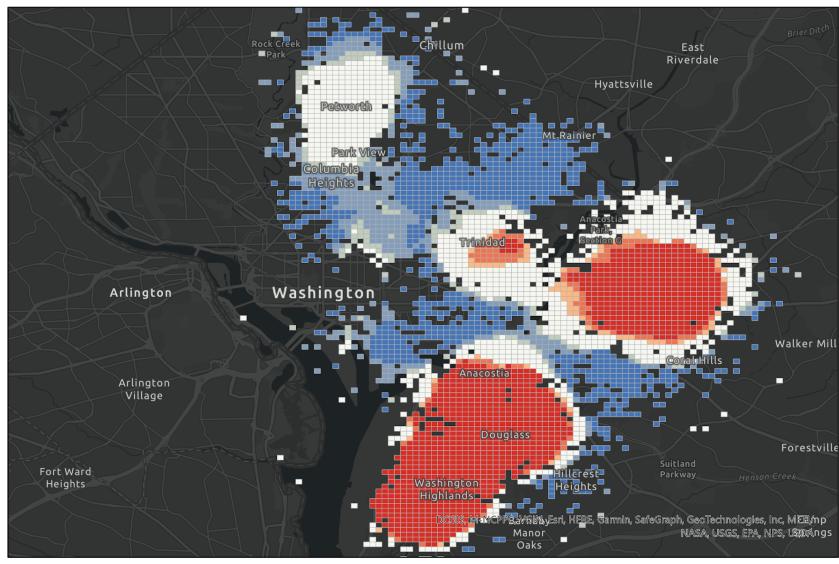
**Figure 5:** Community Exposure to Gun Violence

### Spatial distributions of gunshots and streetlights

In addition, we used an optimized hot-cold spot analysis to statistically visualize and analyze the distribution of gunshot incidents. Our analysis revealed that the gunshot hotspots are concentrated in the east and southeast regions of the city, while the north side of DC has fewer gunshots and appears as a cold spot. This aligns with the descriptive finding above.

Given the importance of streetlights in preventing crime, we also mapped streetlights in D.C. Neighborhoods with higher streetlight density tended to have fewer gunshots. Figure 6 shows the comparison of the two distribution patterns.

Gun Shots Hot and Cold Spot in DC



Street Lights Hot and Cold Spot in DC

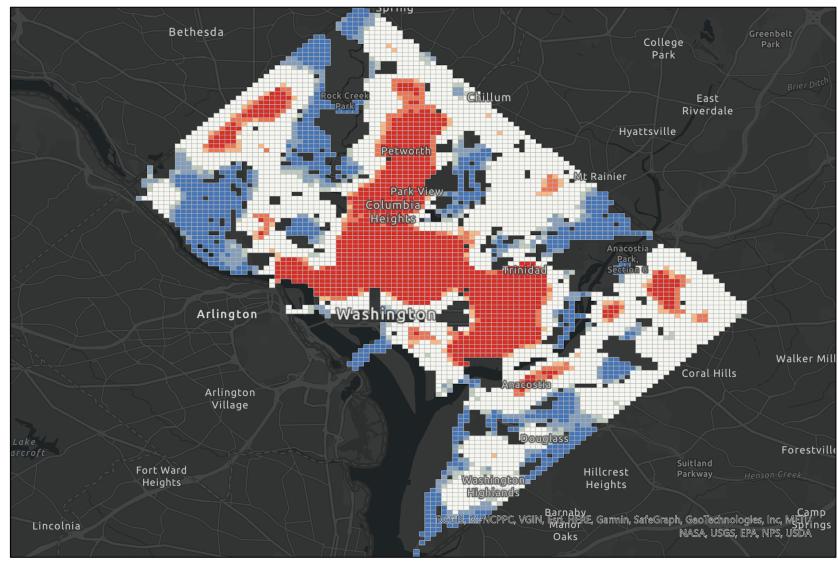


Figure 6: Gun Shots (Left) and Streetlights (Right) Hot and Cold Spot in D.C.

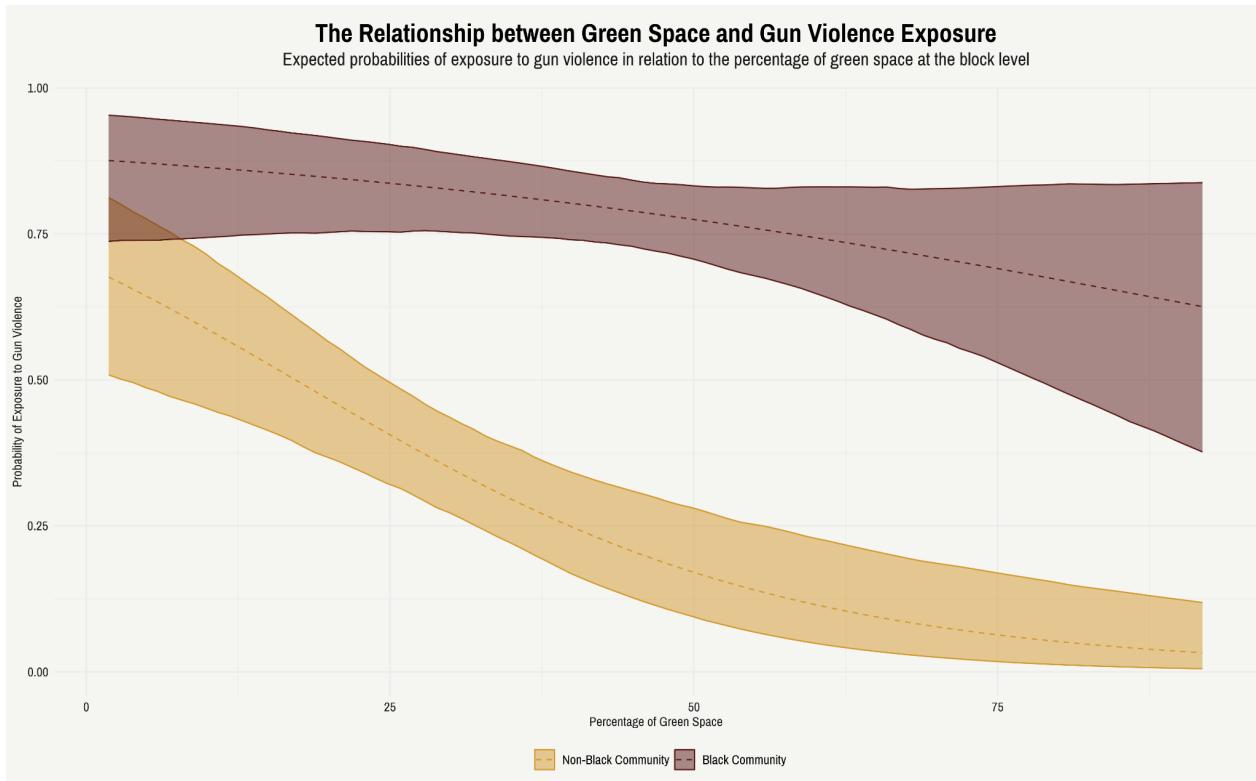
### **Effects of streetlights and green spaces on gun violence**

We used a grid-level Poisson regression to investigate further whether green space and streetlights worked complementarily to reduce gun violence. We constructed a buffering rarea around the large parks in D.C. A descriptive result shows that the buffering areas on average have 1.657 fewer streetlights than other places.

For places outside the buffer, one additional streetlight is associated with a 2.9% decrease in gun shot per capita. For places within the buffer, it is associated with a 4.5% decrease in gun shot per capita, suggesting a need for developing brighter green spaces.

### **Effects of percentage of green space on gun violence across communities**

We conducted logistic regressions to investigate the impact of green space on gun violence across communities. Overall, expanding green space would lead to a reduction in gun violence, but the mitigation effect was much smaller for communities of color. When the percentage of green space increased from 25% to 75%, gun violence decreased by approximately 10% for communities of color, compared to around 35% for other groups. While increasing green space for communities of color may help reduce gun violence to some extent, this finding suggests that additional measures should be taken to combat gun violence effectively.



**Figure 8: The Relationship Between Green Space and Gun Violence Exposure**

### Effects of park sizes across different communities

With Poisson regressions, we observed differing effects of park sizes across communities. For black communities, proximity to small parks sees a significant reduction in gun violence, whereas for non-black communities, proximity to large parks is associated with a significant decrease in gun violence.

We then examined the most nearby surrounding neighborhoods with buffer analysis. Surrounding neighborhoods in black communities are associated with an increased risk of gun violence, especially for small parks. For non-black communities, living nearby large parks reduces gunshot exposure, while living nearby small parks still observes higher gun violence.

### Conclusion

Washington D.C. excels across many measures of green space, including equal access to green spaces and park quality. However, crime remains a severe issue in the city and

disproportionately affects communities of color. Our analyses reveal that increasing green spaces is associated with reduced crime rates, but this effect is trivial for communities of color, highlighting the need for targeted interventions. Based on our findings, we offer the following recommendations for enhancing green space in D.C.:

1. Install additional streetlights in parks and surrounding areas to enhance public safety.
2. Invest in more neighborhood parks for communities of color to provide easier access to safe green spaces.

# Documentation

<b>Background</b>	<b>1</b>
<b>Construction of Datasets</b>	<b>6</b>
Gunshots	6
Green Space	6
Demographics	8
Grid-level socioeconomic data	9
<b>Descriptive Patterns</b>	<b>9</b>
Green Space across States	9
Green Space and Gunshots	10
Park Types	14
Gunshots Distribution	15
Street Lights Distribution	17
<b>Statistical Modeling</b>	<b>18</b>
Block-level Analysis	18
Grid-level Analysis	20
<b>Story Map: <a href="https://arcg.is/1evv1y0">https://arcg.is/1evv1y0</a></b>	<b>22</b>

## Background

Despite being a small city, Washington DC has the highest homicide rate among all U.S. states, with 226 deaths and 1,330 emergency department visits due to gunshot wounds in 2021<sup>1</sup>. Washington, D.C. has a number of parks and green spaces throughout the city, including large parks like the National Mall and other types of parks including Rock Creek Park, Meridian Hill Park, and the Tidal Basin. The D.C.

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<sup>1</sup> Economic justice without tackling gun violence.

<https://www.peacefordc.org/#:~:text=Compared%20to%20all%20states%2C%20DC.taxpayers%20%241,%20billion%20in%202021>

Department of Parks and Recreation operates over 40 community gardens throughout the city.

Previous Researchers have found that the relationship between green space and crime is complicated. Factors like the type of green space, the location of green space and the characteristics of the neighborhood environment, historical issues as well as socioeconomic status can affect the outcome<sup>2</sup>. The results of studies focusing on the impact of green space on social security are found to be different: some showed that green space such as parks can have a positive impact on reducing crime rates in urban areas<sup>3</sup> while others show mixed results indicating that certain types of green spaces, such as large, isolated parks or those with poor maintenance, can actually increase crime rates which provides opportunities for illegal activities, such as drug dealing or prostitution<sup>4</sup> while in comparison, small parks were associated with lower levels of crime (especially violent crimes). Studies also indicate that the effect of green space on reducing crime was not consistent across all neighborhoods.

We started the exploration of this study with a brief overview of demographics in Washington DC. The estimated total population in Washington DC was around 670,050 in 2021<sup>5</sup>. 45.8% of the total population are Black or African Americans and 11.5% are Hispanic or Latin.

Historically, certain neighborhoods in D.C. have been associated with racial or ethnic groups. For example, neighborhoods like Anacostia and Southeast D.C. have a high percentage of African American residents, while areas like Georgetown and Capitol Hill have a higher percentage of White residents. In recent years, there has been some

<sup>2</sup> Lee, J. (2020). Does greenery matter? The relationship between urban vegetation and crime in Chicago. *Landscape and Urban Planning*, 196, 103731.

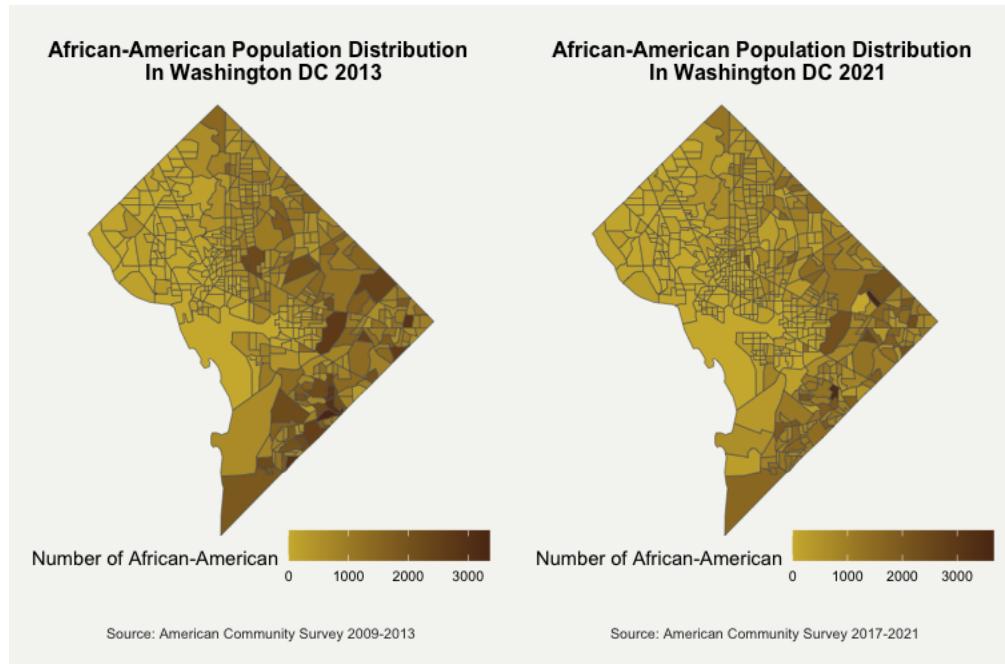
<sup>3</sup> Taylor, L., Hochuli, D. F., & Licari, M. K. (2021). Crime prevention through environmental design (CPTED) in public parks: A systematic review. *Landscape and Urban Planning*, 209, 10

<sup>4</sup> Linares, A. C., & Jacobs, H. E. (2020). The effects of park size and vegetation on crime: A comparison of adjacent small and large urban parks. *Journal of Environmental Psychology*, 67, 101379. T

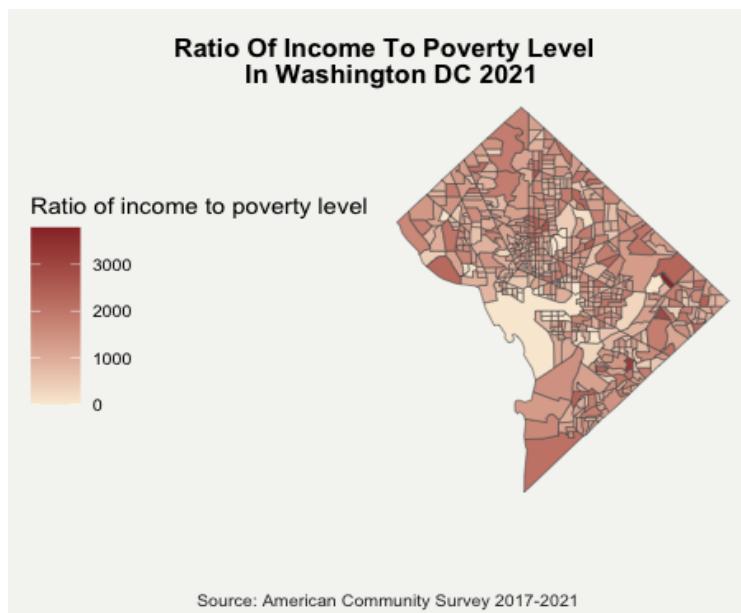
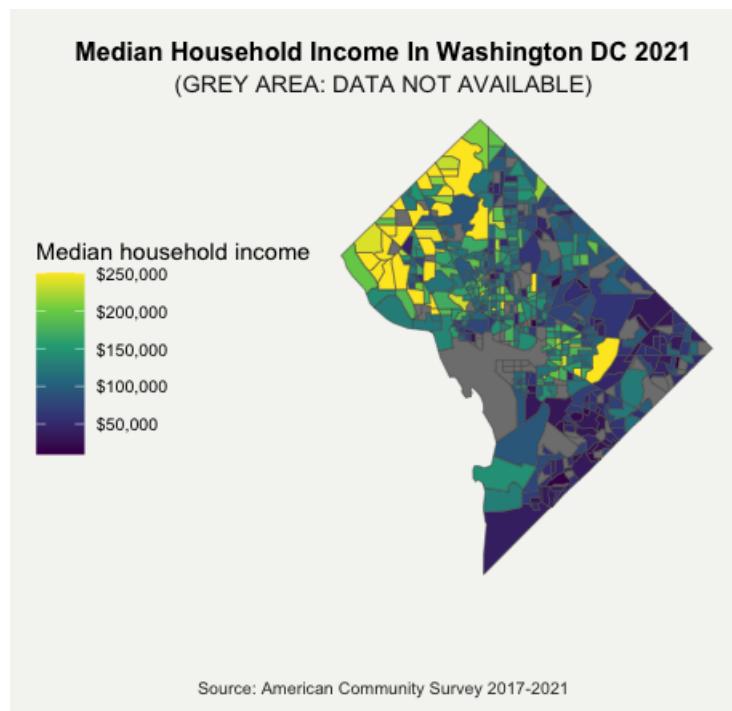
<sup>5</sup> QuickFacts, District of Columbia; Washington city, District of Columbia.

<https://www.census.gov/quickfacts/fact/table/DC.washingtoncitydistrictofcolumbia/RHWe225221>

gentrification in certain parts of the city, which has caused shifts in the racial makeup of some neighborhoods. For example, given the geographic distribution of African-Americans in 2013 and 2021, it is evident that this racial group has been driven to the southeastern part of DC, with the number exceeding 3000 in certain neighborhood blocks.

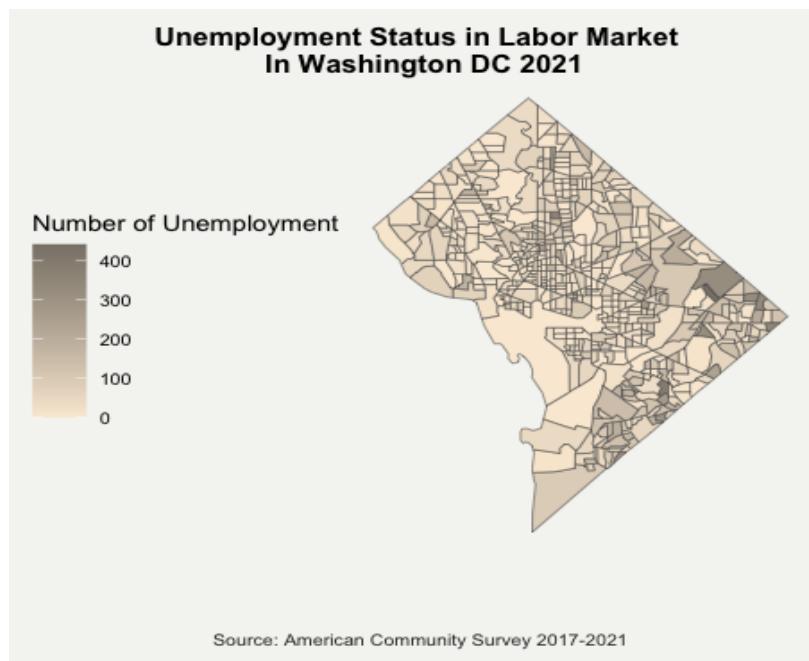


According to the American Community Survey (ACS) 2017–2021 report, till 2021, there were 310,104 households in total and the median household income across the state was around \$93,547. The average poverty rate across the region was 15.4% in 2021. The average household ownership rate was 44.2% in Washington DC based on the current population survey of the U.S. Census Bureau. We also explored the geographic disparities within blocks. Compared with the northwestern blocks of DC, the southeastern blocks, on average, have lower median house income, with less than \$50,000 for most blocks located in that region. We also took an overall look at the mapping of income to poverty level in 2021, the ratio was lower in the middle of the state while higher in eastern and southern blocks of DC.



The District of Columbia's Department of Employment Services also reported that the seasonally adjusted preliminary unemployment rate had a dramatic fall (6.7 percent)

in July 2021 compared with last year (8.9 percent) across the state<sup>6</sup>. The number of employed residents had increased by 2,500 to 379,800 in 2021. Similarly, the civilian labor force also experienced an increase, with the number rising from 402,600 to 407,200<sup>7</sup>. The unemployment rates can vary by neighborhoods within the city. Given the block group analysis in 2021, the southeastern part of the DC showed a higher density of unemployment status among people aged 16 and older. According to the D.C. Department of Employment Services, by the end of 2021, the ward with the highest unemployment rate was **Ward 8** (also in the southeastern part of DC), which had an unemployment rate of 8.3%. **Ward 8** includes neighborhoods like Anacostia and Congress Heights, which have a higher percentage of African American residents and lower median household incomes than other parts of the city. On the other hand, ward 3 (in the northwestern part of DC) has the lowest unemployment rate (2.5%), which includes neighborhoods like Chevy Chase and Tenleytown, which have a higher median household income and a lower percentage of African American residents than other parts of the city. There was also an unproportional high-density distribution of unemployment status in the middle of Washington DC.



<sup>6</sup> DC unemployment rate. <https://does.dc.gov/release/district-columbia-unemployment-rate-67-percent-july>

<sup>7</sup> DC unemployment rate. <https://does.dc.gov/release/district-columbia-unemployment-rate-67-percent-july>

## Construction of Datasets

We use two units of analysis to build our statistical model. The block-level analysis gathered data at census block group level. The grid-level analysis defines the grid as 0.001 degree × 0.001 degree, which is the finest resolution of the gunshot incidents data.

### Gunshots

The gunshot data came from [ShotSpotter](#) where we extracted recorded gunshot instances in 2021, excluding firecrackers and other non-gunshot sounds. Shotspotter system uses gunshot detectors to locate real-time gunfire incidents and performs well in distinguishing random noise, like firecrackers, from gun incidents. Since its implementation in 2006, Shotspotter system has increased the number of sensors to cover areas with high population density and high gun violence exposure. While most crime analysis research relies heavily on administrative data from police departments, Shotspotter data can address the concern of selective underreporting and provide accurate location stamps. However, as the system has higher coverage in high population density and high gun violence exposure areas, it might underestimate gunshots in safer and less populated areas. For the purpose of our study, we focus our analysis mainly on the high-risk areas to minimize possible bias.

To allow for matching gunshots with block-level characteristics later, we applied a spatial join and computed the number of gunshots per block group.

### Green Space

We obtained green space data from four sources: tree equity scores from [American Forests](#), green space attributes from EnviroAtlas, reviews of parks from City78 parks, and parks and recreation area shapefiles from [Open Data DC](#).

We also obtained more complete green space data through land use shapefiles from the open-source package **OpenStreetMap**. Land use types that are related to green space are summarized in the following table. Allotments, orchards and farmlands are private properties and usually not open to the public. Forests and grasslands that are not maintained as public parks are either too small or too remote and have few public activities. Therefore, for the purpose of studying the influence of green space on public safety, we include only the two types of publicly accessible green space, parks and natural reserves.

Land use type	Park	Natural Reserves	Forests & Grass	Allotments	Orchards & Farmlands
Usage	yes	yes	no	no	no

We cleaned the dataset based on the observations' locations and names so that observations with similar names and adjacent locations will be identified as the same park. Observations are then classified into large parks ( $>10$  acres) and small parks ( $<10$  acres) for further analysis. Descriptive statistics are summarized in the following table.

	Large parks ( $>10$ acres)	Small park ( $<10$ acres)	Total
Number	73	630	703

To represent public perceptions of parks, which are a primary type of green space, we extracted reviews specifically related to parks in Washington DC and used a word cloud to display the results. The overall sentiment expressed in the reviews was positive, with common themes including the cleanliness of the parks, their dog-friendliness, and their suitability for family gatherings.

We then created a metric that reflects the number of parks per block group. First, We used the Google Maps API to geocode each park and then performed a spatial join to determine the number of parks located within each census block. We combined this data with the tree equity score and other green space attributes at the block level.



## Demographics

In order to examine how green space impacts gun violence in various communities, it is necessary to have metrics that define each racial or ethnic group. To obtain this information, we used the `tidycensus` package in R to retrieve demographic variables at

the block level from the American Community Survey, including population, median household income, African American population, and Hispanic or Latino population. We then examined the size of its primary population per census block to identify which racial or ethnic community it belongs to.

#### Grid-level socioeconomics data

To aid analysis at a more refined unit of analysis, we collected some grid-level socioeconomic data as control variables. We used the 2020 gridded population dataset from ArcGIS Pro Living Atlas of the World at 0.001 degree × 0.001 degree resolution<sup>8</sup>. Because there is no economic data at the grid level, we obtained the 2021 annual average nighttime light data from Earth Observation Group at 500m × 500m resolution<sup>9</sup>. Nighttime light data is a state-of-the-art proxy for economic data, widely used in social science research. These satellite retrieval data are reported to have strong positive correlation with a region's economic status. Researchers also found that nighttime light data tend to underestimate economic activities where lights are sparse and dim, such as in rural areas. Therefore we use the map of streetlights to complement the nighttime light data as a measure for economic status and street activities.

#### Descriptive Patterns

##### Green Space across States

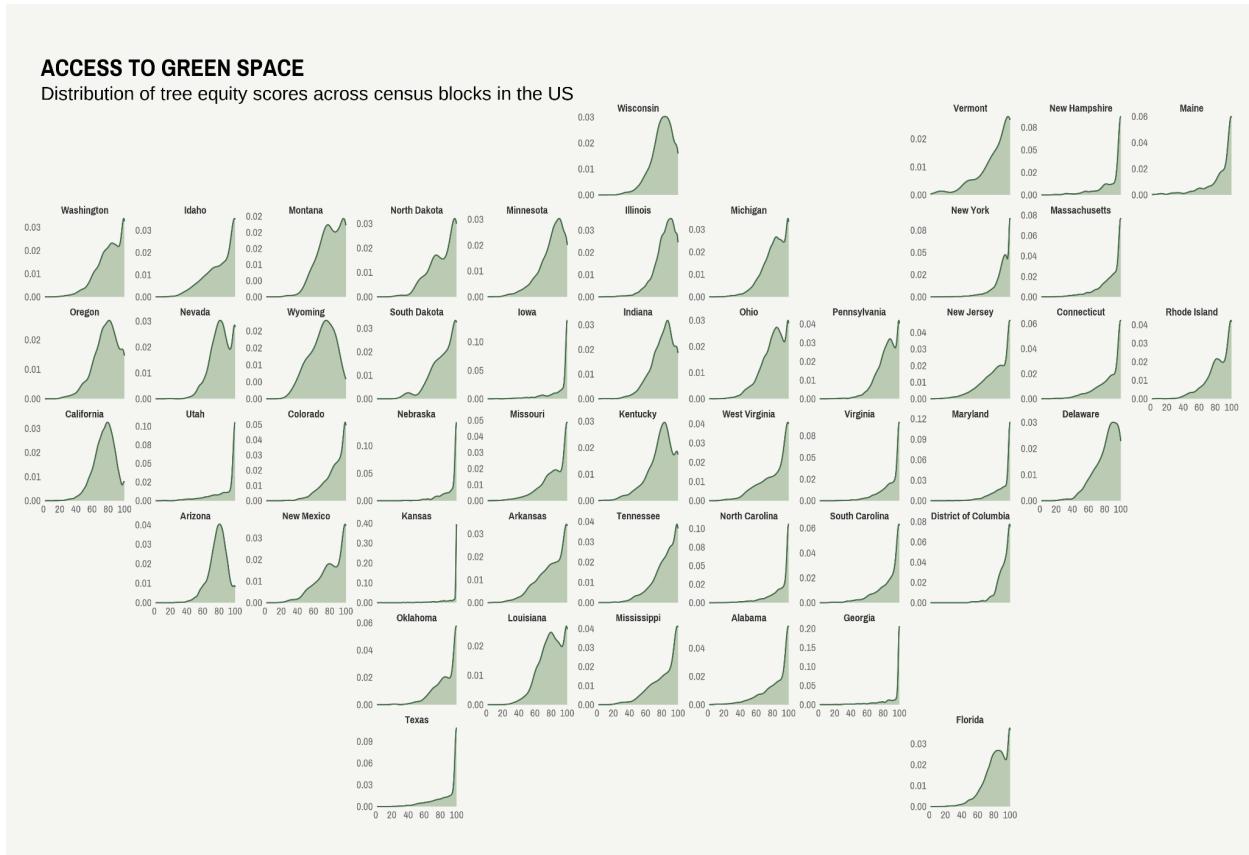
We began by examining the distribution of tree equity scores across states in the United States. Using the geofacet package in R, we created a series of density plots per state on each spatial grid in the U.S. Our analysis revealed that Washington D.C. exhibits comparatively elevated levels of tree equity scores throughout the country.

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<sup>8</sup> Bondarenko M., Kerr D., Sorichetta A., and Tatem, A.J. 2020. Census/projection-disaggregated gridded population datasets for 189 countries in 2020 using Built-Settlement Growth Model (BSGM) outputs. WorldPop, University of Southampton, UK. doi:10.5258/SOTON/WP00684

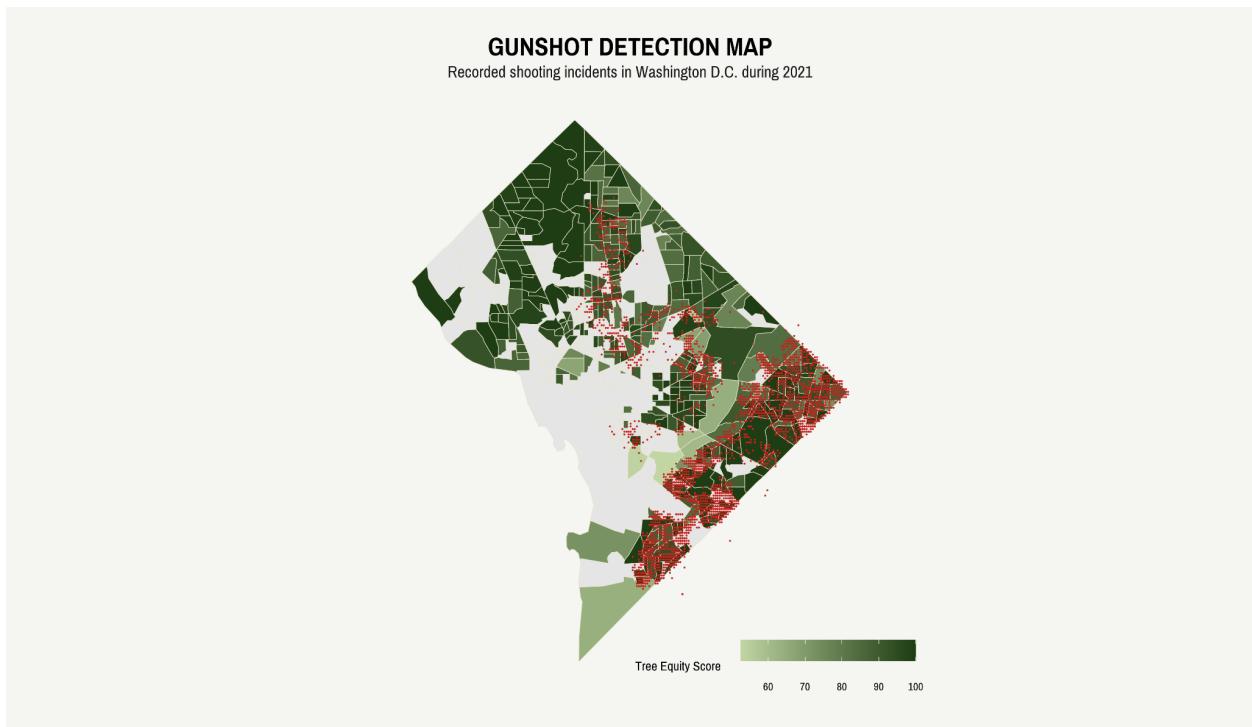
<sup>9</sup> Elvidge, C.D., Zhizhin, M., Ghosh T., Hsu FC, Taneja J. Annual time series of global VIIRS nighttime lights derived from monthly averages:2012 to 2019. *Remote Sensing* 2021, 13(5), p.922, doi:10.3390/rs13050922

This finding presents a conundrum: why does a region with reasonably equitable access to green space experience heightened exposure to gun violence?

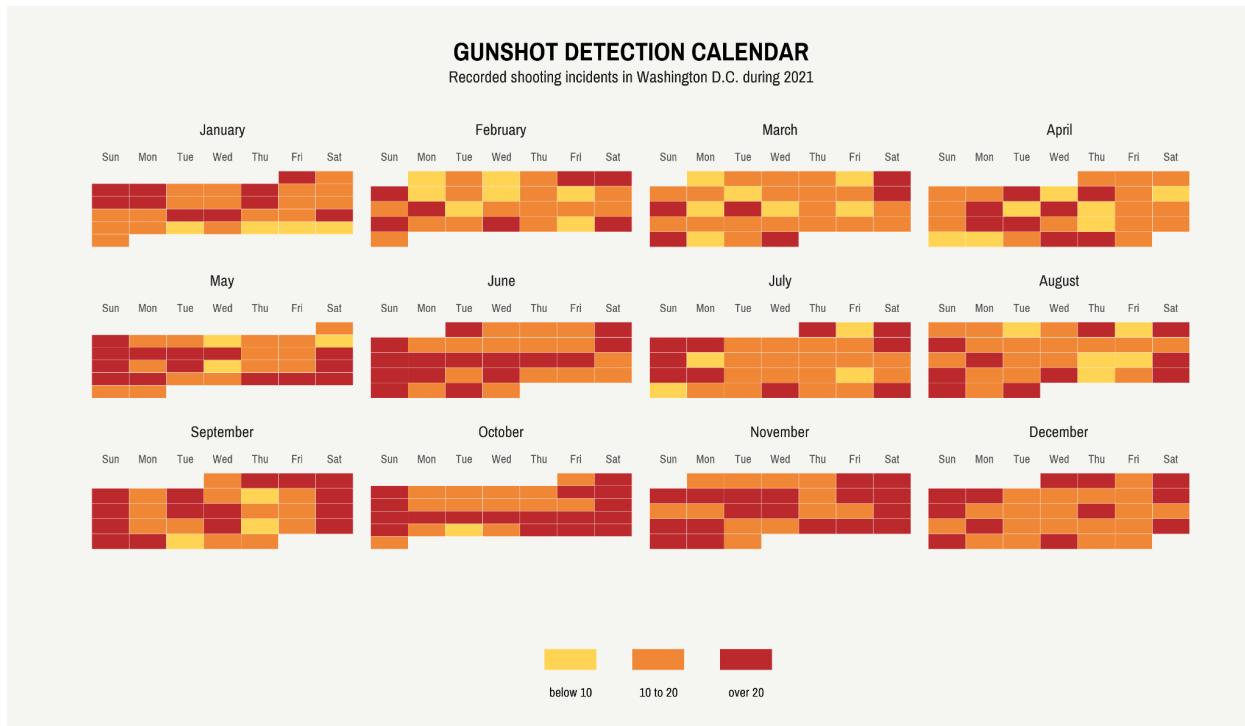


## Green Space and Gunshots

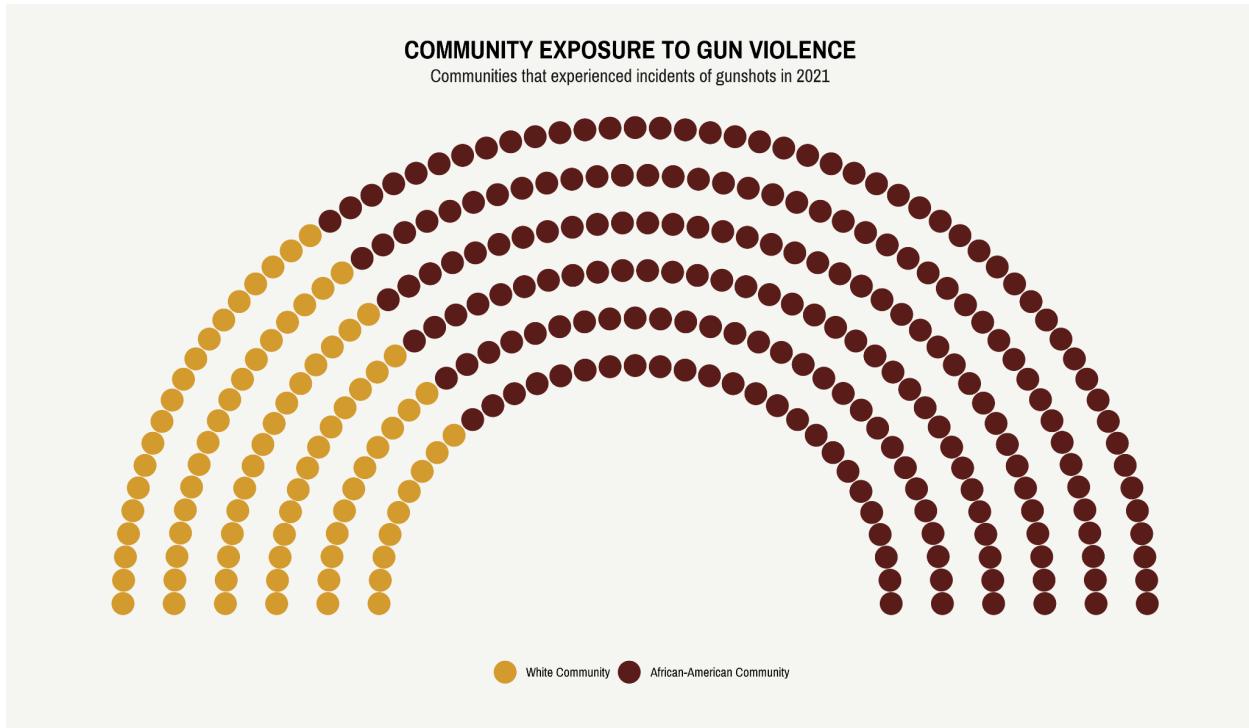
Next, we narrowed our focus to Washington D.C. and investigated the spatial distribution of tree equity scores and gunshots. We found that gunshots tend to be concentrated in Southeastern areas, while Northwestern areas experience fewer incidents. This observation aligns with our earlier discovery that Washington D.C. boasts comparatively high levels of tree equity.



To enhance our comprehension of the temporal patterns of gunshots, we opted for a calendar-style plot instead of a line chart, allowing for more detailed information. Our findings suggest that gun incidents occur more frequently on weekends than on weekdays. Furthermore, the months of November and June appeared to exhibit the highest levels of gun activity.



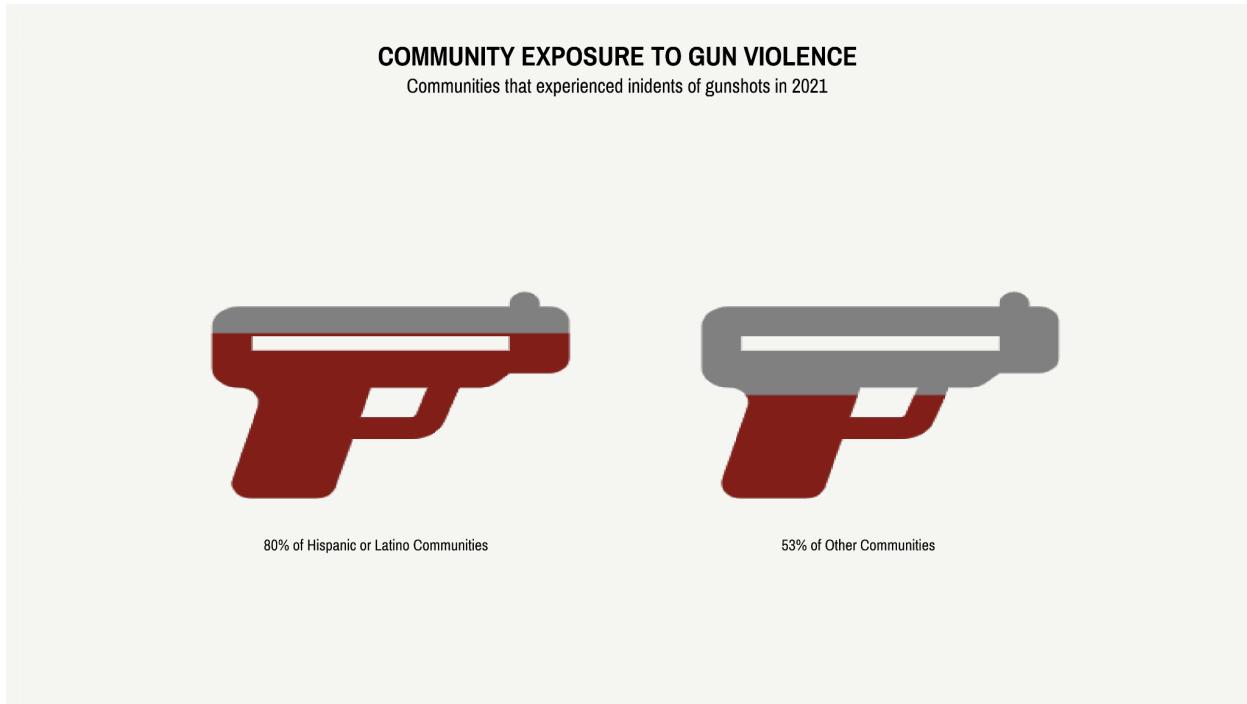
Next, we examined whether there were any racial or ethnic disparities in gun violence exposure. Upon analysis of the cleaned data, it is more apparent that among the 555 communities in the city, 293 have experienced gun violence. Of significant concern is the fact that over 70% of these affected communities are African-American, indicating a clear instance of racial disparity. In order to more effectively convey these disparities, a parliament chart was constructed, which serves as an aesthetically pleasing means of visually displaying categorical data in a two-dimensional grid format. This chart is particularly valuable in facilitating comparisons across multiple categories, enabling the differences in the number of affected communities between racial groups to be presented in a clear and concise manner.



When attempting to replicate this graph by comparing Hispanic/Latino communities to others, a challenge arose due to the low number of Hispanic/Latino communities, with only five out of the 555 total communities in the dataset. Displaying the raw counts of communities experiencing gun violence could potentially create a misleading impression that non-Hispanic or non-Latino communities experienced greater exposure to gun violence, when in fact, four out of the five Hispanic/Latino communities also experienced gun violence. To accurately compare ethnic communities, it is important to display proportions rather than raw counts.

To address this issue, we utilized a pictogram chart to visualize the proportions of communities that experienced gun violence. This chart utilizes filled icons, such as handguns, with varying heights of filled colors to represent the proportions of affected communities. This approach allows for clear and concise visualization of the

proportions of gun violence in Hispanic/Latino communities compared to other ethnic communities, despite the small sample size of the former.



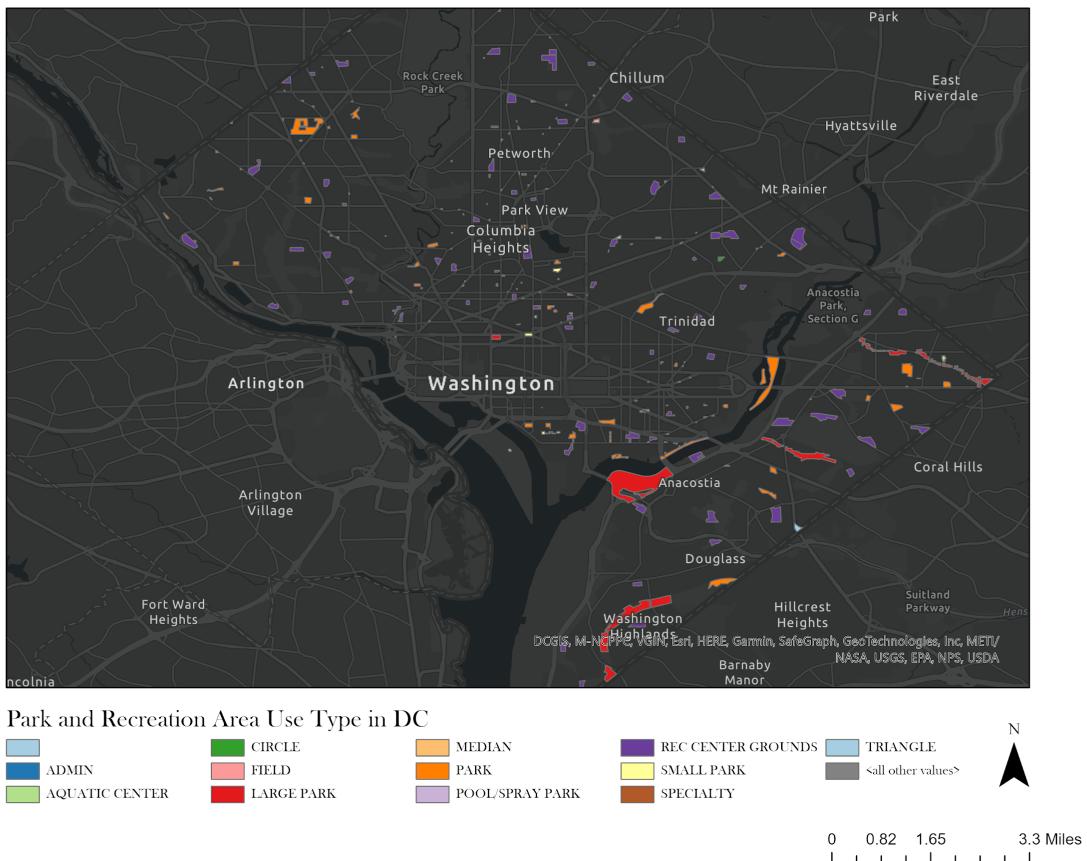
## Park Types

Not all green spaces have positive effects on community safety and wellness. For example, some studies have found that specific green spaces, such as large, isolated parks or those with poor maintenance, can increase crime rates by providing opportunities for illegal activities, such as drug dealing or prostitution<sup>10</sup>. We used the park and recreation shapefile from Open Data DC and visualized park types using unique symbology in ArcGIS Pro. It is showing that “large park” colored in red located mostly in the southeast side of DC, where most gunshots happened. Large parks sometimes function as a “shelter” for crimes.

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<sup>10</sup> The Impact of Green Space on Violent Crime in Urban Environments: An Evidence Synthesis.  
[https://www.researchgate.net/publication/337958109\\_The\\_Impact\\_of\\_Green\\_Space\\_on\\_Violent\\_Crime\\_in\\_Urban\\_Environments\\_An\\_Evidence\\_Synthesis](https://www.researchgate.net/publication/337958109_The_Impact_of_Green_Space_on_Violent_Crime_in_Urban_Environments_An_Evidence_Synthesis)

## Park and Recreation Area Use Type in DC



## Gunshots Distribution

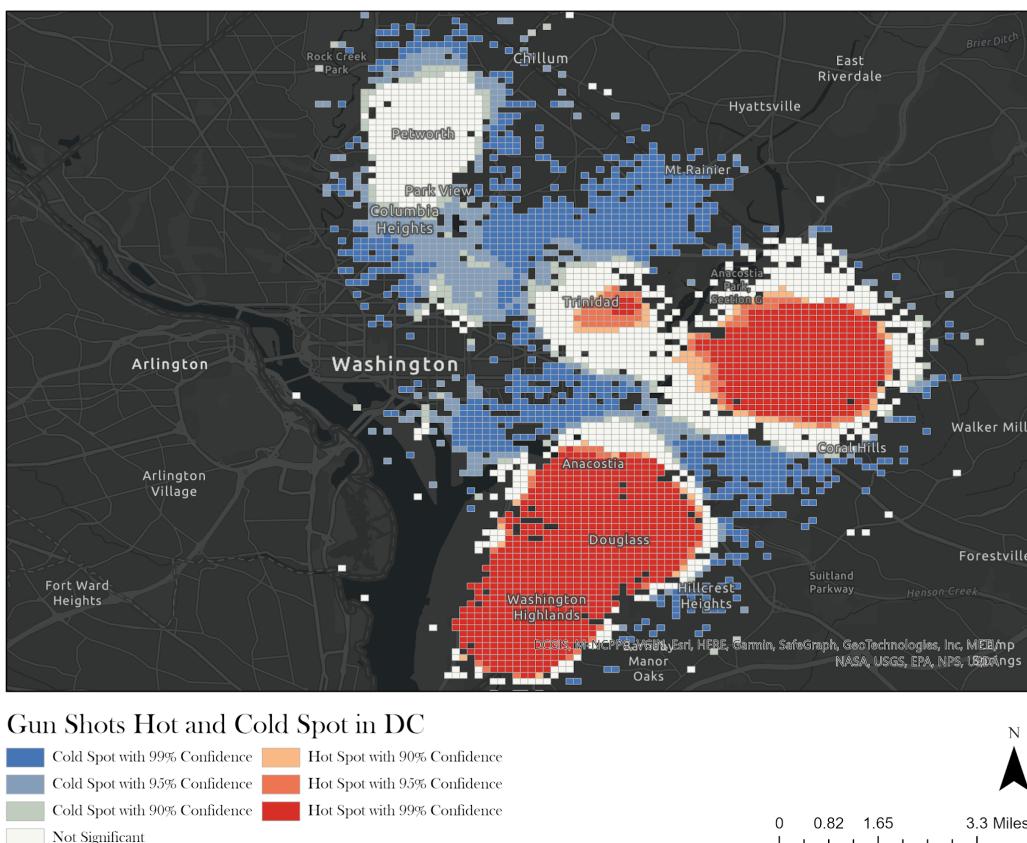
We also used optimized hot-cold spot analysis in ArcGIS Pro<sup>11</sup> to visualize and analyze gunshots data. This tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). It automatically aggregates incident data, identifies an appropriate scale of analysis, and corrects for both multiple testing and spatial dependence. We can see the gunshots hotspots are located on the east and southeast sides of DC, showing clusters; whereas the north side of DC has fewer gunshots (showing as cold spots). This aligns with a lot of other findings in this study, such as demographic and socio-economic characteristics. According to the DC's fiscal

<sup>11</sup> Optimized hot-cold spot analysis in ArcGIS Pro.

<https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/optimized-hot-spot-analysis.htm>

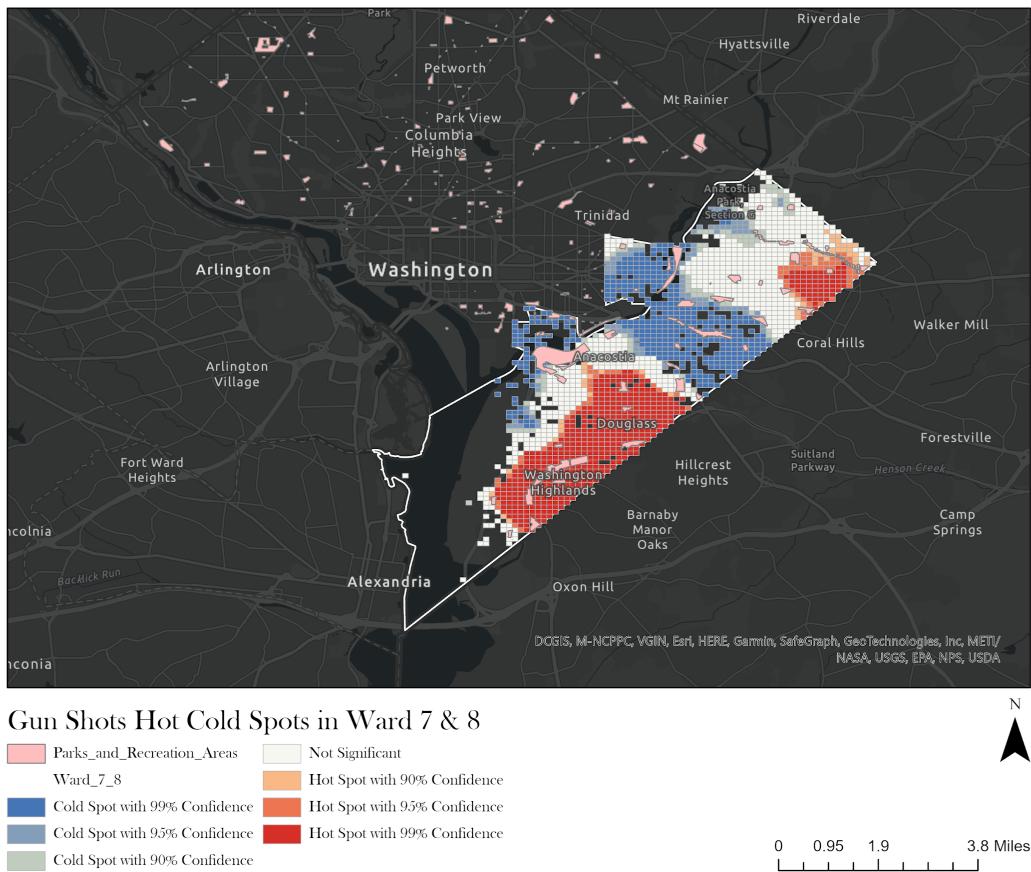
policy institute report<sup>12</sup>, the District's African American residents increasingly live east of the Anacostia River, where the poverty rate is three times higher than the rest of DC. We then clipped the gun shots shapefile within Ward 7 & 8, and ran the hot cold spots analysis again. The reason for this step is we want to see a more localized distribution of gun shots. We found out two clusters next to the southeast boundaries of both wards; but this time park Anacostia is not included in the hot spot, which corresponds to some online reviews of this park that a lot of people view this park as a nice place for weekend activities.

Gun Shots Hot and Cold Spot in DC



<sup>12</sup> DC's Black Residents Increasingly Live East of the Anacostia River.  
<https://www.dcfpi.org/all/dcs-black-residents-increasingly-live-east-of-the-anacostia-river/>

## Gun Shots Hot Cold Spots in Ward 7 & 8



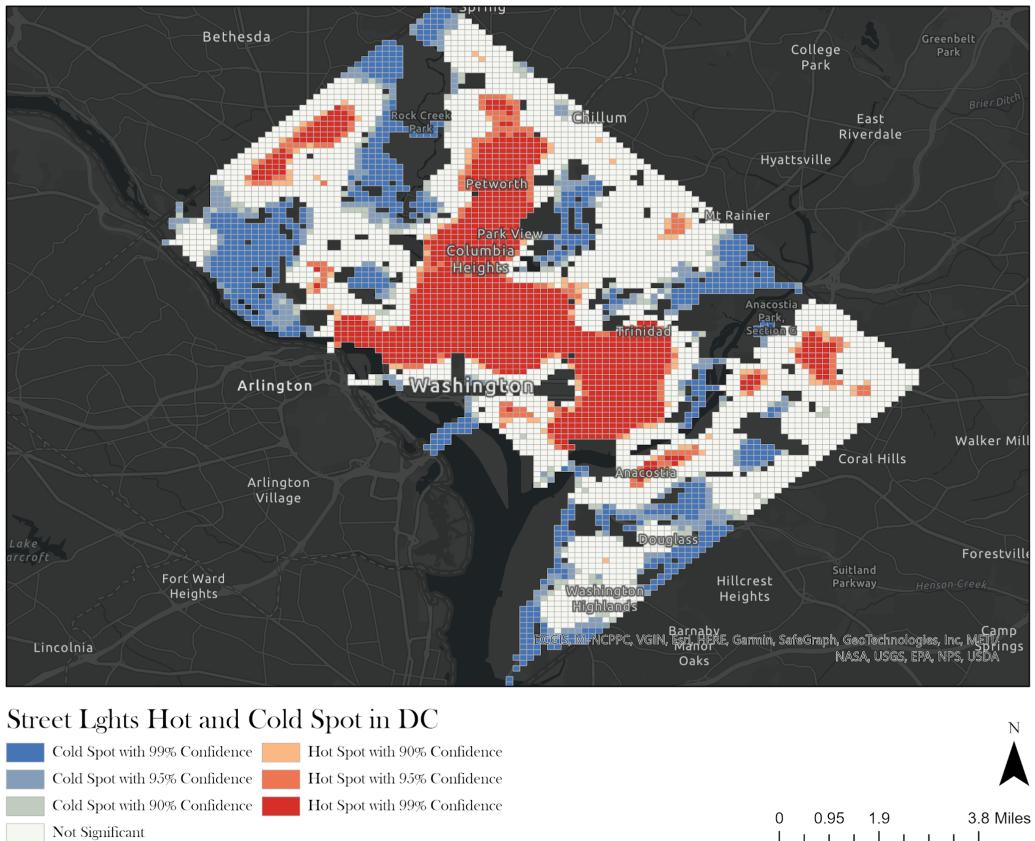
## Street Lights Distribution

In most people's minds, there is a simple and direct relationship between lighting and crime: better lighting will deter offenders who benefit from the cover of darkness. Improved lighting means that offenders are more likely to be seen by someone who might intervene, call the police, or recognize the offender<sup>13</sup>. Because of the importance of street light in preventing crime, in this study we mapped street lights in DC. We can see a general trend that neighborhoods with higher density of street lights tend to have fewer gunshots. To be specific, the center and the north side of DC have a higher density of street lights, which also shows a lower density of gunshots and crime. But

<sup>13</sup> Improving Street Lighting to Reduce Crime in Residential Areas.  
<https://cops.usdoj.gov/ric/Publications/cops-p156-pub.pdf>

this is not always the case because street lights also reflect population density, and crimes often happen where most people gather.

Street Lights Hot and Cold Spot in DC



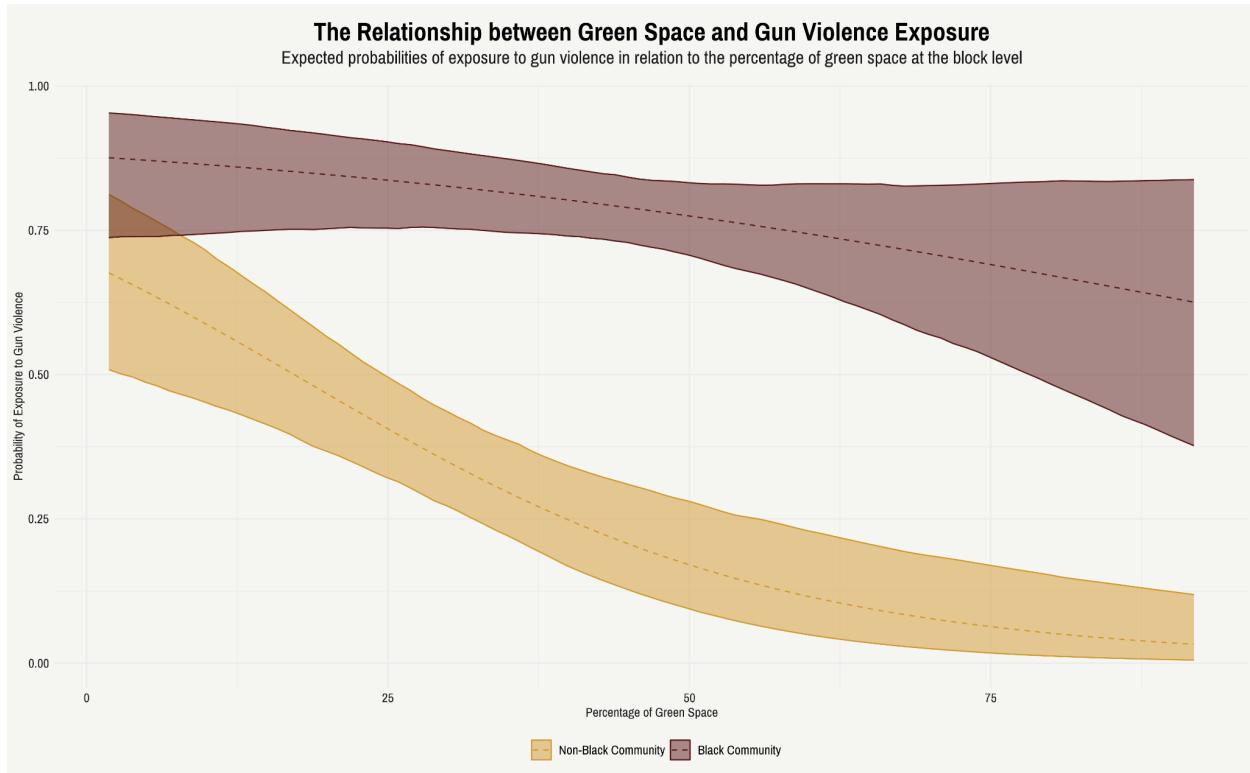
## Statistical Modeling

### Block-level Analysis

To investigate the impact of green space on gun violence across different communities, we conducted a series of logistic regressions. The outcome variable was whether a census block was exposed to gun violence, and the key variables of interest were green space, measured by (1) the percentage of green space, (2) green space per capita, and (3) tree equity score, as well as a binary variable indicating whether the block belonged to a community of color. Control variables included socioeconomic characteristics at the block level. We included an interaction term between green

space and community of color, which allowed us to examine whether there were heterogeneous effects of green space on gun violence across different racial communities.

To aid in interpreting the nonlinear relationship resulting from the logistic regressions with an interaction term, We simulated the model coefficients 10,000 times and visualized the expected probabilities of exposure to gun violence for different communities as green space varied. Overall, we found that expanding green space would lead to a reduction in gun violence, but the mitigation effect was much smaller for communities of color. When the percentage of green space increased from 25% to 75%, there was about a 10% decrease in gun violence for communities of color, compared to a corresponding decline of around 35% for other groups. While increasing green space for communities of color may help reduce gun violence to some extent, this finding suggests that additional measures should also be taken to combat gun violence effectively.



## Grid-level Analysis

To gain a finer-grained understanding of the relationship between green space and gun violence, we then conducted grid-level analyses at a resolution of 0.001 degree  $\times$  0.001 degree.

The outcome variable is gunshots per capita in each grid. We obtained gunshot counts in each grid by collecting data on all gunshot events that occurred at the grid level in 2021. Population data is at the same resolution level. Thus the data was reprojected by weighted average to match gunshot observations.

The first explanatory variable is the distance to the nearest park. We used QGIS to calculate the distance from each grid to the border of the nearest park. To account for potential varying effects of large and small parks, we also computed the distance to the nearest large and small park, respectively.

The second explanatory variable is whether the grid was located in the buffering area of the parks. We constructed the buffering range to be 300% of the original park size

for the large and small parks respectively. We constructed a dummy variable denoting whether the grid was located within or outside of buffering range of large and small parks.

The control variables includes nighttime light, the number of streetlights, and the distance to the nearest police stations. To match the resolution of the gunshot count data, we resampled the original nighttime light data using the nearest neighbor method at a resolution of 0.001 degrees by 0.001 degrees. We collected point observations of streetlights at the grid level and calculated the count of streetlights in each grid. Using QGIS, we calculated the distance from each grid to the point location of the nearest police station in D.C.. Waterways and grids where population equals 0 were excluded from observations.

We first established a Poisson regression model to explore the differential influence of large and small parks on black and non-black communities. We then conducted further analysis to explore the differential effects of parks based on park size and the racial composition of the surrounding community. Consistent with our findings at the block level, the results suggest that proximity to parks is in general associated with a reduction in gun violence.

For the general population, proximity to both large parks and small parks is significantly associated with a reduction in gun violence. However, the effect of each varies greatly across communities. For black communities, proximity to large parks does not have a significant effect, but proximity to small parks is associated with a significant reduction in gun violence. In contrast, for non-black communities, proximity to large parks is associated with a statistically significant decrease in gun violence, but proximity to small parks is associated with increase in gun violence.

We then used the buffering range of large parks and small parks as the explanatory variables. Compared to the analysis above, this buffer analysis only considered the nearby surrounding neighborhoods, at most 0.49 miles to the large parks and 0.14 miles to the small parks. The average distance to park within and outside the buffering range is summarized in the table below.

	Max distance to the nearest large park (meter)	Max distance to the nearest small park (meter)
Within the buffering range	2021.1	2065.0
Outside the buffering range	794.8	222.0

The result shows that for the black community, living just nearby the parks is associated with increased risk in gun violence, especially for small parks. While for the non-black community, living nearby the small parks still faces higher gunshot risk, but living nearby the large parks reduces the gunshot risks.

We then examined whether green space and streetlights worked complementarily to reduce gun violence. A descriptive result shows that the buffering areas on average have 1.657 fewer streetlights than other places.

We added an interaction term of number of streetlights with buffering area in the model. We first examined the pattern for the general population. For places outside the buffering range of the parks, one additional streetlight is associated with 2.9% decrease in gun shot per capita. However, for places within the buffering range of the parks, one additional streetlight is associated with an additional 2.1% decrease in gun shot per capita, suggesting a need for developing brighter green spaces. For black communities, streetlights in the buffer range of small parks has a larger reduction effect than those in large parks. For white communities, streetlight has a significant reduction effect only in the buffering area of small parks.

Story Map: <https://arcg.is/1evv1yo>