Alexis Hancz
Korede Ajogbeje
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Geospatial Analysis of Crime Frequencies in Detroit Neighborhoods, Zip Codes and Grocery Store Radii

**Introduction:** This report provides a comprehensive profile of crime frequencies within specific Detroit neighborhood and zip code boundaries, as well as around grocery stores, to inform appropriate safety, security and justice initiatives for Detroit residents. I conducted my analysis using four geospatial datasets from the Detroit Open Data Portal. I created three geospatial maps using R's *tmap* and *sf* packages; they visualize 2021 crime incident frequencies by neighborhood and by zip code, as well as grocery store locations and their surrounding 1 mile, 2 mile and 3 mile buffer areas. Finally, I created an Excel spreadsheet of robbery crime incidents occurring within the 1, 2 and 3 mile buffer radii of neighborhood grocery stores.

**Methods:** I was provided with four shapefiles to work with. Two shapefiles are vector polygons consisting of Detroit neighborhoods (n=205) and zip code areas (n=31), respectively. The other two shapefiles for grocery stores (n=74) and crime are vector points, respectively. I executed two major tasks with the files: mapping crime incidents and analyzing robbery incidents around grocery stores. To prepare for my analyses, I loaded the necessary *sf*, *tmap* and *dplyr* libraries for geospatial visualization and data manipulation. I read in each shapefile as spatial object dataframes. I retrieved the coordinate reference systems (CRS) of each dataframe and checked if each CRS was projected, a necessary component of geospatial analysis. If unprojected, I transformed the longitude-latitude coordinates into planar (x,y) coordinates. I then explored the resulting data by column name.

## I. Task 1.1: Mapping 2021 Detroit Crime Frequencies by Neighborhood

**Methods:** The first task was to create a color-coded map of low-crime and high-crime neighborhood areas **(Fig. 1)**. To prepare my data, I filtered the projected crime data to extract incidents from 2021 and projected the new filtered dataframe. Next, I joined the filtered dataframe with my neighborhood dataframe. I then grouped the joined data by neighborhood name and calculated the frequency of crime incidents in each neighborhood. Finally, I joined the grouped dataframe with the initial neighborhood dataframe to create a new joined dataframe. I used the new joined dataframe to initialize a color-coded map of Detroit neighborhoods based on crime frequency, emphasizing low crime (<100 incidents, green) and high crime (>1200 incidents, red) neighborhoods. First, I defined the ranges of crime counts in a numeric vector and assigned color and label vectors to the interval breaks. Next, I initialized a *tmap* object with the new joined dataframe. I added neighborhood borders (polygons), arguing for the crime frequency variable as the fill color. I specified the breaks, color palette and labels as previously defined. I then set the title for the legend and set transparency levels and colors for the polygons. Next, I added neighborhood name labels, and removed the framing, and adjusted the map title, margins, legend position, legend title, size and font. I saved the resulting map as a PDF.

## II. Task 1.2: Mapping 2021 Detroit Crime Frequencies by Zip Code

**Methods:** The second task was to create a color-coded map of low-crime and high-crime zip code areas **(Fig. 2)**. To prepare my data, I grouped the 2021 crime data by zip code. I joined the grouped crime data with the initial zip code data. I then assigned breaks, colors and labels to the relevant crime count intervals using numeric vectors (<1000 incidents in green, >5000 incidents in red), and converted the zipcode variable to a character type for labeling purposes. To create the map, I initialized a *tmap* object with the joined data. I added the zip code borders (vector polygons) to the map object and assigned the fill color to the 2021 crime counts variable. Next, I specified the breaks, color palette and labels using the objects defined previously. For the legend, I set the alpha value for the transparency level, the border transparency level, and the border color of the polygons. I added zip code labels to the map, removed the framing, set the map title, and adjusted the inner margins. I adjusted the legend's position, title size and font. I saved the resulting map as a PDF.

### III. Task 2.1: Mapping Detroit Neighborhoods and Grocery Store Locations

**Methods:** The next task was to create a map of Detroit neighborhoods highlighting grocery store locations with 1 mile, 2 mile and 3 mile buffers around each store **(Fig. 3)**. I created each buffer using the projected grocery data and saved them as separate objects. To create the map, I set the initial shape to the neighborhood border polygons from the projected neighborhoods data and adjusted their boundary transparency. Next, I added grocery store location points using the projected grocery data, as well as black dots for each location, and adjusted their style. I also added polygons for each of the three distance buffers, and set their border and fill color (blue = 1mi, green = 2mi, red = 3mi), and transparency. Finally, I titled the map, adjusted the title position and size, and removed any framing. I saved the map as a PDF.

### IV. Task 2.2: Finding 2021 Detroit Robbery Frequencies by Radii of Grocery Store

**Methods:** For the final task, I created an Excel file displaying the frequency of robbery incidents within 1 mile, 2 mile and 3 mile buffer zones **(Fig. 4)**. First, I filtered the 2021 crime data for robbery incidents and projected the new filtered robbery dataframe. I then created three new datasets containing the frequencies of robberies occurring within each buffer zone. I grouped each dataset by grocery store name and address and then joined them into a single dataframe. I dropped unnecessary columns, renamed the columns, and saved the data as an Excel file. I ran summary statistics of the dataframe in R **(Fig. 5)**.

## Findings

**Task 1:** The first choropleth map shows how crime levels are distributed across Detroit neighborhoods. Most neighborhoods experienced moderate levels of crime in 2021, between 100 and 1200 incidents. In fact, both high-crime and low-crime neighborhoods stand out as outliers, indicating that the selected crime frequency intervals emphasize extremes in both directions. However, low-crime neighborhoods are more numerous than high-crime neighborhoods. Additionally, low-crime neighborhoods tend to cluster together, which may indicate that these neighborhoods share similar features contributing to low crime risk. Although Southeast Detroit generally has more low-crime neighborhoods and Midwest Detroit has more high-crime neighborhoods, diversity can still be found in both areas. High-crime neighborhoods also tend to cover larger geographic areas than low-crime neighborhoods, although there are some exceptions of

geographically large low-crime neighborhoods. Lastly, there are three cases where a small low-crime neighborhood borders a high-crime neighborhood, which suggests that the potential risk features of one neighborhood may not always be associated with the risk features of another neighborhood.

The second choropleth map shows that high-crime zip codes outnumber low-crime zip codes; but as before, both are outliers compared to moderate-crime zip codes. About three of the five high-crime zip codes are also some of the geographically largest zip codes. High-crime zip codes tend to border one another, indicating potential shared risk features in their region. Interestingly, exactly half of the low-crime zip codes border a high-crime zip code, suggesting extreme differences between their potential risk features. Similarly, the two geographically smallest zip codes, which are low-crime, border large high-crime zip codes. Further research would do well to investigate causal determinants of the patterns between the geographic size of zip codes and their crime rates, and why high-crime and low-crime neighborhoods often either cluster amongst themselves or border their extreme counterparts.

**Task 2:** There are several neighborhoods that lack access to grocery stores within a three-mile radius, such as the central area of Brightmoor (geographically large, high-crime), as well as nearby neighborhoods to its south and the central Midwest area (moderate crime). Other areas of low and moderate crime such as the southern peninsular area and Detroit's northern border also have limited grocery store access. However, there are many areas where overlapping buffer zones indicate a high concentration of grocery stores, particularly in the southern and central regions of Detroit. Without further research, it is difficult to conclude whether areas with more grocery stores contribute to lower crime rates or if areas with limited grocery stores simply have higher crime rates.

Exploring descriptive statistics **(Fig. 5)**, the average number of robberies as well as the median both more than double as the distance from grocery stores increases from within one mile to within three miles. Similarly, the interquartile range widens as each buffer distance increases, indicating greater variation in the number of robberies in areas farther from grocery stores. Based on these observations, the risk of a robbery is significantly higher in areas 2-3 miles away from grocery stores compared to those within a 1-mile radius.

**Conclusion**

Several key findings emerge from this analysis. For one, the choropleth map of neighborhoods indicates that the majority of Detroit neighborhoods experience moderate levels of crime, while high-crime and low-crime areas are generally outliers that often cluster together, either with themselves or sometimes with the opposite extreme. The distribution of crime across the choropleth zip code map follows a very similar pattern. Additionally, the Excel data and descriptive statistics suggest that areas 2-3 miles from grocery stores are at a higher risk of experiencing robberies than areas within 1 mile. These insights are intended to support appropriate justice initiatives for high-crime areas of Detroit. Further research would do well to investigate the causal determinants of crime rate variation in Detroit in order to develop a framework for the safety and success of at-risk residents.

**Appendix**

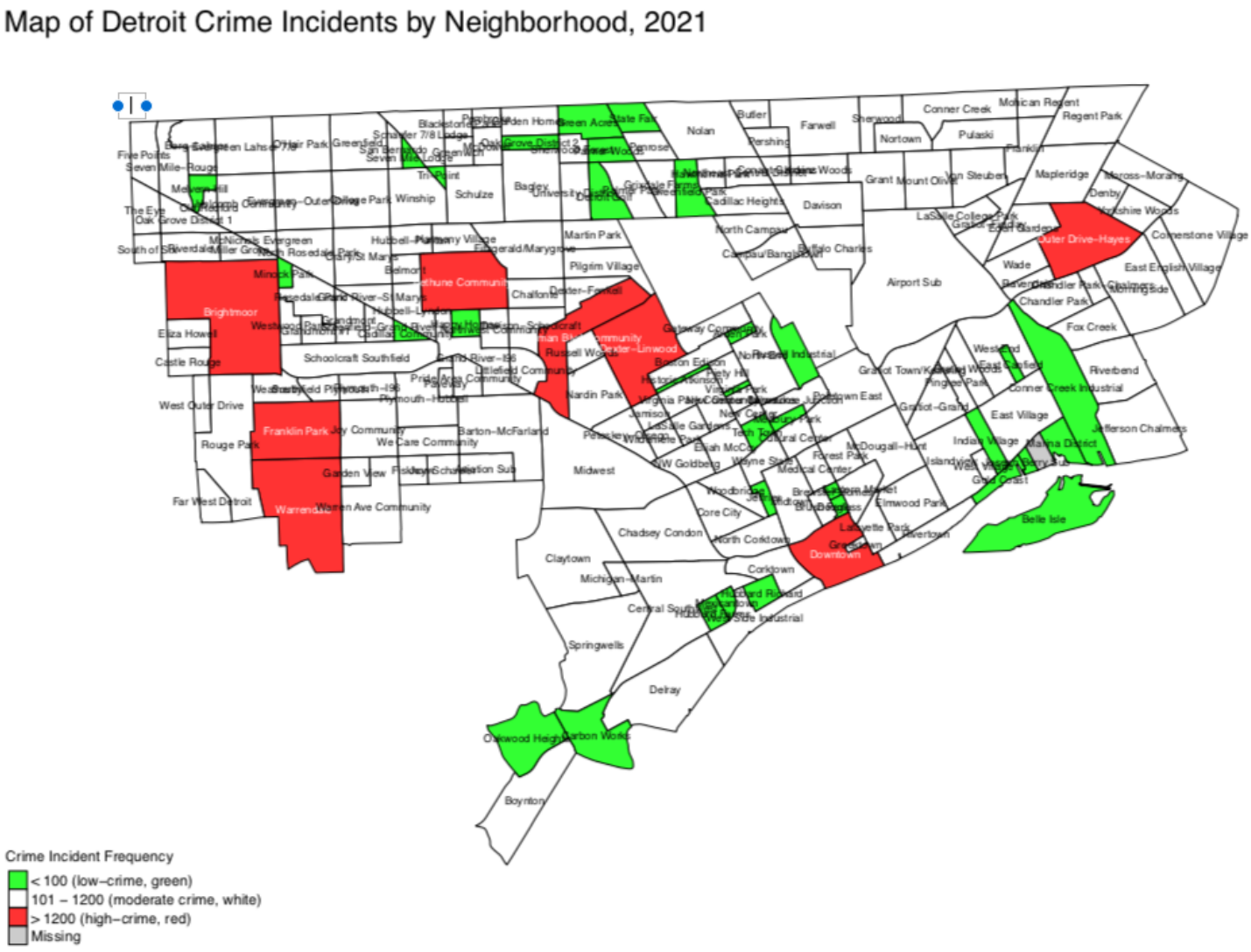



**Fig. 1 Map of Detroit Crime Incidents by Neighborhood, 2021**

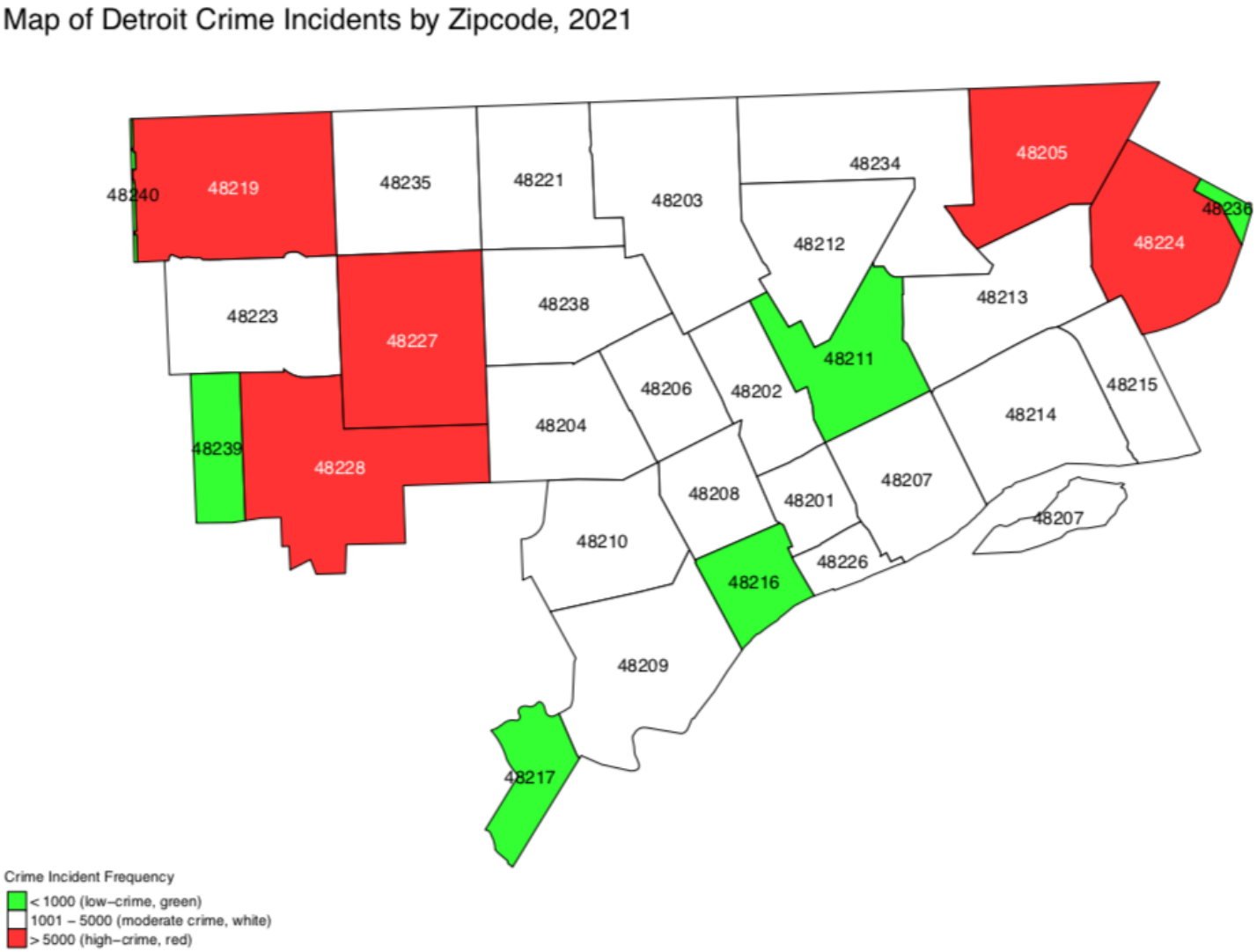



**Fig. 2 Map of Detroit Crime Incidents by Zip Code, 2021**

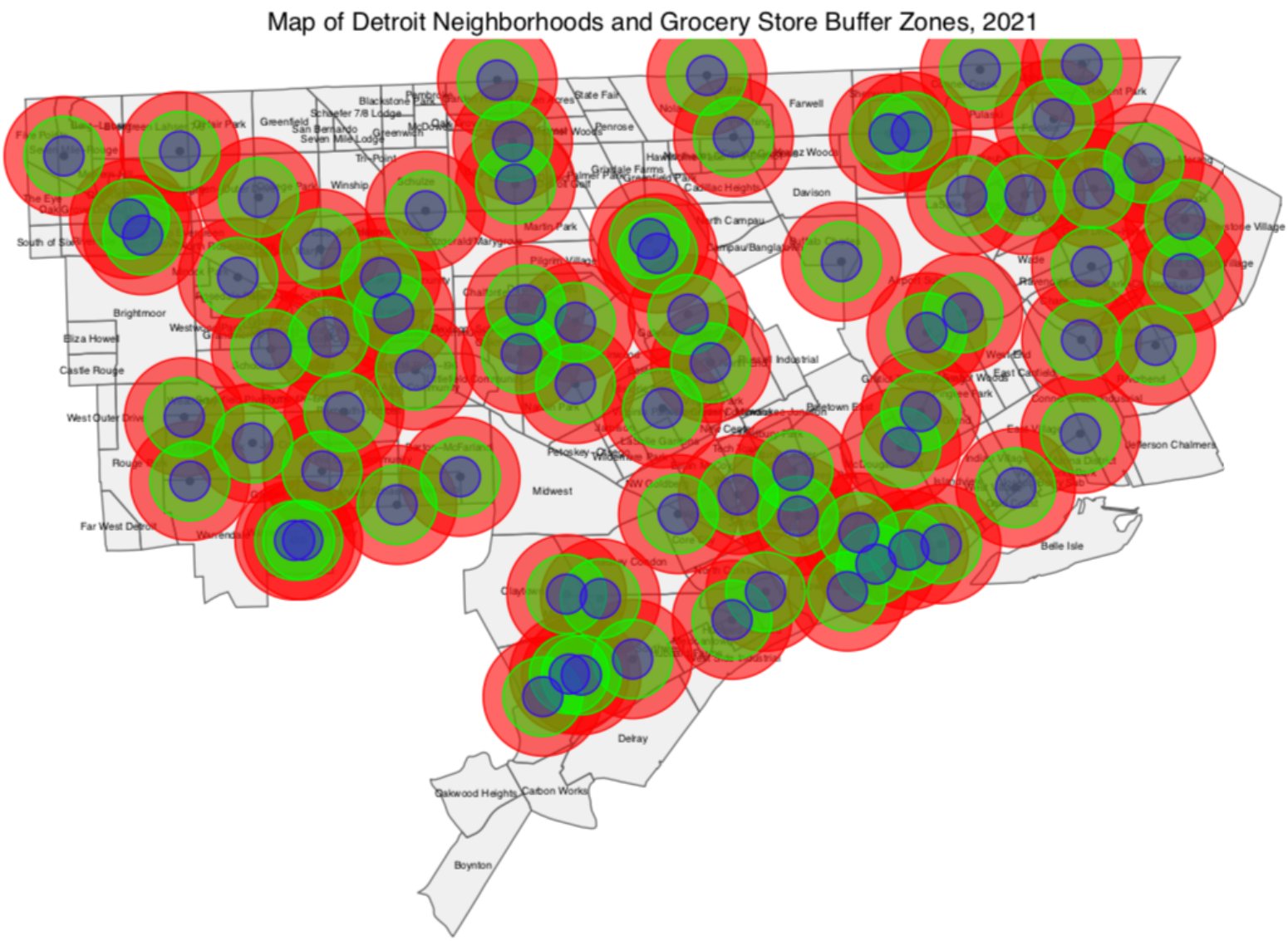
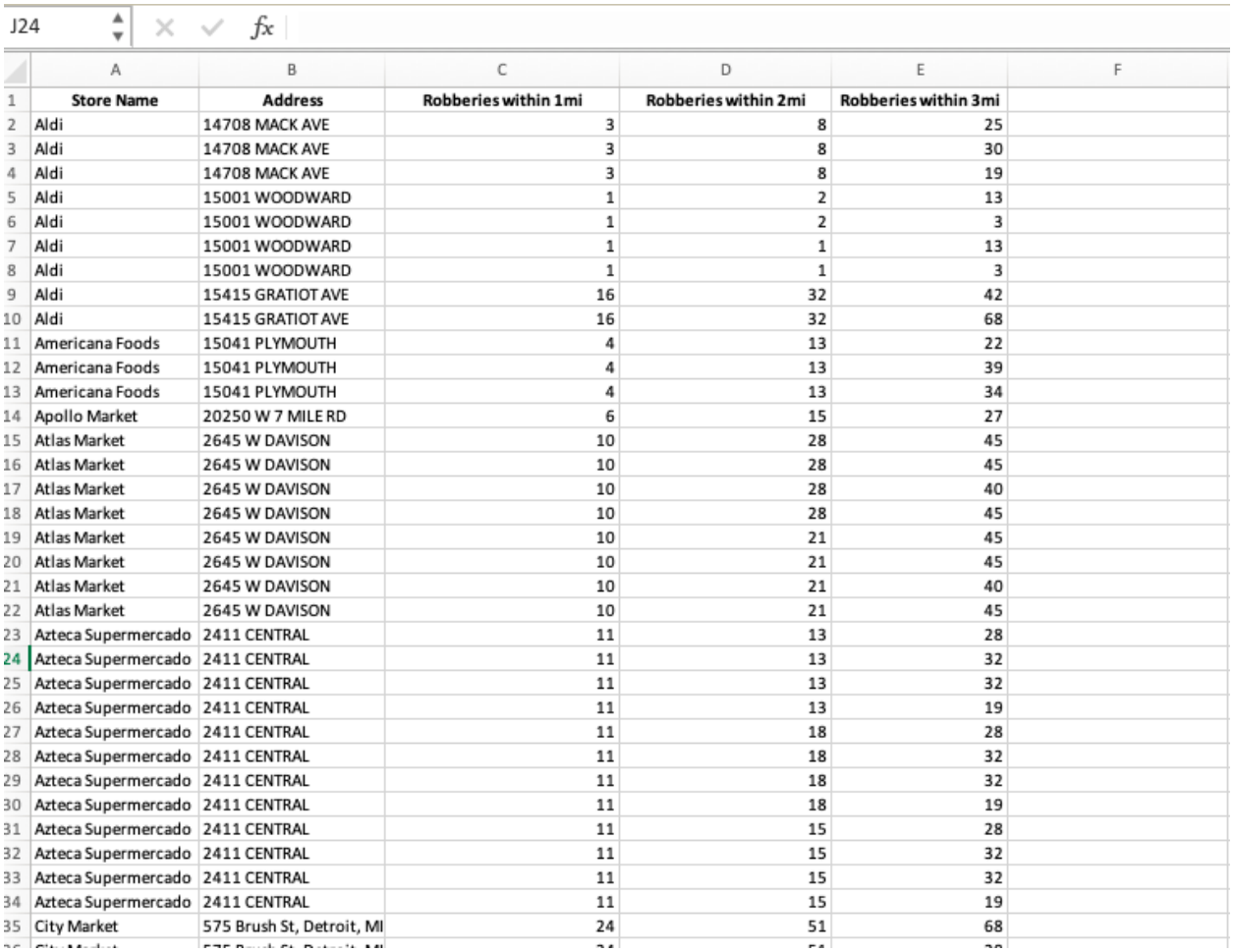



**Fig. 3 Map of Detroit Neighborhoods and Grocery Stores, 2021**

**Fig. 4 Excel Spreadsheet of Frequency of Robberies within Buffer Radii of Grocery Stores, 2021**



| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | Store Name | Address | Robberies within 1mi | Robberies within 2mi | Robberies within 3mi | |
| 2 | Aldi | 14708 MACK AVE | 3 | 8 | 25 | |
| 3 | Aldi | 14708 MACK AVE | 3 | 8 | 30 | |
| 4 | Aldi | 14708 MACK AVE | 3 | 8 | 19 | |
| 5 | Aldi | 15001 WOODWARD | 1 | 2 | 13 | |
| 6 | Aldi | 15001 WOODWARD | 1 | 2 | 3 | |
| 7 | Aldi | 15001 WOODWARD | 1 | 1 | 13 | |
| 8 | Aldi | 15001 WOODWARD | 1 | 1 | 3 | |
| 9 | Aldi | 15415 GRATIOT AVE | 16 | 32 | 42 | |
| 10 | Aldi | 15415 GRATIOT AVE | 16 | 32 | 68 | |
| 11 | Americana Foods | 15041 PLYMOUTH | 4 | 13 | 22 | |
| 12 | Americana Foods | 15041 PLYMOUTH | 4 | 13 | 39 | |
| 13 | Americana Foods | 15041 PLYMOUTH | 4 | 13 | 34 | |
| 14 | Apollo Market | 20250 W 7 MILE RD | 6 | 15 | 27 | |
| 15 | Atlas Market | 2645 W DAVISON | 10 | 28 | 45 | |
| 16 | Atlas Market | 2645 W DAVISON | 10 | 28 | 45 | |
| 17 | Atlas Market | 2645 W DAVISON | 10 | 28 | 40 | |
| 18 | Atlas Market | 2645 W DAVISON | 10 | 28 | 45 | |
| 19 | Atlas Market | 2645 W DAVISON | 10 | 21 | 45 | |
| 20 | Atlas Market | 2645 W DAVISON | 10 | 21 | 45 | |
| 21 | Atlas Market | 2645 W DAVISON | 10 | 21 | 40 | |
| 22 | Atlas Market | 2645 W DAVISON | 10 | 21 | 45 | |
| 23 | Azteca Supermercado | 2411 CENTRAL | 11 | 13 | 28 | |
| 24 | Azteca Supermercado | 2411 CENTRAL | 11 | 13 | 32 | |
| 25 | Azteca Supermercado | 2411 CENTRAL | 11 | 13 | 32 | |
| 26 | Azteca Supermercado | 2411 CENTRAL | 11 | 13 | 19 | |
| 27 | Azteca Supermercado | 2411 CENTRAL | 11 | 18 | 28 | |
| 28 | Azteca Supermercado | 2411 CENTRAL | 11 | 18 | 32 | |
| 29 | Azteca Supermercado | 2411 CENTRAL | 11 | 18 | 32 | |
| 30 | Azteca Supermercado | 2411 CENTRAL | 11 | 18 | 19 | |
| 31 | Azteca Supermercado | 2411 CENTRAL | 11 | 15 | 28 | |
| 32 | Azteca Supermercado | 2411 CENTRAL | 11 | 15 | 32 | |
| 33 | Azteca Supermercado | 2411 CENTRAL | 11 | 15 | 32 | |
| 34 | Azteca Supermercado | 2411 CENTRAL | 11 | 15 | 19 | |
| 35 | City Market | 575 Brush St, Detroit, MI | 24 | 51 | 68 | |

**Fig. 5 Descriptive Statistics of Robberies within Buffer Radii of Grocery Stores, 2021**

| Radii | Mean (Robbery Count) | Median (Robbery Count) | 1st Quartile (Robbery Count) | 3rd Quartile (Robbery Count) |
|---|---|---|---|---|
| **Within 1 mi (blue)** | 6.78 | 7 | 4 | 9 |
| **Within 2 mi (green)** | 16.55 | 15 | 11 | 20 |
| **Within 3 mi (red)** | 32.91 | 32 | 23 | 42 |