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Doane Mathematics

OPD Crime Analysis

November 29, 2020

Omaha Police Department - Exploratory Crime Analysis

Collecting and analyzing crime data has been common in the United States for over one hundred years. Crime started to be recorded in big cities in the late 1800's but the actual analysis didn't start until the early 1900's. The purpose of analyzing crime is to investigate police-related topics including socio-demographic, spatial, and frequential trends. The objective of these types of analyses is to aid law enforcement officers in criminal apprehension, crime and disorder reduction, crime prevention, and evaluation. By optimizing a police department's resources, they'll be able to focus their efforts on hot spot areas and evaluate their previous processes.

The Omaha Police Department (OPD) is the largest law enforcement agency in Nebraska. With an annual budget over 160 million dollars and 902 employed police officers, they respond to on average over 50,000 reports a year. OPD publicly releases all of their reported crime incident data. They began publicly releasing their crime data on June 1, 2015. As of November, 2020, over 250,000 crimes have been recorded within their database. The variables located within the dataset are as follows: report date, report time, ordinance description, address, and latitude and longitude coordinates. In order to analyze this data further, the weekday, month, year and crime category variables were created.

A variety of statistical and visual programs were used to conduct this crime analysis. The four main programs are RStudio, ArcGIS Pro, Tableau, and Excel. RStudio is a statistical program mainly used for data cleaning, statistical testing, plotting, and filtering. For this project, a free version of RStudio 3.6.3 Desktop was used. ArcGIS Pro is a mapping program that creates detailed spatial maps. Within this analysis, it was used specifically to create and

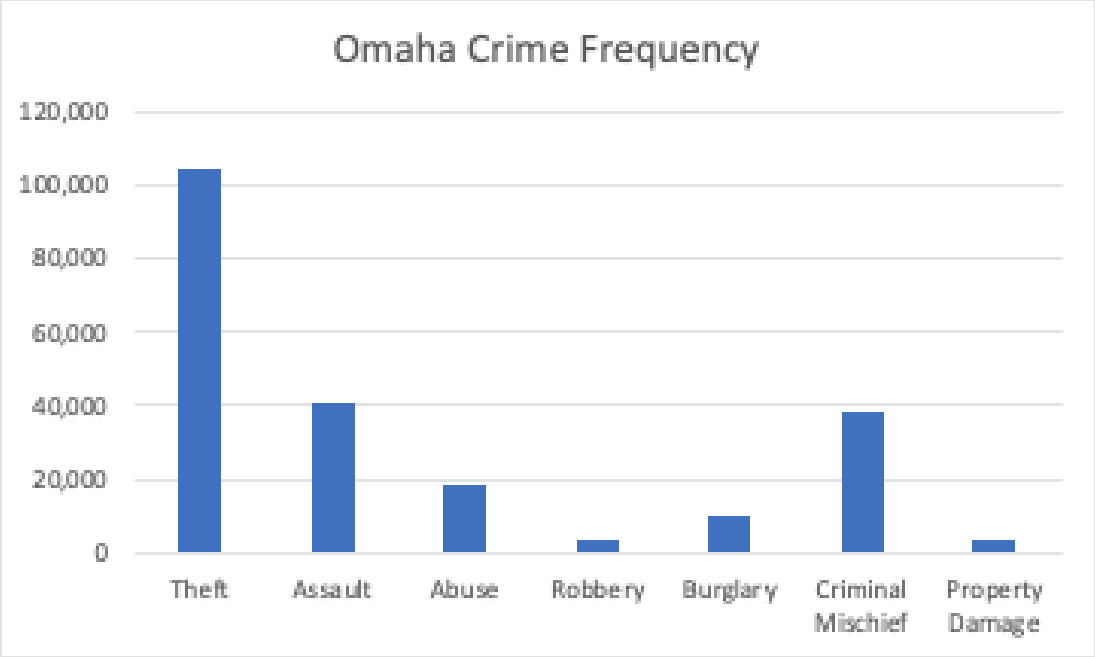
visualize different crime category heat maps. It also aided in identifying hotspots and trends in crime over time. A student license was obtained in order to gain access to ArcGis Pro. Tableau is a drag and drop visualization program which allows for a variety of plots to be created. This program played a key role within this project because it was used to create time series visualizations which helped in determining if particular crimes had periodicity. A student license was also required to access this program. Excel is a spreadsheet program that works well for storing, wrangling, manipulating, and visualizing data. This program played a key role in categorizing crime ordinances into categories from established keywords. Excel's conditional formatting functionality also played a critical role in spotting significant findings. Microsoft Excel 2019 was used for this project's analyses.

The first step of this project was to conduct a variety of data cleaning procedures. OPD's incident data is organized by year. This meant that the data wasn't able to be analyzed yet as a whole. In order to fix this issue, the 2015, 2016, 2017, 2018, 2019, and 2020 (as of September 26th) incident reports were combined together in RStudio. Once the dataset was merged, there were over 250,000 rows of crime data observations. Since the objective of this project is to determine how crime has changed within Omaha over time, more time-series variables were created. These variables include weekday, month, and year that the crime was reported. Another important aspect is to be able to determine what types of crimes have seen the most amount of change. With 267 unique crime ordinances reported, it would've been extremely difficult to determine what type of crime has been impacted. The 267 unique crime ordinances were categorized into six different categories that include: theft, assault, abuse, criminal mischief, robbery, burglary, and property damage. The categorization of these crimes was possible by the use of Excel. A function call was used to read through the ordinance column and categorize the ordinance based on keywords that were contained in the report description.

The next step of the project was to determine how the crime data is distributed within weekdays and months and to determine what crimes are the most frequently reported. A series

of bar charts were created to help aid with visualizing the distribution of crime. An important aspect to consider is that OPD started publicly releasing its crime data on June 1, 2015 and the dataset ends on September 26, 2020. In order to remove any bias from the distribution, crime data from 2015 and 2020 were not used within the month bar charts. After creating several plots, a variety of significant findings stood out.

From this bar graph containing crime frequency counts, it is clear that theft definitely



occurs the most with 104,203 reports since June 1st, 2015. From there, ArcGIS was used to visualize how theft compares to the other reported crimes. The heat maps located in Appendix E, show that the majority of crime is located in the eastern part of Omaha, which prompted a new question. How are precincts situated to most efficiently manage crime?

With Omaha rapidly expanding westward, the city had to rezone its policing precinct districts in 2019. The issue with rezoning a city's policing districts is that the location of the precinct headquarters is no longer centrally located. In Appendix A, you can see how the precinct boundaries have changed in Map #1. With the addition of the West Precinct, the Northwest and Southwest precincts now have their headquarters located in the western part of their territory.

With a boundary change, it would be ideal to be able to move the location of the precinct headquarters. Unfortunately, moving a headquarters would be extremely expensive and time consuming. If money and logistics were not an issue, let's determine where a precinct should be located with a boundary change. A precinct should not necessarily be located directly in the center of the territory. This is because crime is not typically evenly distributed with the precinct. A subset of the data was used to determine where a police headquarters should go according to the precinct's center of mass for crime. In order to do this, all the theft reports occurring in 2015 within the Southeast Precinct were selected. ArcGIS was used to wrangle the data located within this precinct and export the incidents to a CSV file. Two different centers of mass methodologies were used, utilizing the following center of mass formula:

$$Center\ of\ mass\ =\ (x,\ y)\ =\ ((1/n)\sum_{i=1}^{n} w_i x_i,\ (1/n)\sum_{i=1}^{n} w_i y_i)$$

$$where\ (x_i, y_i)\ is\ the\ (longitude, latitude)\ for\ crime\ i, i\ =\ 1,\ 2,\ 3,\ldots\ n,\ and\ w_i\ is\ the\ associated\ weight.$$

The first methodology weighted each crime the same in regards to severity. The second methodology gave thefts that involved higher amounts of money more weight. Both of these center of masses were calculated and plotted on Map #2 in Appendix A. It is clear that the weighted and unweighted center of masses should be located north of where the current precinct is located. Since the weighted and unweighted center of masses are close to each other, the severity of theft crimes reported within the Southeast Precinct is relatively evenly distributed. This process could be replicated in the other precincts to determine where the optimal location for a police precinct is.

Another common way to analyze crime data is by looking at how crime is geographically distributed. With over 267 unique ordinances used by OPD, determining spatial trends would be difficult. In order to look at Omaha's crime data we're going to focus on its primary crime categories of abuse, assault, burglary, criminal mischief, property damage, robbery, and theft. In

Appendix E, theft is represented by a red dot in Map #1. Theft is the most frequently reported crime in Omaha so it's not surprising that this map has the highest amount of red dots. Robbery has the least amount of reports so it's expected that there are much fewer pink dots representing robbery. One of the most effective ways of determining hotspot areas is by using heat maps. In the Appendix E, there are 8 heat maps (Map #2 - Map #8) that identifies hot spots for each of the crime categories.

Map #2 displays a heat map for all of the crime categories combined. As you can see, the majority of the crime reported occurs in Downtown, South Omaha, North Omaha and shopping districts. Map #3 displays the heatmap for abuse reports. Abuse is prevalent in North Omaha, the Old Market, and a small region in South Omaha. Map #4 displays hotspots for assault reports. The map indicates that assault is mostly reported in the neighborhoods of North Omaha, the Old Market, and the neighborhoods in South Omaha. Map #5 highlights where there are hotspots for burglaries. The eastern neighborhood in South Omaha, and the shopping districts near Downtown, North Omaha, Benson and near the Knolls Golf Course have large amounts of incidents. Map #6 shows that the Old Market has the highest amount of criminal mischief reports. The neighborhoods surrounding Downtown to the north and south also have high volumes of criminal mischief reports. Map #7 displays that Downtown and the shopping district in Benson have a high number of property damage reports. Map #8 displays the heat map of robberies within Omaha. The highest number of robberies typically occur near 28th in Leavenworth and surrounding nearby gas stations and convenience stores. There are also prominent hot spots in North Omaha and the western and eastern neighborhoods in South Omaha. Map #9 shows that there are several major hotspots for theft within the city. Some of these areas include the Village Pointe Mall, Oak View Mall, Westroads Mall, the shopping district on West Center Road, the 72nd and Pacific Walmart, Downtown, and the neighborhoods south of Downtown in South Omaha. The shopping centers and districts appear to have the highest concentrations of theft which would make sense since these locations have high

amounts of valuable items. What is interesting is that even though North Omaha has high frequencies of other crimes, theft is not nearly as prevalent.

From these heatmap interpretations, it's easy to infer that crime is much more prevalent in North Omaha, Downtown, South Omaha, and at shopping centers. Before jumping to conclusions, several things must be considered. For instance, this data represents all reported crime. Every crime reported is not necessarily factual evidence that the crime actually happened. Another thing to consider is that eastern Omaha has a population density that is much greater than the central and western regions of Omaha. This is important to consider because an increase in population size will also most likely increase the number of crime reports. The majority of crimes are also significantly high within the Old Market. The Old Market is home to a wide variety of bars, restaurants, and entertainment venues. This area is frequently populated with a large number of people. This means that the number of crimes here being high is not surprising. During the summer of 2020, several protests occurred due to civil unrest. During these protests, there were groups of individuals who were not with the peaceful protesters that caused significant damage and committed a variety of crimes. Since these protests occurred at 72nd and Dodge St. and the Old Market, seeing a hot spot in these areas is not surprising. Even with all of these considerations, these crimes still were reported in these locations in high frequencies and should still be identified as hotspots.

A common objective of analyzing crime is to determine how it has changed over time. Knowing how crime has changed over time can give police officers insight on how to serve and protect their cities better. With the Omaha Police Department having over five years of data available, a time series analysis may be able to describe significant trends. The first step was to determine how the different crime categories are distributed on a weekday and monthly basis. After making a variety of plots in Appendix B, several interesting trends were discovered. For instance, according to the Theft by Month plot (Plot #7), it appears that the fall months (August, September, October, and November) typically have more reports than the earlier months of the

year. Another interesting finding is that in Plot #2, it appears that the summer months (May, June, July, August, and September) have a higher frequency of assault crimes than the later part of the year. For Plot #6, the number of robbery reports increase during the last few months of the year and seem to be higher during the summer months. For criminal mischief, the frequency of reports are higher during the months of March, April, June, July, August and September in Plot #4. In respect to weekday, it appears that more theft, abuse and burglary reports occur during the beginning of the week than the end of the week in Plots #8, #10 and #14. This may be because some reports would happen on Mondays after they were discovered from the weekend. Another interesting finding is that it appears that Wednesday has the greatest number of criminal mischief reports.

Even though bar plots can display data pretty well, there is not enough evidence to determine if a month or weekday exhibits significantly higher or lower crime averages than another month or weekday. One way to determine if two months or weekdays have significant average differences is to run a Tukey HSD test. A Tukey HSD test compares each crime category's month or day average frequency against each other. The resulting p-values determine the significance of the mean differences. In order to check the inferences made above, a Tukey HSD test was run to compare each pairwise average. Let’s look at a few of the pairwise comparison charts that were created. The comparisons made for theft by month and criminal mischief by weekday are located in Table #1 and Table #2 in Appendix C.

As you can see from the month pairwise comparison for theft, the summer months of May, June, July, August and September typically have higher frequency averages than the last few months of the year. The significant p-values below 0.05 are highlighted in green. An important aspect to note is that none of the significant intervals contain the value zero. This occurs because an interval containing zero shows that neither month or weekday being compared is consistently higher or lower than the other.

From the criminal mischief weekday chart, the average number of criminal mischief thefts on Wednesday is significantly higher than any of the other days of the week. Within the chart there is not a single example where another day had a higher criminal mischief average then Wednesday. This finding is interesting because criminal mischief is unlike several of the other crimes. The other crimes typically peak during the beginning and end of the week.

After each month and weekday pairwise comparison was analyzed for significance, several interesting trends were discovered. The following chart displays the significant trends displayed by the Tukey HSD Test.

Significant Pairwise Comparison Trends	
Month Comparisons	
Theft	The average number of theft reports during the fall season (August, September, October and November) are typically significantly higher than the beginning months of the year, spring season and summer season.
Abuse	There are no significant differences in monthly abuse report averages.
Assault	The average number of assault reports during the summer months (May, June, July, August and September) are higher than the last few months of the year (October, November, and December).
Robbery	The average number of robbery reports during the later months of the year (September, October, November and December) are higher than any of the other months of the year.
Burglary	The average number of burglary reports during the summer and fall seasons (June, July, August, September and October) are higher than the beginning and ending months of the year.
Criminal Mischief	The average number of criminal mischief reports during the spring and summer months of the year (March, April, June, July, August, and September) are typically significantly higher than the beginning and ending months of the year.
Property Damage	There are no significant differences in monthly property damage averages.
Day Comparisons	
Theft	The average number of theft reports occurring during the beginning of the week is higher than the end of the week.
Abuse	The average number of assault reports occuring during the beginning of

	the week is lower than the end of the week.
Assault	The average number of abuse reports occurring during the beginning of the week is higher than the end of the week.
Robbery	There are no significant differences in daily robbery occurrence averages.
Burglary	The average number of burglary reports during the beginning of the week is higher than the end of the week.
Criminal Mischief	The average number of criminal mischief reports on Wednesday is higher than any other day.
Property Damage	The average number of property damage reports on Sunday is less than Wednesday.

Since there are significant time series trends in the data, there is a possibility that this data is periodic. Periodic means that an event occurs at the same time during each cycle of time. In this case, it would be interesting to determine if certain crimes have significant periodic trends. In order to conduct an analysis like this, the data must be in a certain format. Instead of having each row be a specific incident, each row must instead display the frequency of each crime category associated to a specific date. The “Time Series Frequency Data” table displays a small sample of the newly created time-series data frame.

Time Series Frequency Data							
Date	Theft	Assault	Abuse	Burglary	Robbery	Property Damage	Criminal Mis
6/23/15	47	19	10	7	1	1	17
6/24/15	86	15	13	2	1	1	23
6/26/15	58	21	9	4	1	1	20
6/27/15	46	25	7	6	2	2	27
6/30/15	39	25	15	4	2	1	26

Within RStudio, the decomp() function was used to determine if any significant periodic trends existed. Unfortunately, zero periodic tendencies were significant. Instead of analyzing periodicity of all crimes, each crime category was assessed individually. Each crime category

was determined to have insignificant periodicity. This means that the average number of crimes that happen each day for each of the crime categories don't follow any significant periodic daily trends. The plots in Appendix D display time series plots for all crime, and each of the crime categories. As you can see from the plots, even though it appears that periodicity might exist, enough variance is present to make it insignificant. This does not mean there is no difference in different days and months -- There are significant differences shown from the pairwise comparisons. However, those differences aren't *periodic* differences where all weeks experience the same ups and downs across their days, or all years experience the same ups and downs across their months. However, recent months definitely could provide some unique analyses.

During the month of March in 2020, COVID-19 officially became a worldwide pandemic. This monumental event influenced the lives of everyone on the planet. With quarantining becoming a new norm, national civil unrest growing, and a declining economy, people's behaviors and views were affected. There hasn't yet been time for published research to show how the pandemic has affected crime. In order to see if the pandemic has influenced the frequency of crime in Omaha, the same process to evaluate time series data was followed from above. A subset from the original data was extracted to run these analyses. The first reported date in the subset is March 9, 2020 and the last date is November 10, 2020.

Similar to analyzing the crimes from 2015 to 2020, a series of bar graphs were made to examine the distribution of crime during the pandemic time period. These plots are located in Appendix F. There are several trends that are present. For example, It seems like theft and burglary has been rising since the beginning of the pandemic. There also appears to be fewer robberies in the month of July. In respect to weekdays, it appears Tuesdays and Wednesdays have more assault reports than Sunday. For burglary, Mondays seem like they have the highest number of reports. Instead of having criminal mischief have the highest frequency of reports on Wednesday, it seems like Monday is typically higher than Tuesday and Saturday.

In order to test these inferences, a Tukey HSD Test was run to compare the means of all the months and weekdays. The chart provided below describes how the COVID-19 pandemic time period relates to previous years.

COVID-19 Pairwise Mean Comparison Findings				
Crime	**All data ANOVA**	**COVID ANOVA**	**All data pairwise conclusions**	**COVID pairwise conclusions**
Abuse by Day	Significant Difference	Not Significant	Average reports are higher: • Weekdays than Sat. • Wed. than all other days	No significant difference in average number of reports by day of the week.
Assault by Day	Significant Difference	Significant	Average reports are higher: • Weekdays than Sat. • Wed. than all other days • Tues., Wed. than Sun.	Average reports are higher: • Tues., Wed., Thurs. than Sun. • Sat. than Tues.
Burglary by Day	Significant Difference	Significant	Average reports are higher: • Weekdays than Sat. • Mon. than several days	Average reports are higher: • Mon. than Tue., Sun.
Criminal Mischief by Day	Significant Difference	Significant	Average reports are higher: • Wed. than all other days	Average reports are higher: • Mon. than Tue., Sat. • Sun. than Thurs.
Property Damage by Day	Significant Difference	Not Significant	Average reports are higher: • Thurs. than Sun.	No significant difference in average number of reports by day of the week.
Robbery by Day	Significant Difference	Not Significant	Average reports are higher: • Wed. than Sun.	No significant difference in average number of reports by day of the week
Theft by Day	Significant Difference	Significant	Average reports are higher: • Weekdays than Sat./Sun. • Wed. than all others	Average reports are higher: • Weekdays than Sun.
Abuse by Month	No Significant Difference	Not Significant	No significant difference in average number of reports between months.	No significant difference in average number of reports between months.
Assault by Month	Significant Difference	Significant	Average reports are higher: • May - Sep. than Oct. - Dec. (That is, summer is higher than last month of the year.)	Average reports are higher: • June than Mar., Apr., Sep., Oct. • Aug., Jun. than Oct.
Burglary by Month	Significant Difference	Not Significant	Average reports are higher: • May - Sep. than Oct. - Dec. (That is, summer is higher than last month of the year.)	No significant difference in average number of reports between months.
Criminal Mischief by Month	Significant Difference	Not Significant	Average reports are higher: • May - Sep. than rest of year. (That is, summer is higher than the rest of the year.)	No significant difference in average number of reports between months.
Property Damage by Month	No Significant difference	Not Significant	No significant difference in average number of reports between months.	No significant difference in average number of reports between months.
Robbery by	Significant	Not Significant	No significant difference in average number	No significant difference in average number of

Month	Difference		of reports between months.	reports between months.
Theft by Month	No Significant Difference	Not Significant	No significant difference in average number of reports between months.	No significant difference in average number of reports between months.

There are several interesting changes that have occurred since the pandemic. For example, when looking at the data from 2015 to 2020, Wednesday has significantly higher amounts of criminal mischief than any other day. During the pandemic timeline though this is no longer true.

Since the pandemic, Mondays have more theft reports than Tuesdays and Saturdays. This is interesting because “According to 2013 research done by the Guardian in Great Britain, most theft occurs on Mondays and Tuesdays” (Moss, 2013). However, the Omaha crime data shows that Wednesdays have the most theft crime reports prior to the pandemic. With the influence of the pandemic, Omaha is now more similar to other large cities across the country with less theft being reported during the middle of the week.

Another interesting finding is that several of the other pairwise comparisons are no longer significant. There are several reasons why this is possible. One reason is that there is an insufficient amount of data to provide high significance. There is also no data for the last couple months of the year. No comparisons can be made to the months of November and December because there is a small amount of data provided. Despite these two setbacks, one possible inference is that the pandemic has caused the frequency of crime to become more consistent between the months. While looking at the bar graphs for the pandemic time period in Appendix F, it appears that several of the crime categories have less variance than previous years.

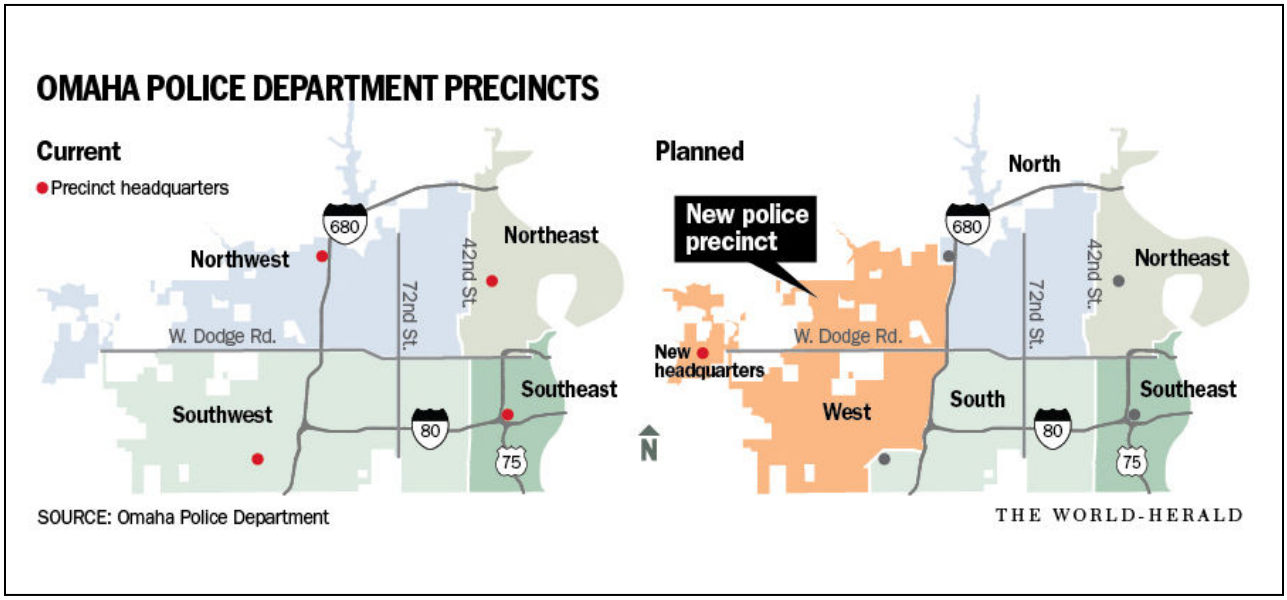
The main purpose of this project was to provide OPD with information to help them make decisions on how they can enforce the law. From Omaha’s crime incident dataset, frequential, geographic, statistical, and time series trends were able to be detected. With a limited budget and number of officers, OPD can use this information to determine when and where specific crimes typically occur. One of OPD’s Policing Values states that they value “Managing our

resources carefully and effectively while utilizing technology to maximize efficiency”. By using some of the methodologies discussed in this analysis, the Omaha Police Department can better serve and protect the citizens of Omaha, Nebraska.

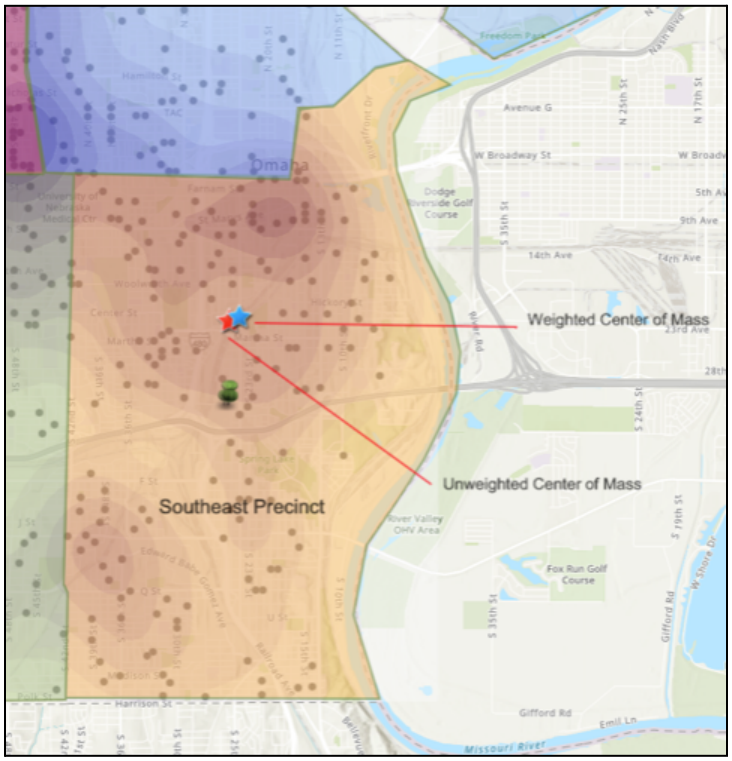
Visualization / Chart Appendix

Appendix A (Precinct Boundary and Crime Center of Mass Maps)

Map #1 (Precinct Boundaries - Omaha Nebraska)



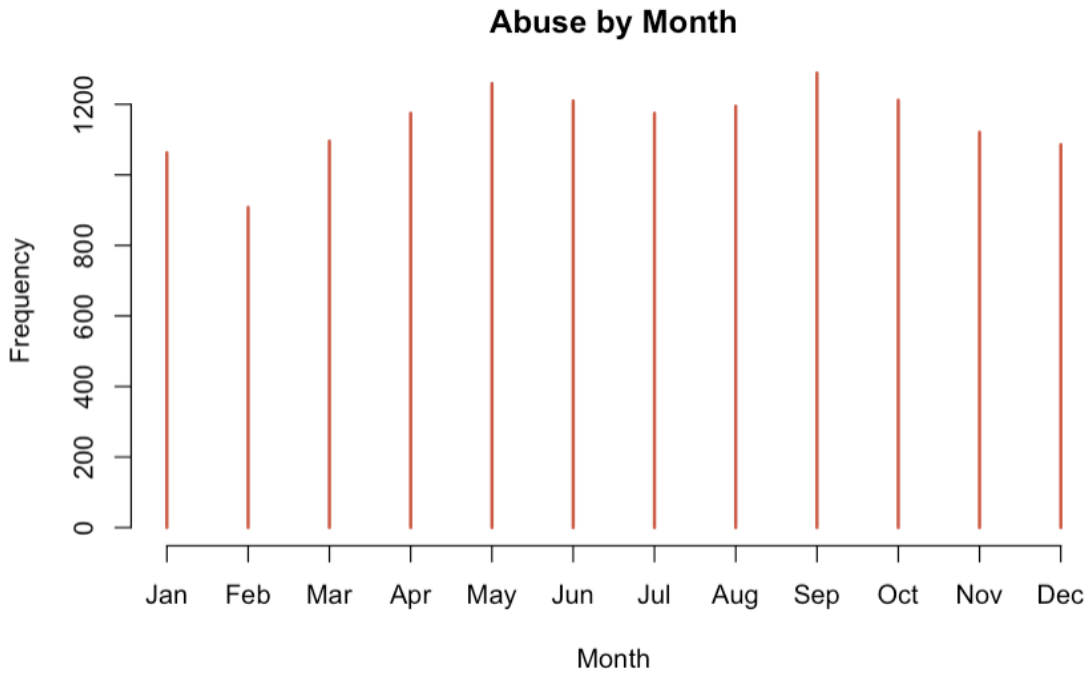
Map #2 (Southeast Precinct weighted and unweighted center of masses)



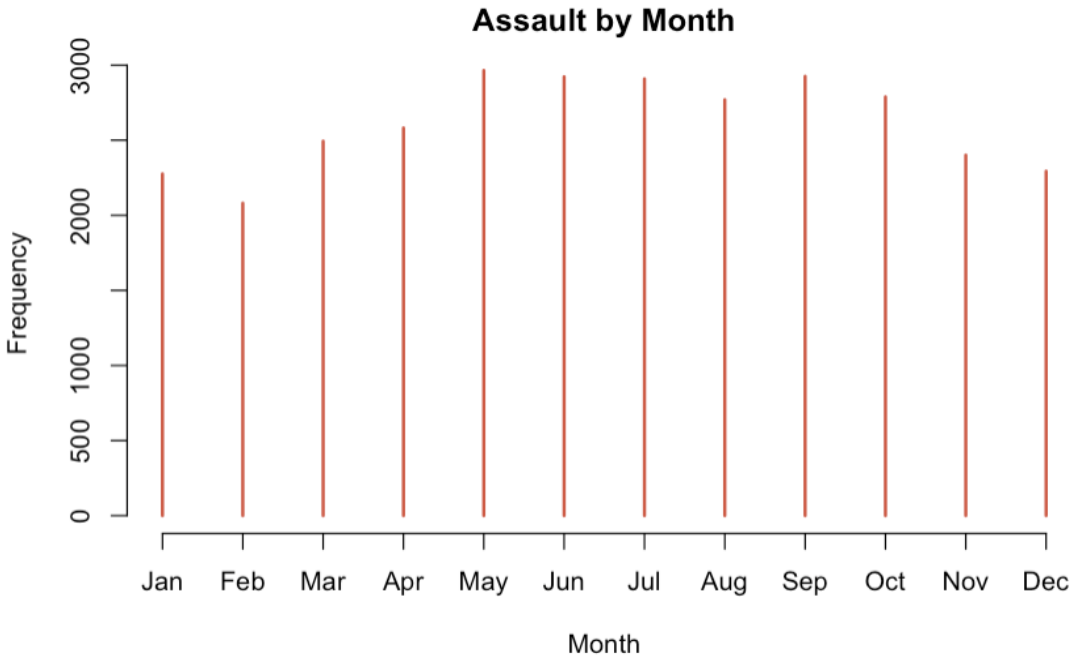
Appendix B (2015-2020 Crime Category Frequency**)**

Months

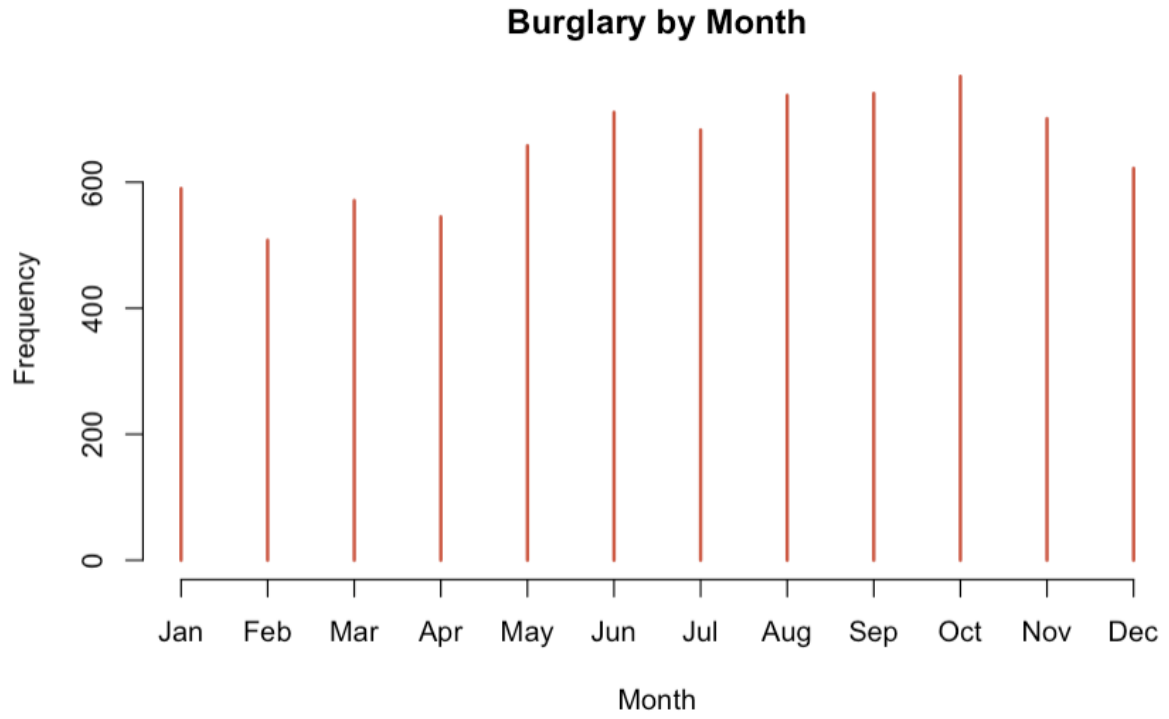
Plot #1



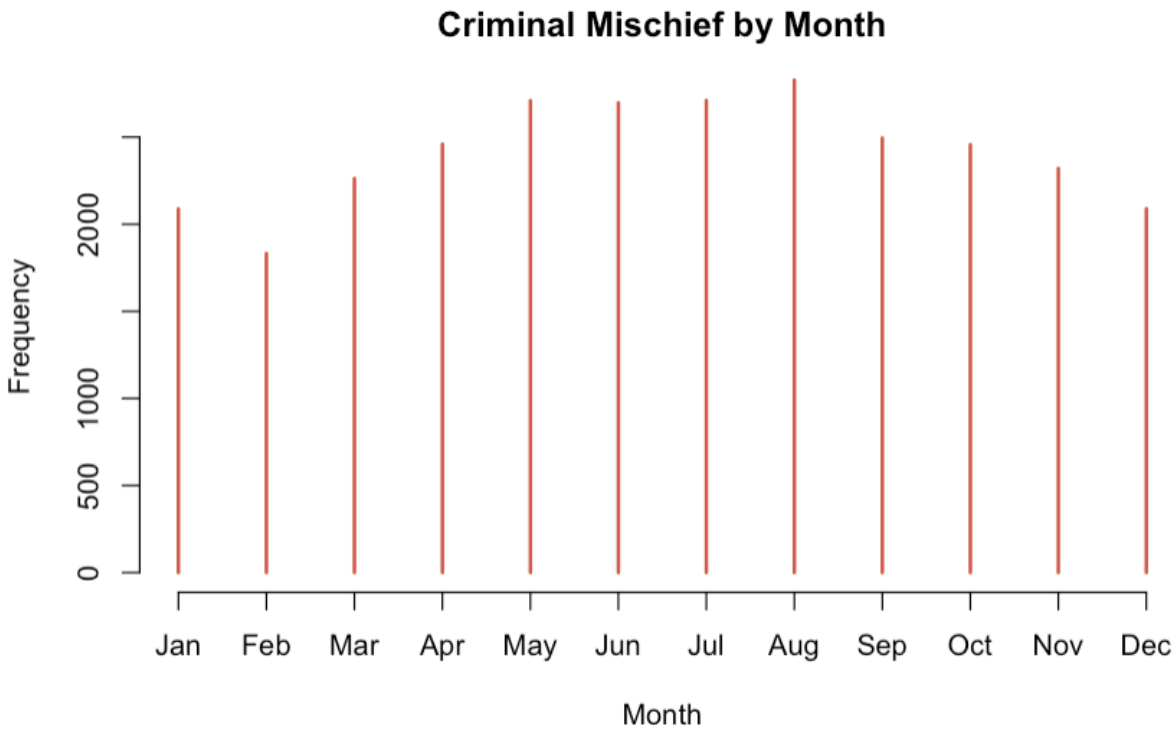
Plot #2



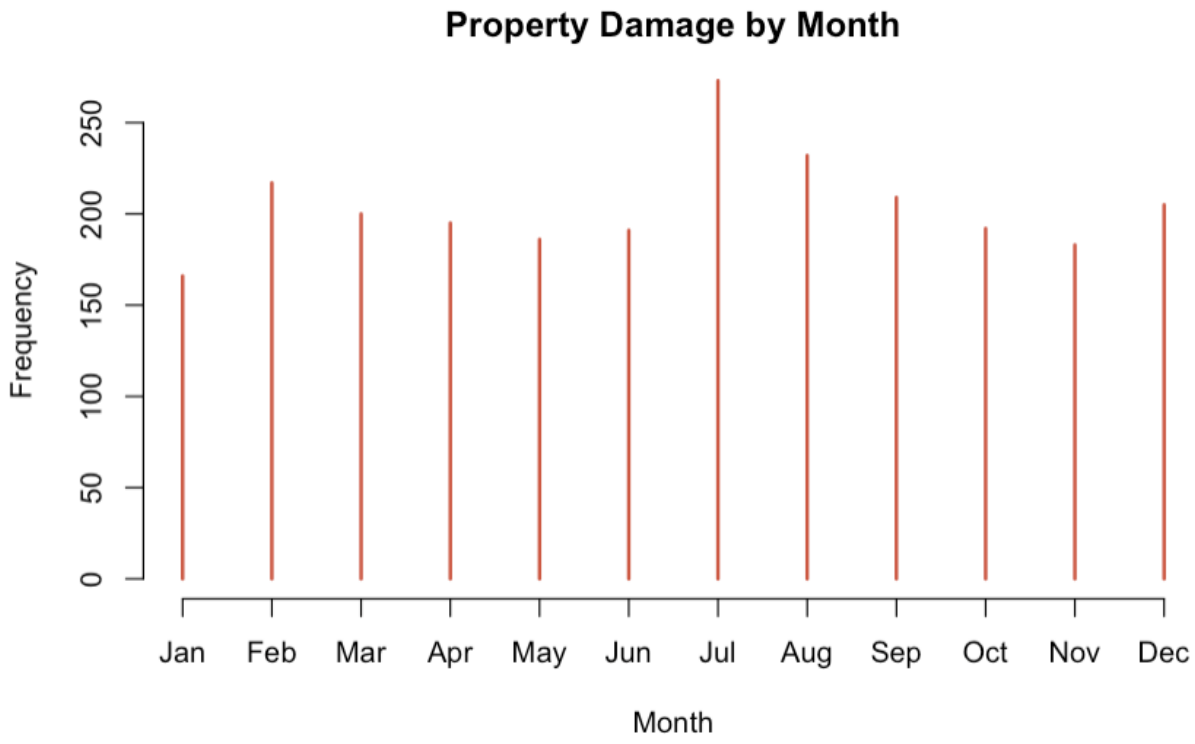
Plot #3


Burglary by Month
Frequency
0
200
400
600
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

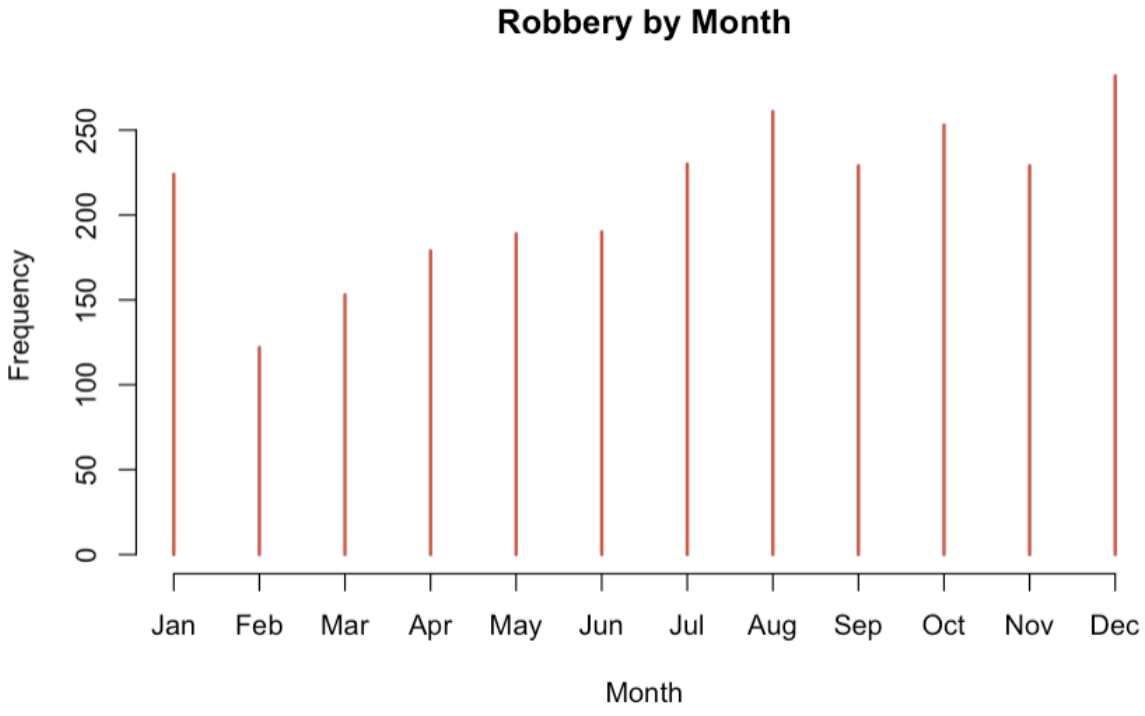
Plot #4


Criminal Mischief by Month
Frequency
0
500
1000
2000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

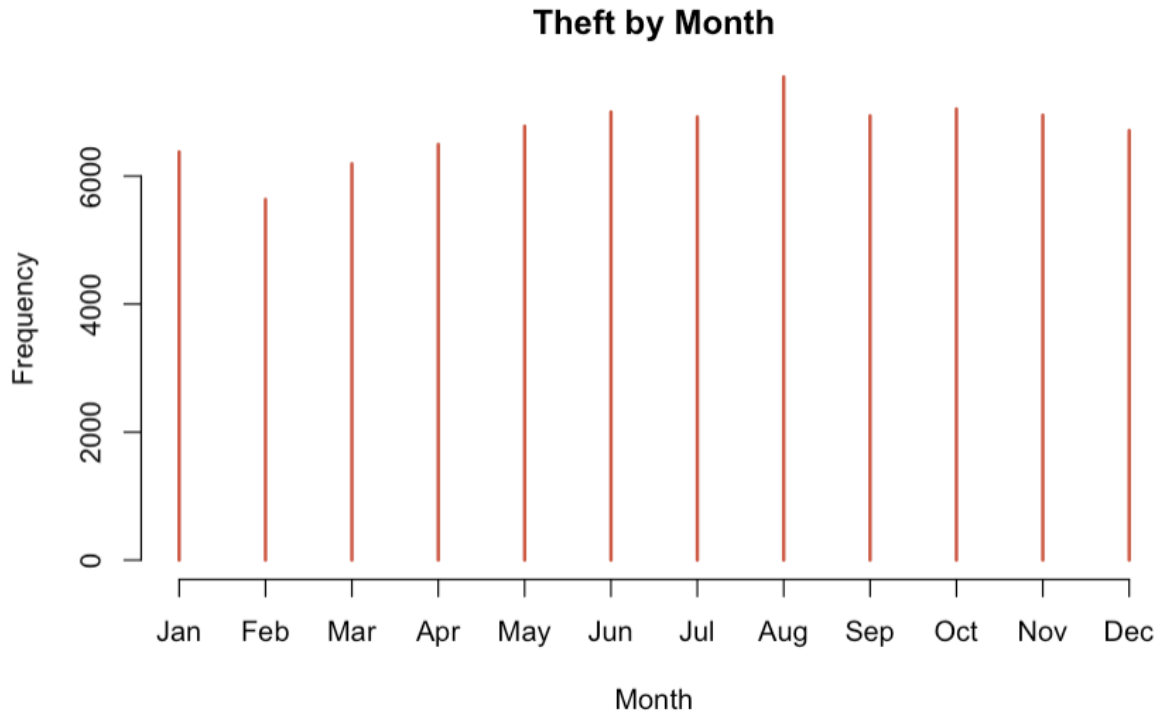
Plot #5


Property Damage by Month
Frequency
0
50
100
150
200
250
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Plot #6

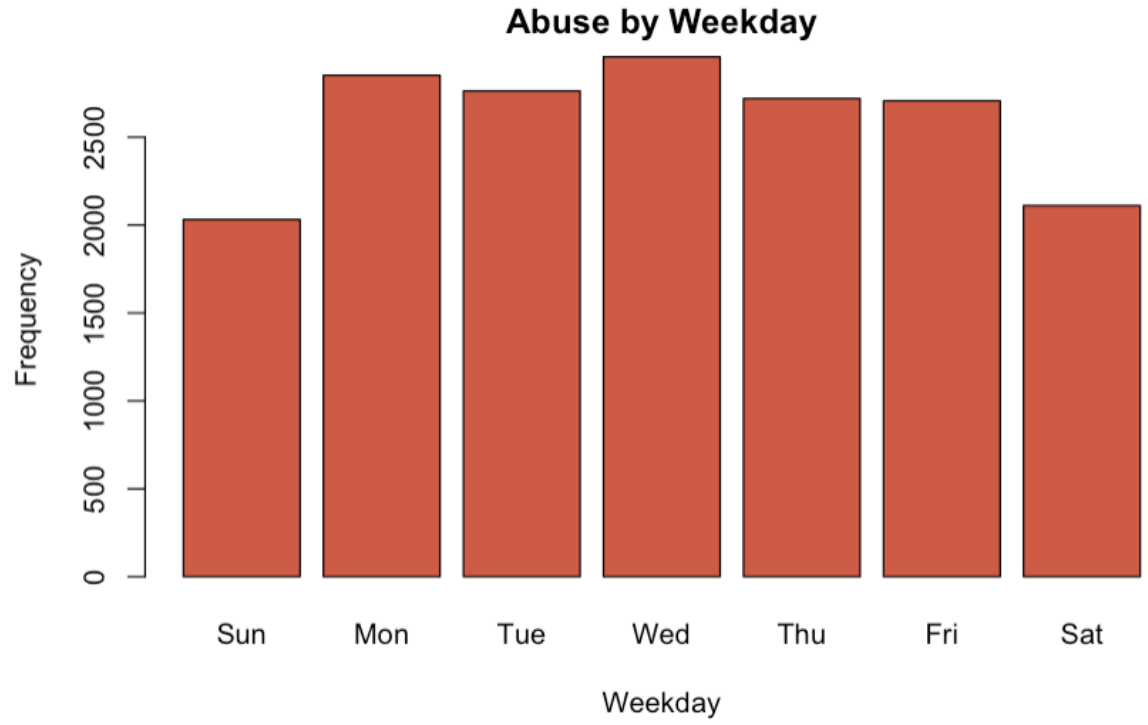

Robbery by Month
Frequency
0
50
100
150
200
250
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Plot #7

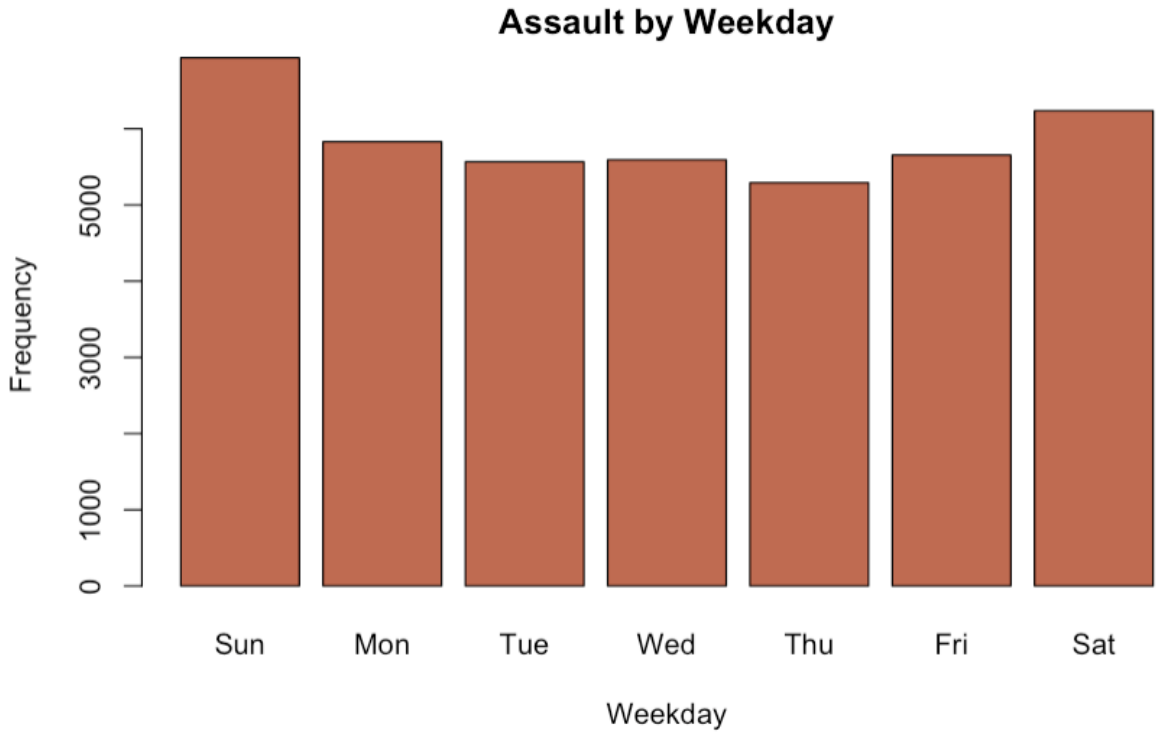


Weekdays

Plot #8



Plot #9



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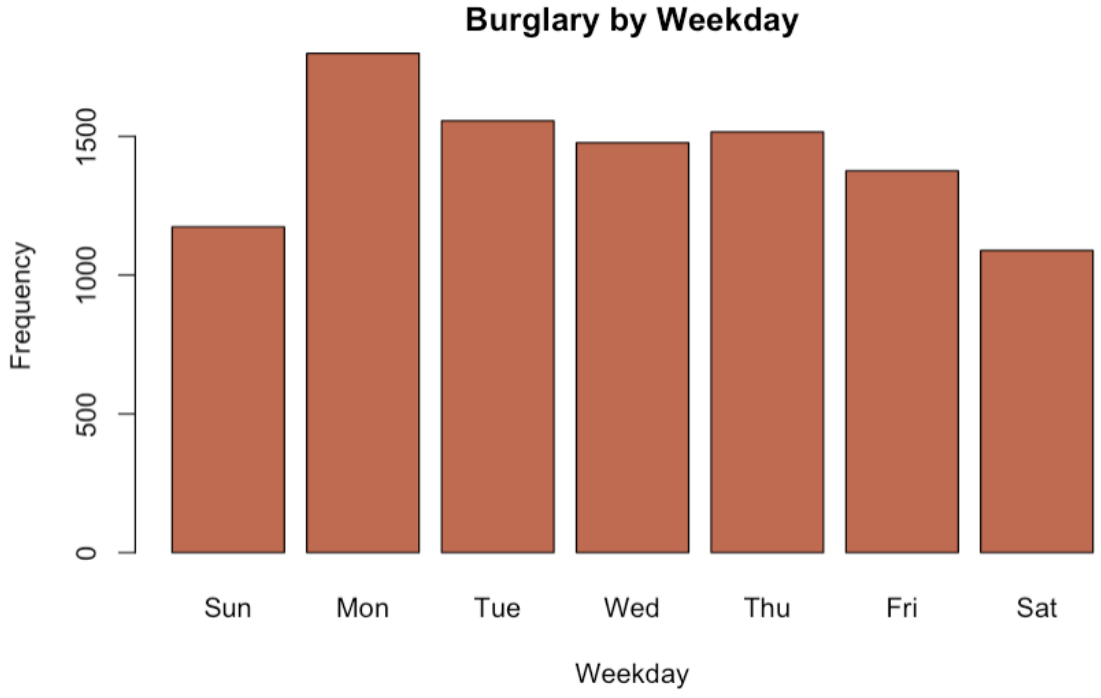
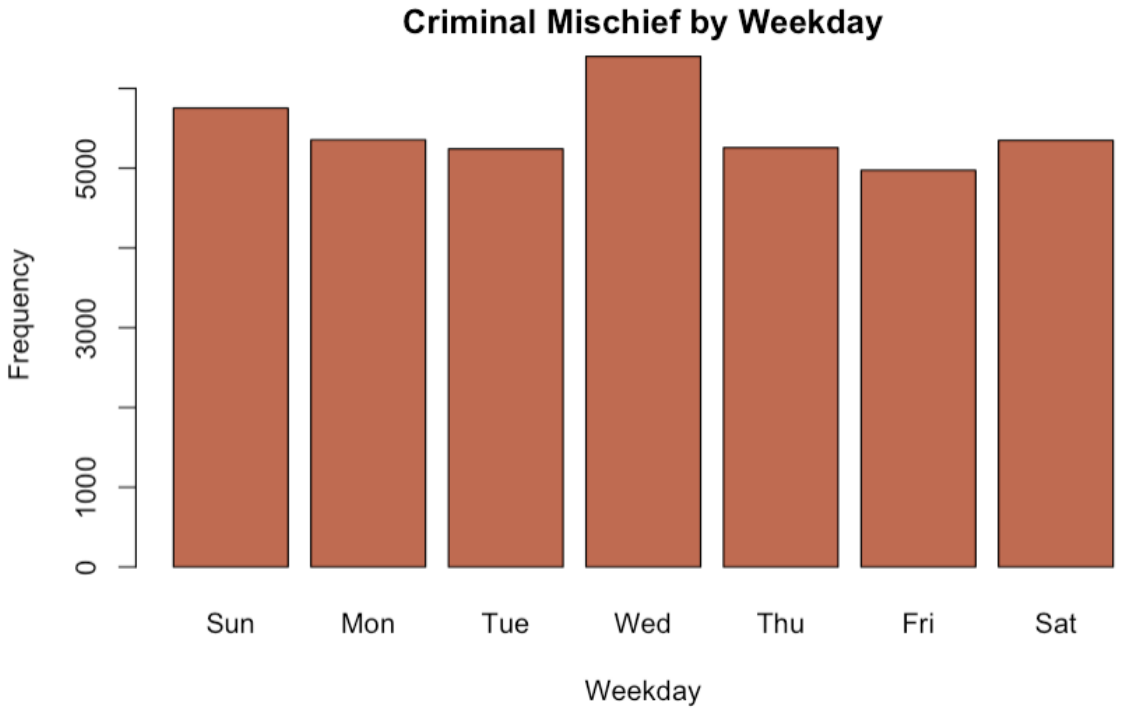
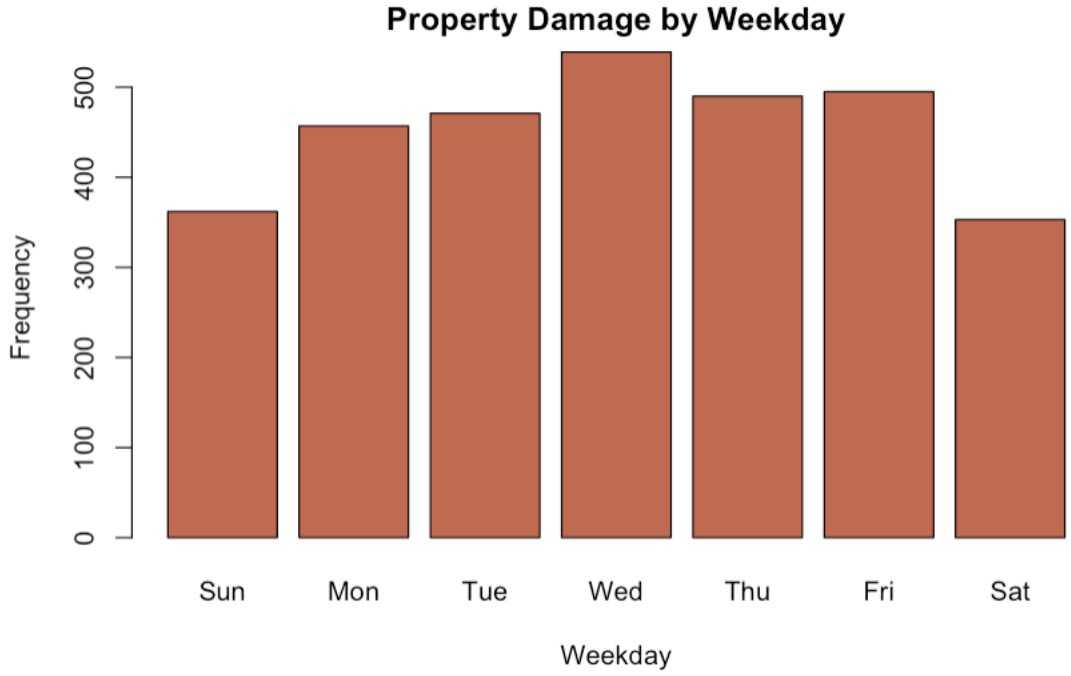


Plot #11



Plot #12



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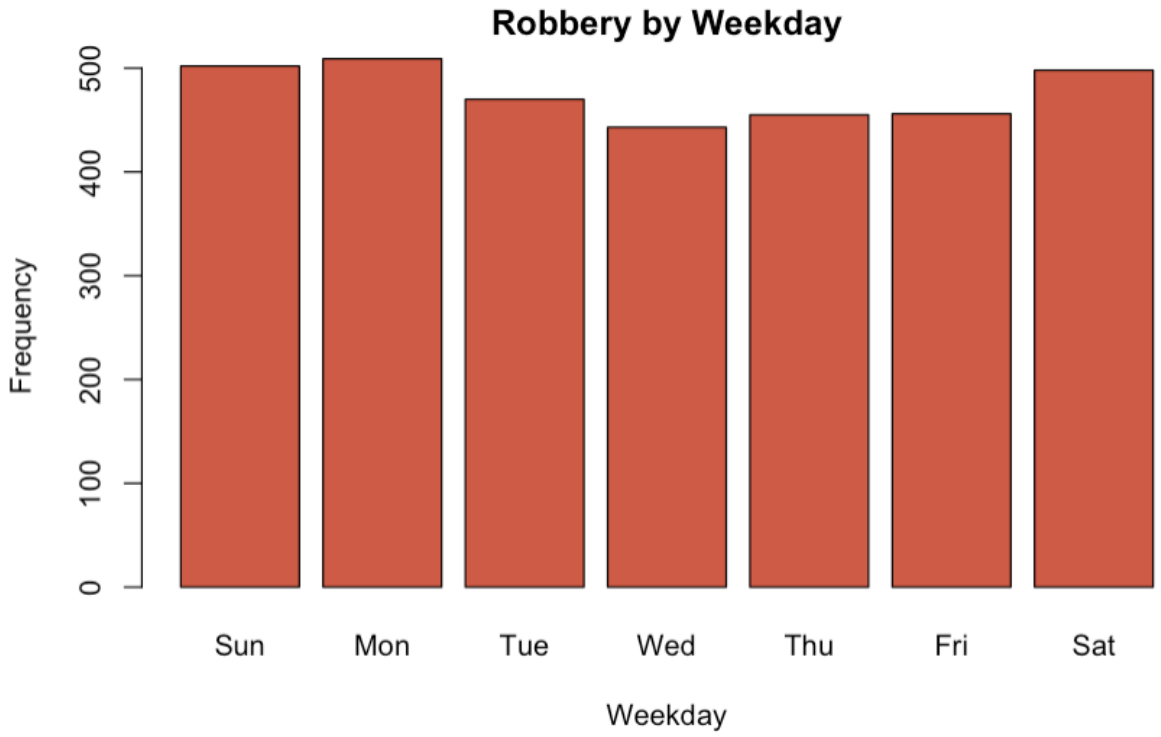
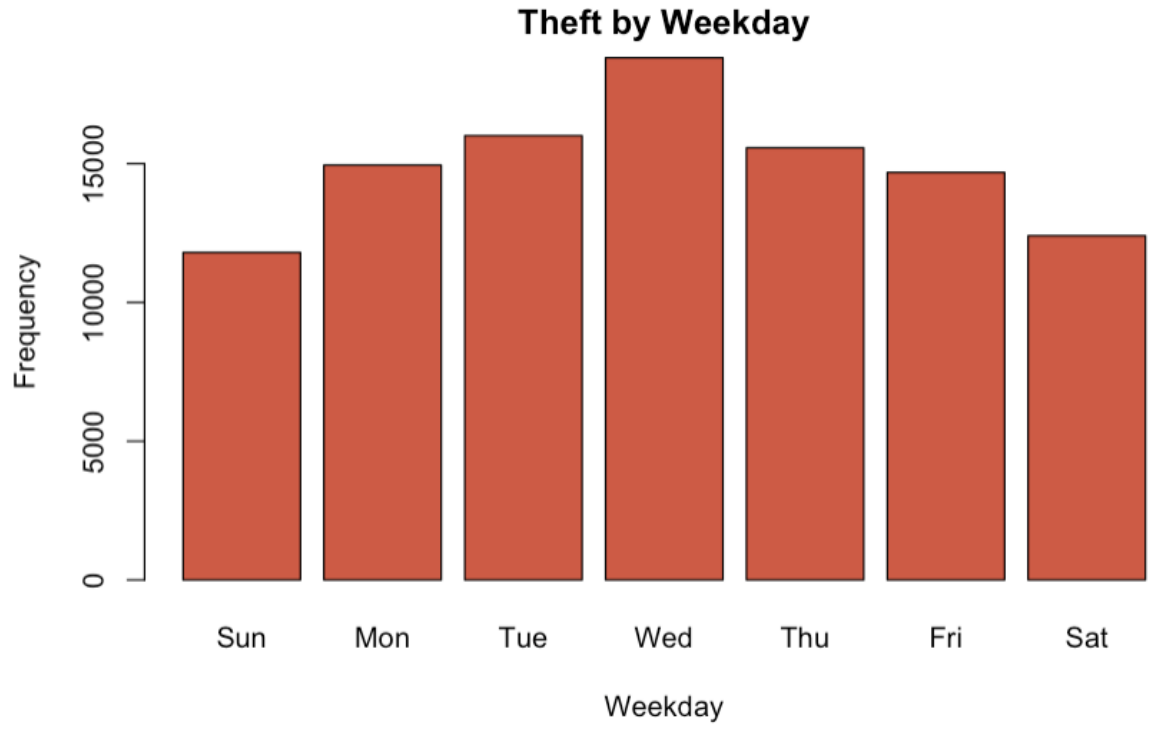


Plot #14



Appendix C (Monthly and Weekday Pairwise Mean Comparisons)

Table #1 (Monthly Pairwise Average Theft Comparison) - 95% Confidence

Month	Compared Month	Difference	Lower	Upper	P-Value < 0.05
June	February	7.73742936	0.9388664	14.535992	0.0109549
August	January	6.9378592	0.9191509	12.956568	0.0091877
August	February	10.7383396	4.2066791	17.27	0.0000058
August	March	9.19471154	2.9727116	15.416711	0.0000942
August	May	7.3746408	1.3559325	13.393349	0.003684
September	February	9.33208955	2.5464207	16.117758	0.0004553
September	March	7.78846154	1.3003187	14.276604	0.0050768
October	February	7.68099065	0.7079994	14.653982	0.0168007
November	February	9.26444249	2.1878595	16.341026	0.0011818
November	March	7.72081448	0.9290016	14.512627	0.0111281

Table Variables

Month = Month selected
Compared Month = Month being compared
Difference = Difference of the means between the two months
Lower = Lower bound difference of means
Upper = Upper bound difference of means
P-Value = A measure of the probability that a difference could have occurred by random chance

Table #2 (Weekday Pairwise Average Criminal Mischief Comparison) - 95% Confidence

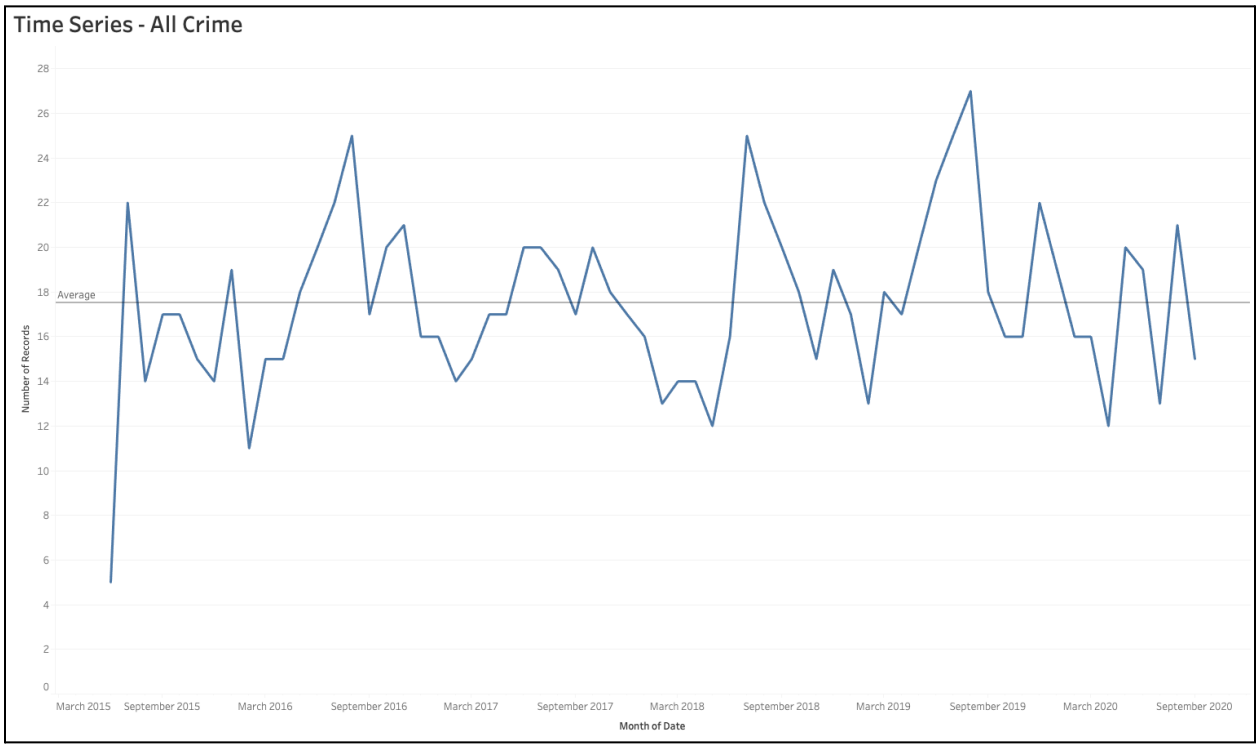
Weekday	Compared Weekday	Difference	Lower	Upper	P-Value < 0.05
Wednesday	Sunday	3.0982474	1.0391261	5.1573688	0.0001959
Wednesday	Monday	4.2730322	2.3110304	6.235034	0.0088800
Wednesday	Tuesday	4.5425365	2.557667	6.5274059	0.0000000
Thursday	Wednesday	-4.1049383	-6.0988918	-2.1109847	0.0000000
Friday	Sunday	-2.4002183	-4.4284147	-0.3720218	0.0088888
Friday	Wednesday	-5.4984657	-7.4604675	-3.5364639	0.0000000
Saturday	Wednesday	-4.4099287	-6.4728975	-2.3469599	0.0000000

Table Variables

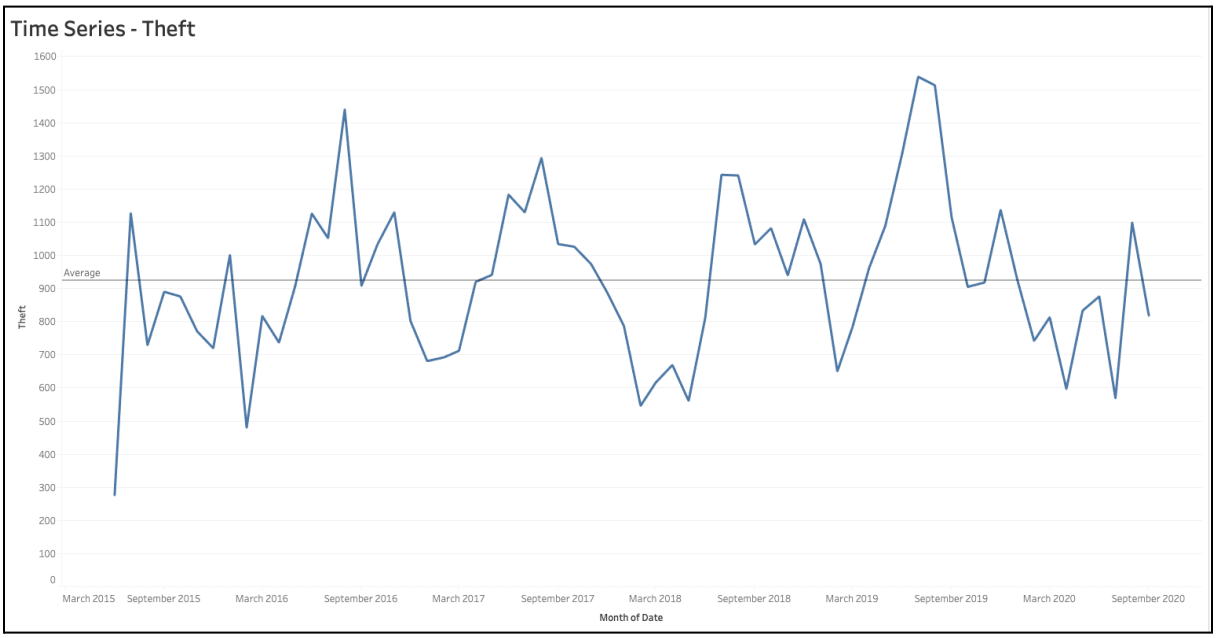
Weekday = Weekday selected
Compared Weekday= Weekday being compared
Difference = Difference of the means between the two days
Lower = Lower bound difference of means
Upper = Upper bound difference of means
P-Value =A measure of the probability that a difference could have occurred by random chance

Appendix D (TIme Series Visualizations)

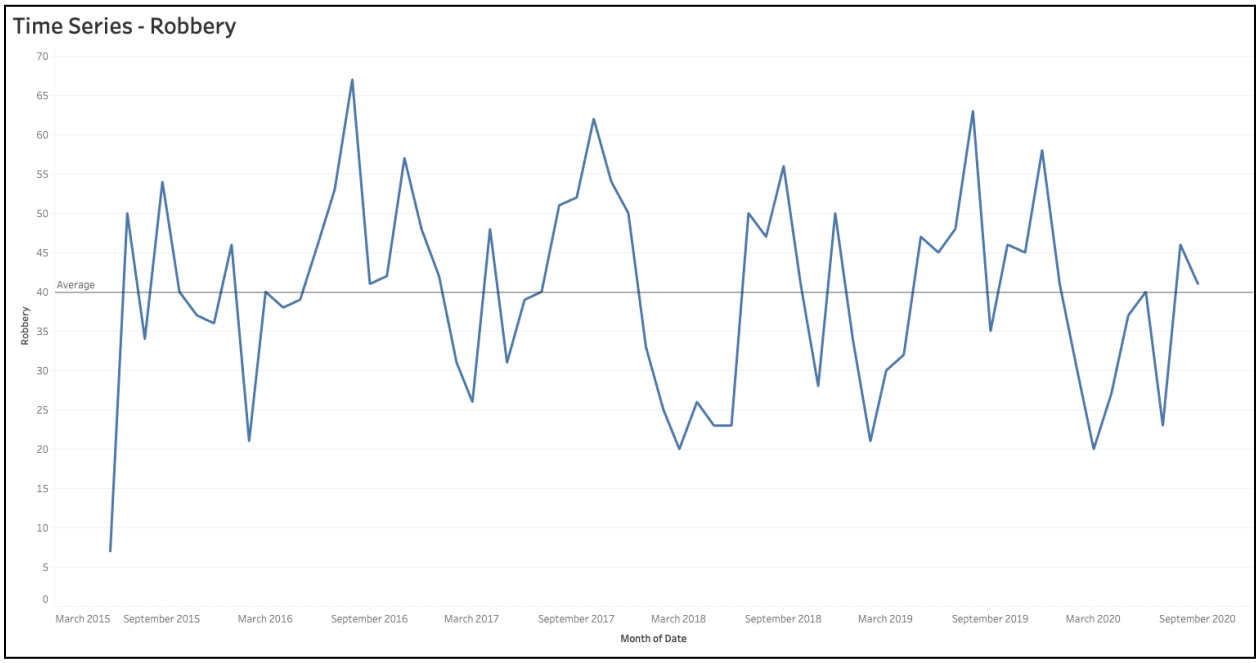
Plot #1



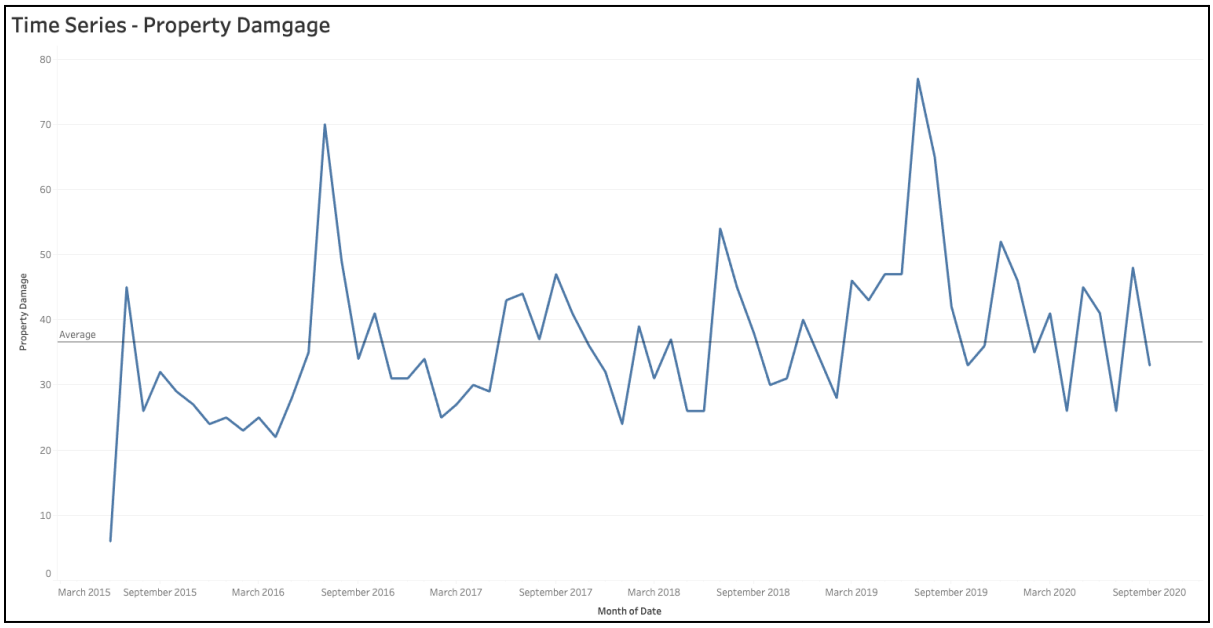
Plot #2



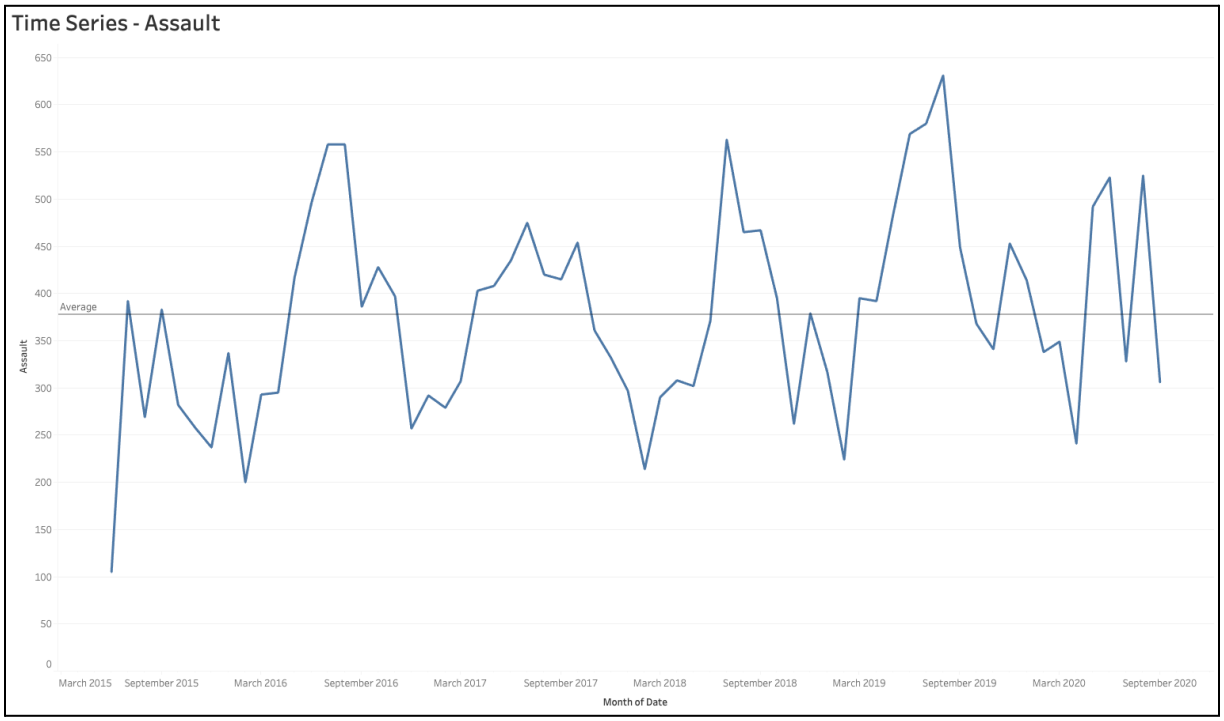
Plot #3


Time Series - Robbery
Robbery
Average
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

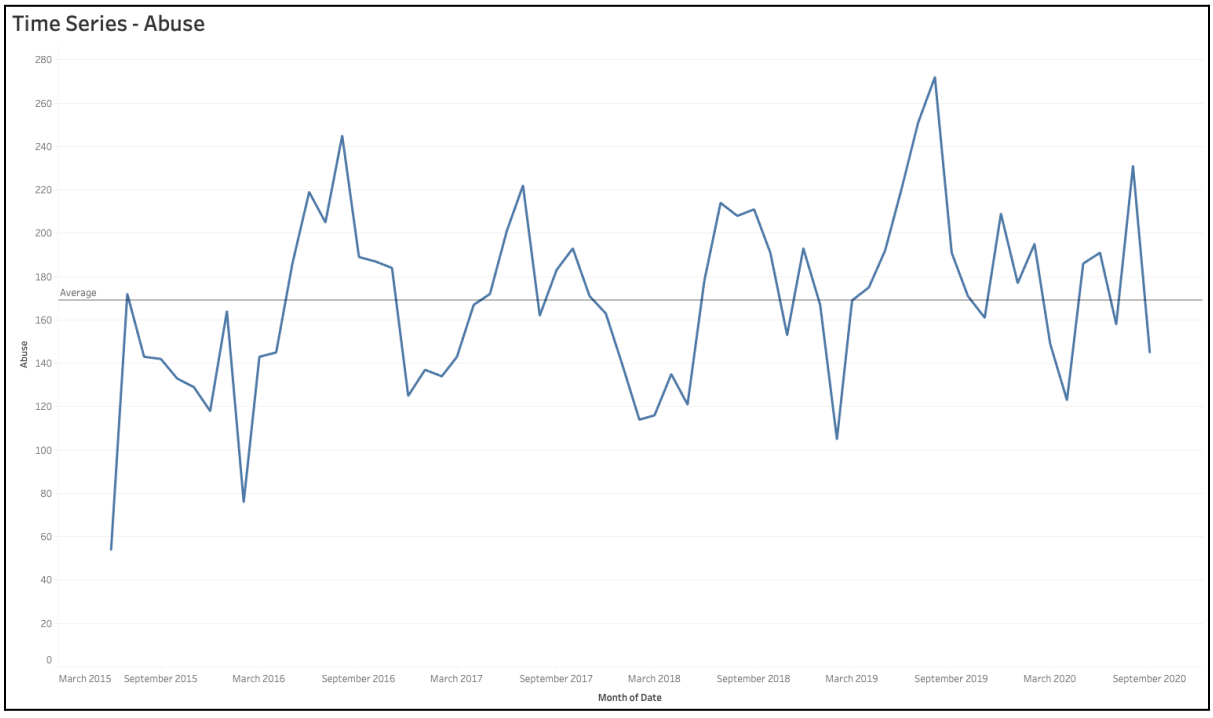
Plot #4


Time Series - Property Damgage
Property Damage
Average
80
70
60
50
40
30
20
10
0
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

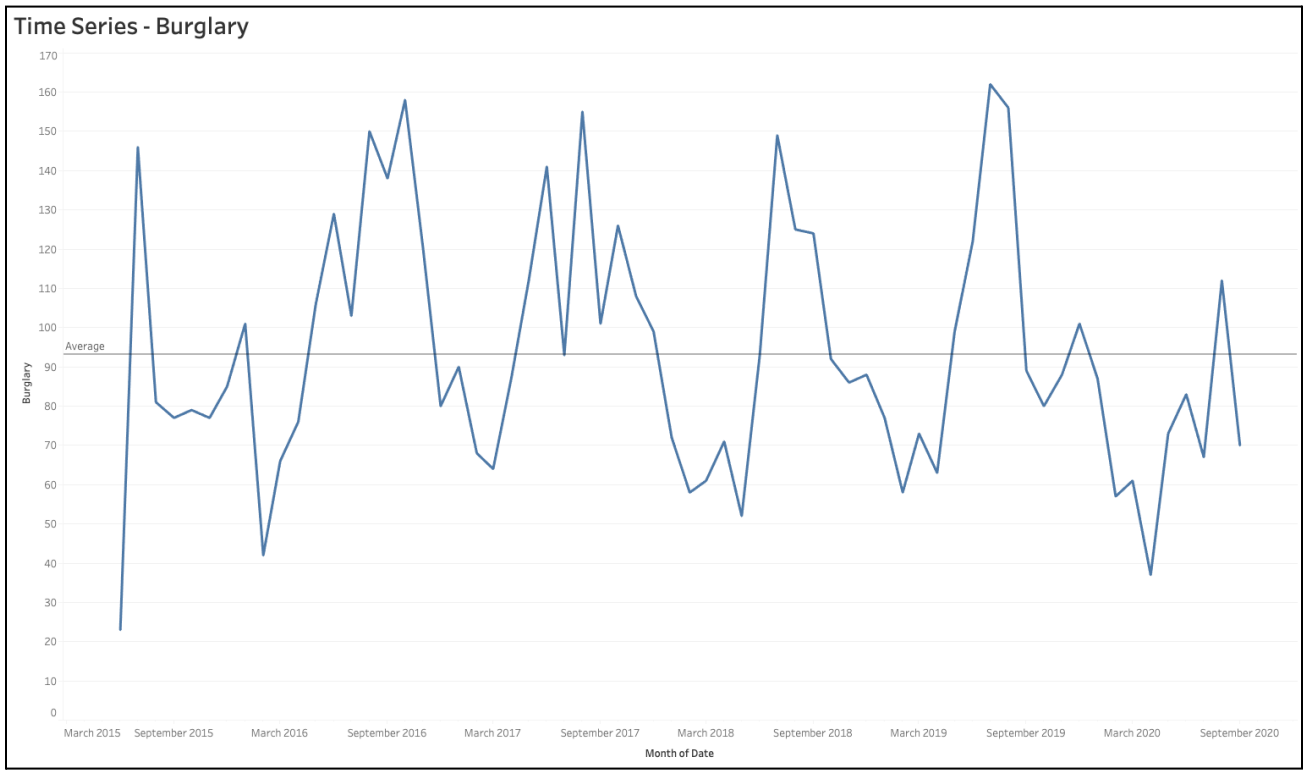
Plot #5


Time Series - Assault
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Average
Assault
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

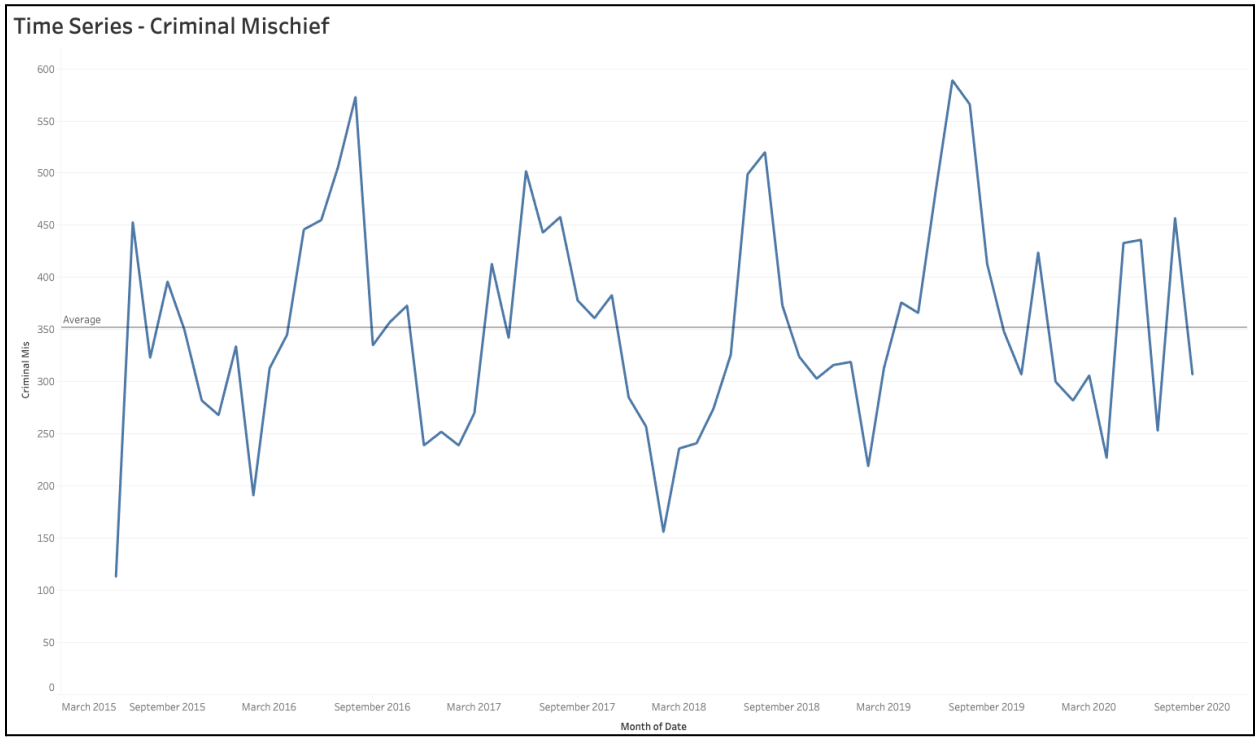
Plot #6


Time Series - Abuse
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Average
Abuse
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

Plot #7

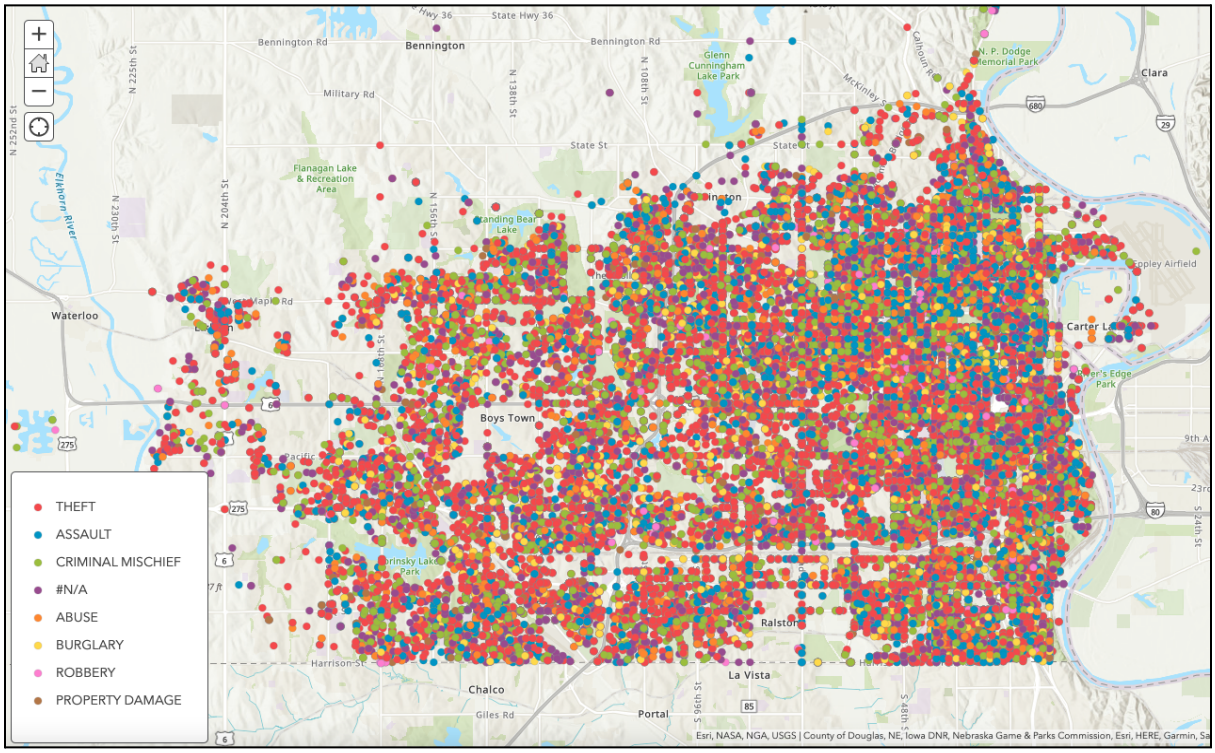

Time Series - Burglary
Burglary
Average
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

Plot #8

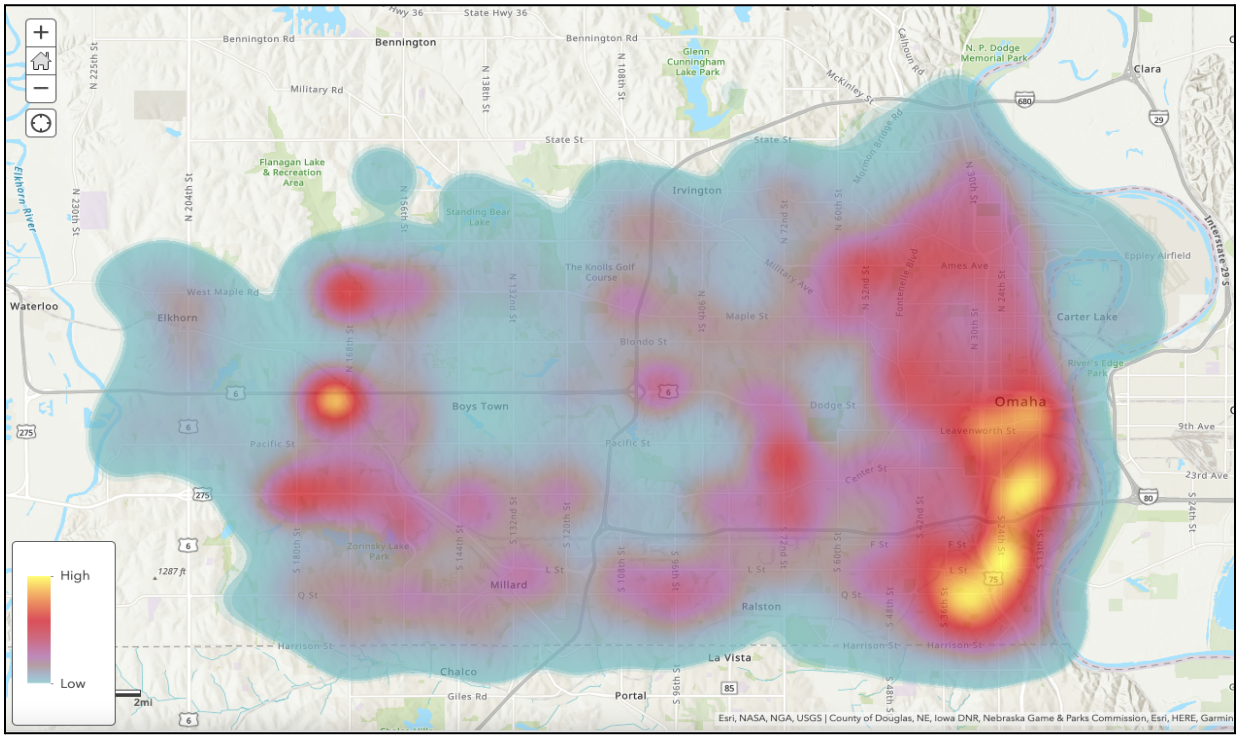

Time Series - Criminal Mischief
Criminal Mis
Average
600
550
500
450
400
350
300
250
200
150
100
50
0
March 2015
September 2015
March 2016
September 2016
March 2017
September 2017
March 2018
September 2018
March 2019
September 2019
March 2020
September 2020
Month of Date

Appendix E (ArcGIS Maps)

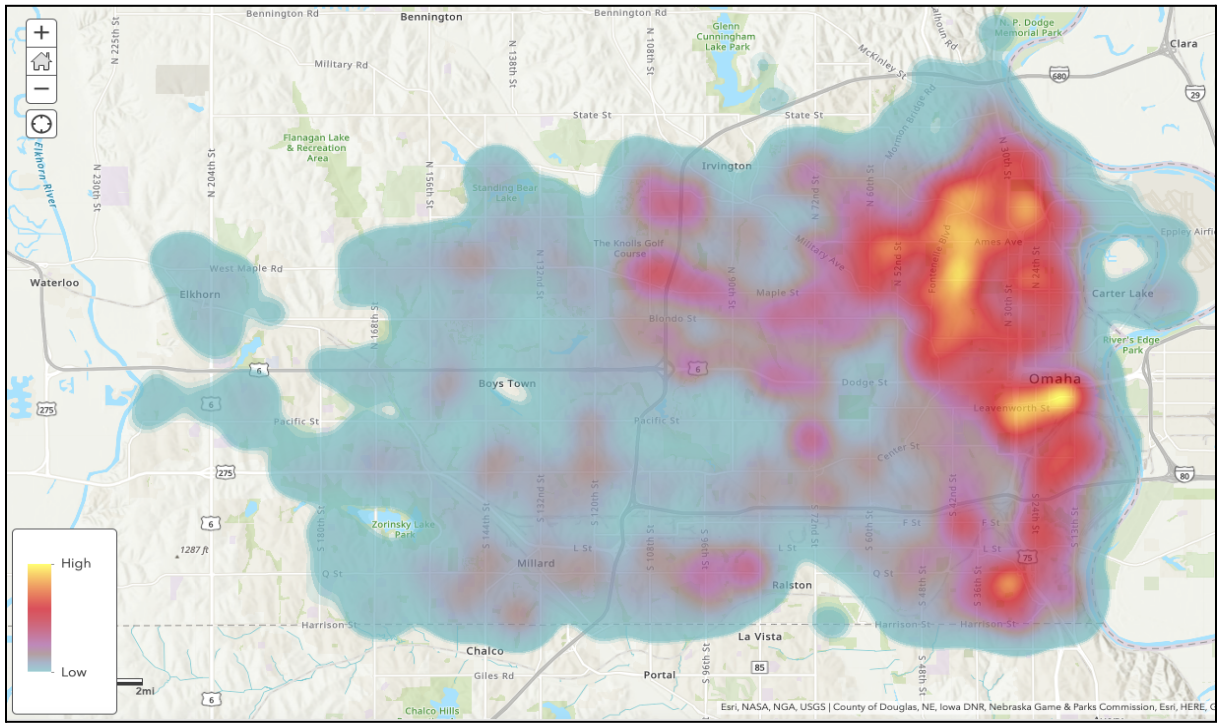
Map #1 (Crime Categories)



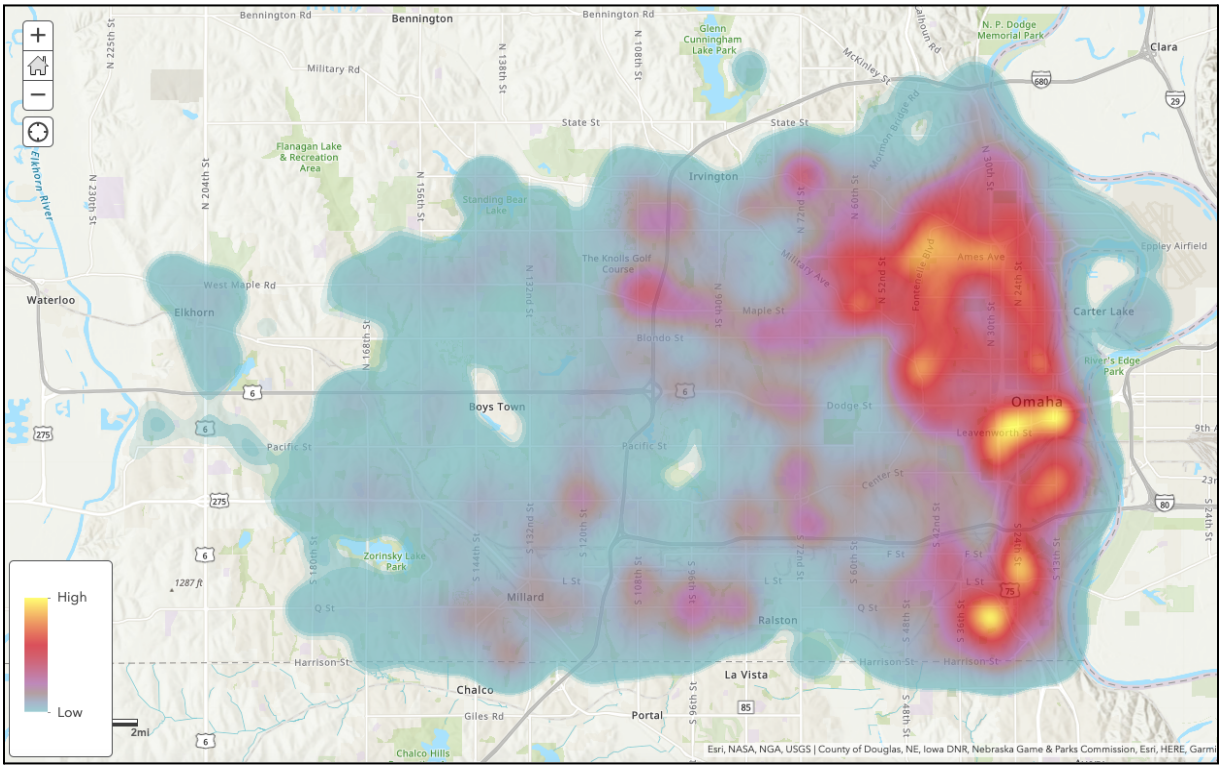
Map #2 (All-Crime Heat Map)



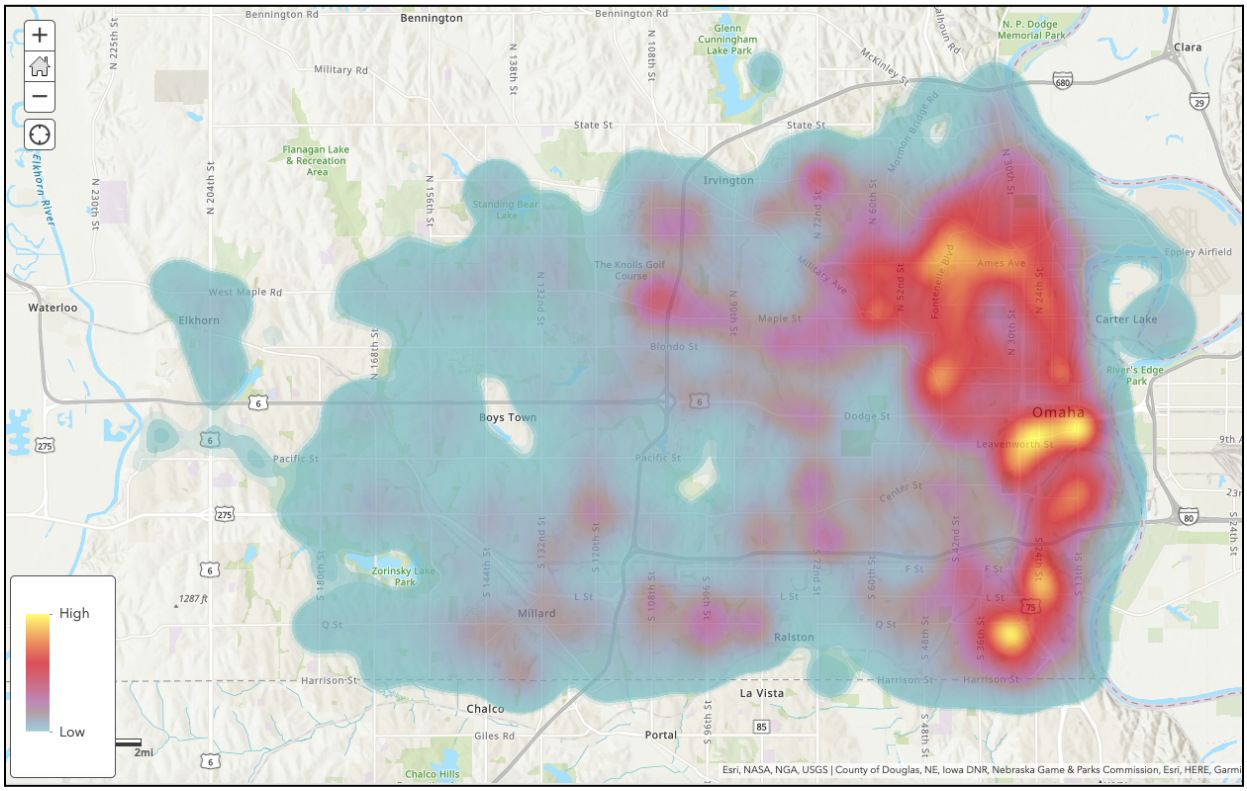
Map #3 (Abuse Heat Map)



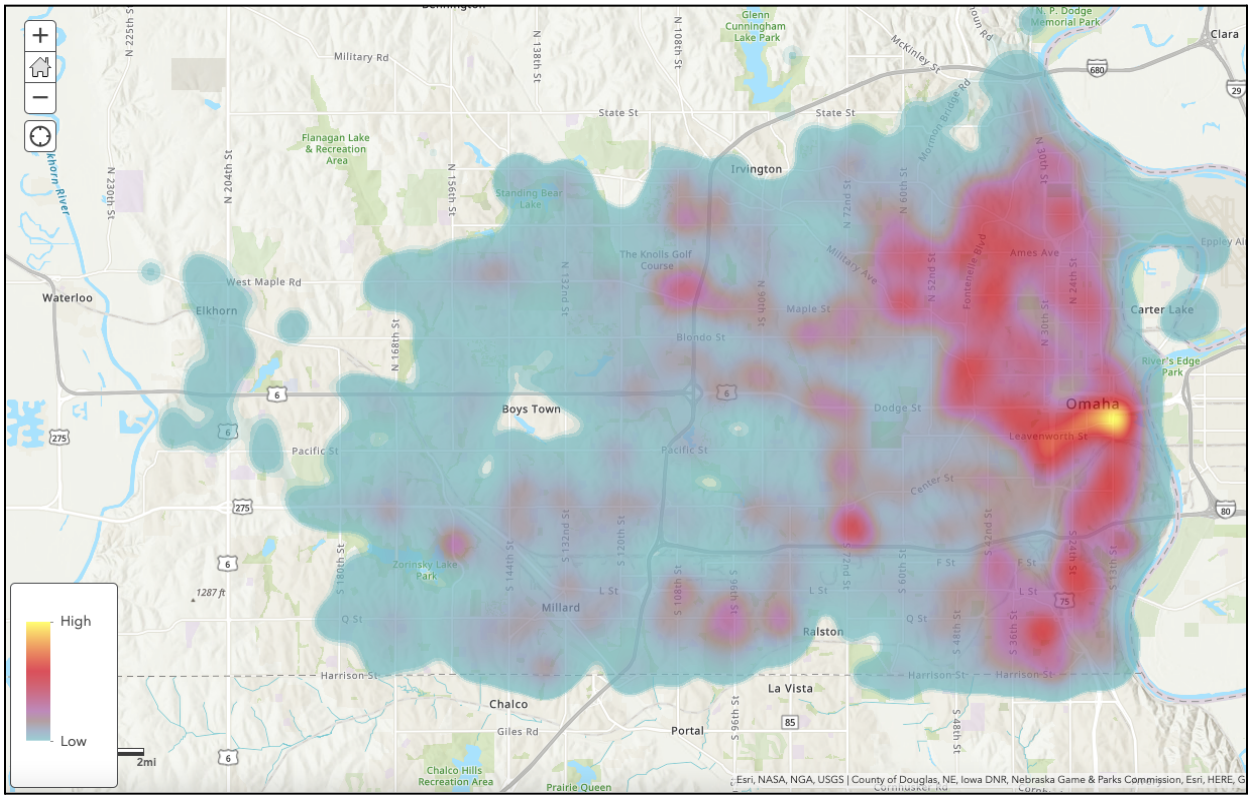
Map #4 (Assault Heat Map)



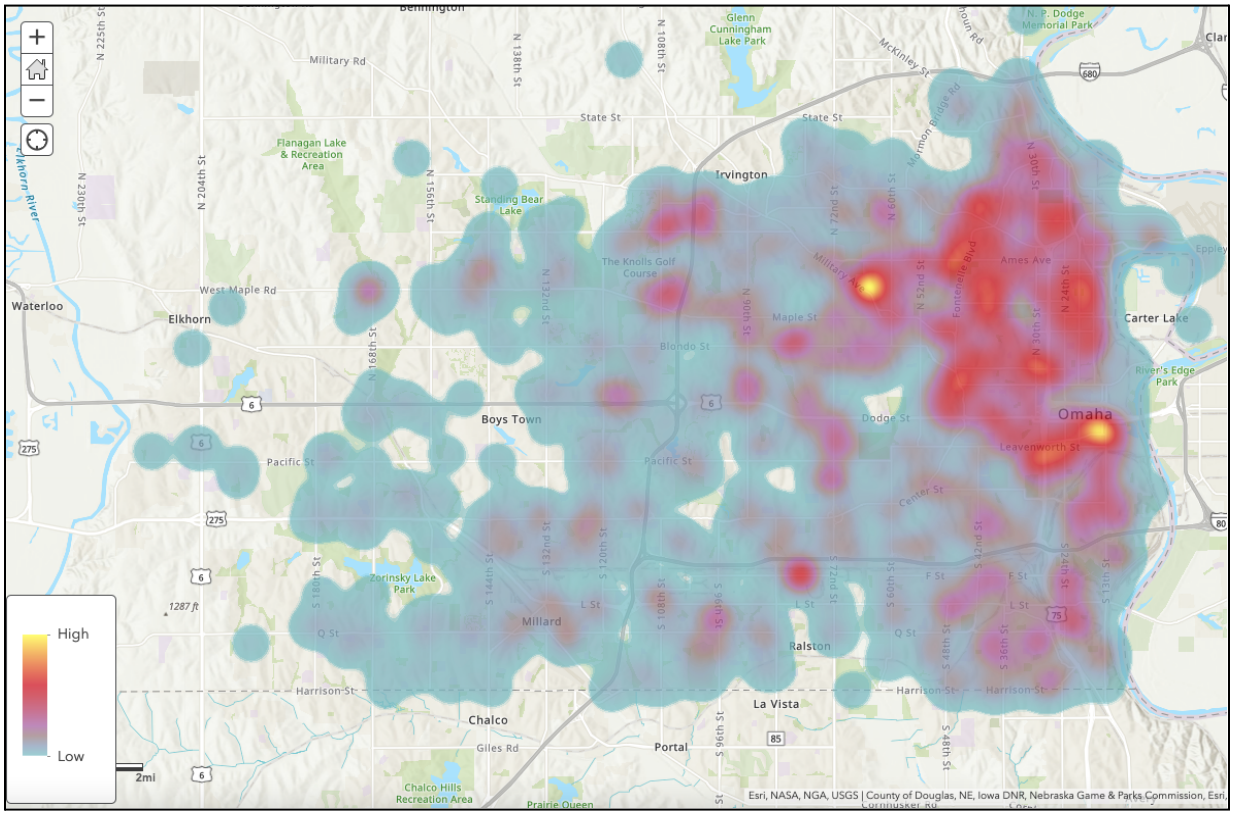
Map #5 (Burglary Heat Map)



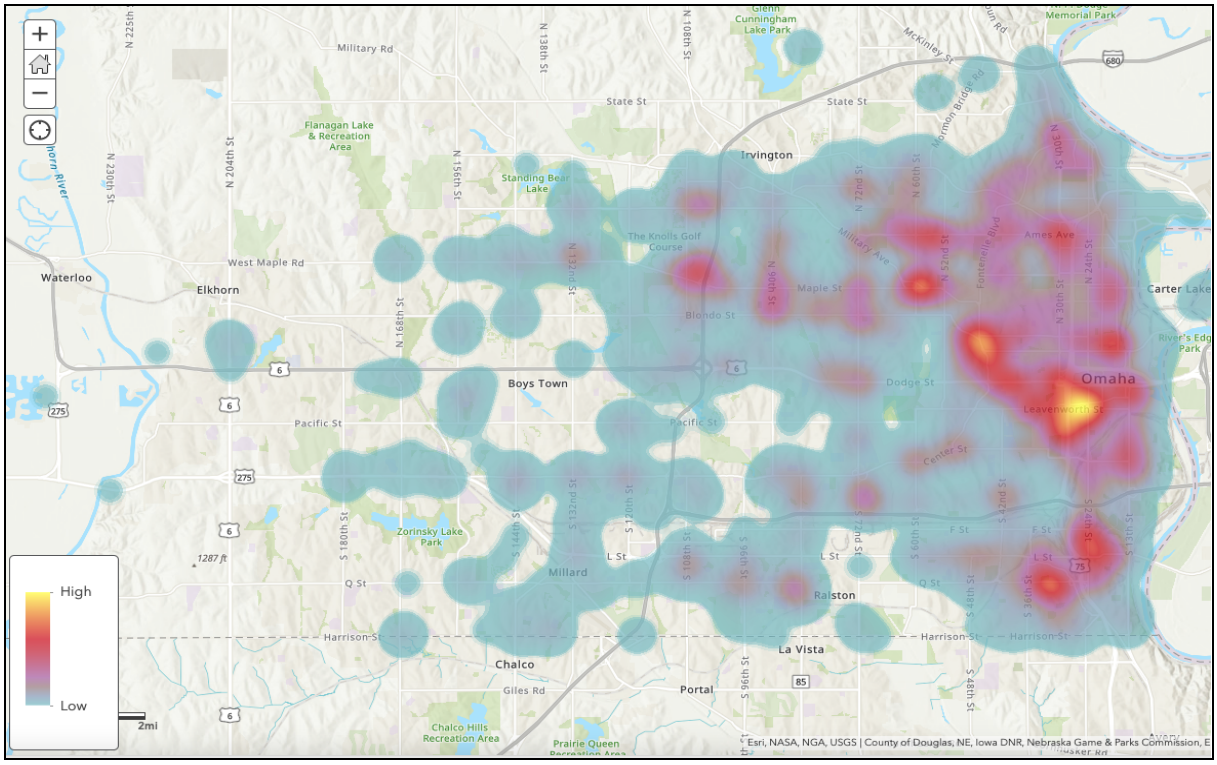
Map #6 (Criminal Mischief Heat Map)



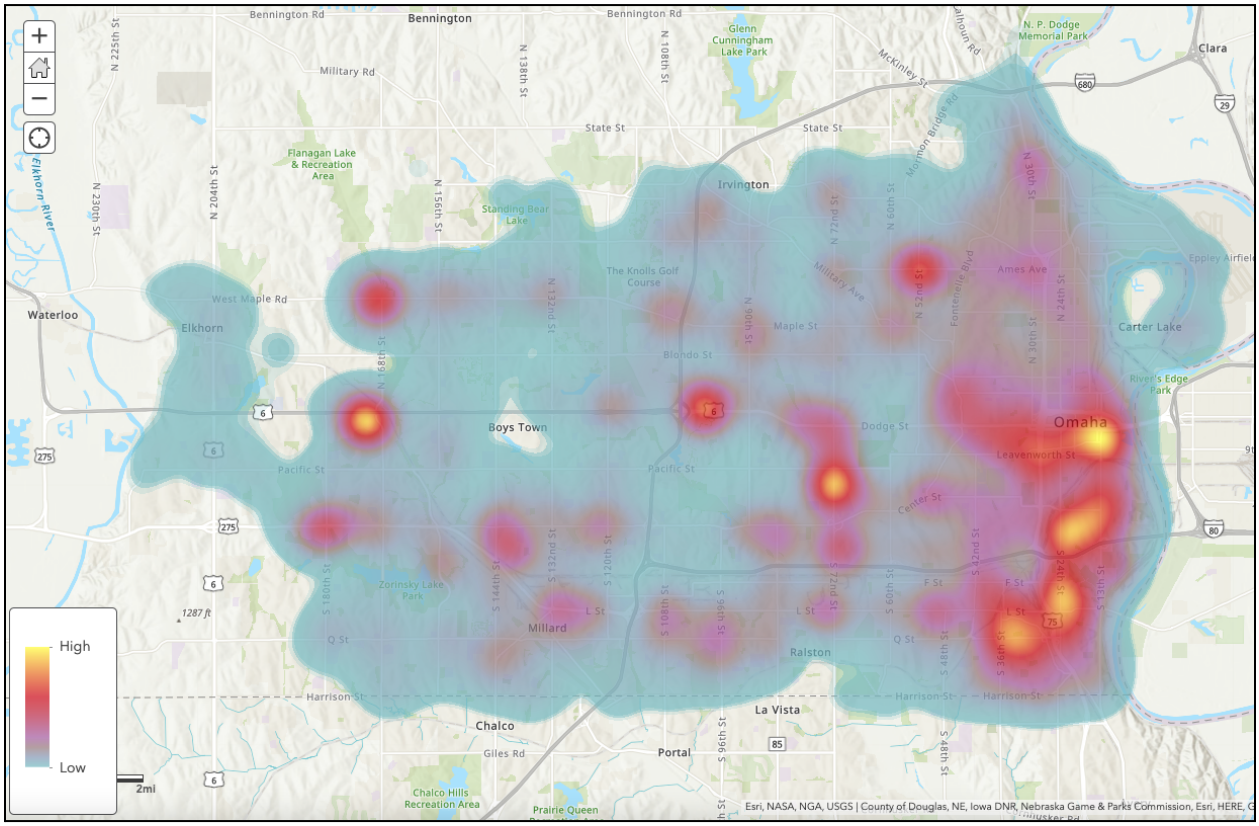
Map #7 (Property Damage Heat Map)



Map #8 (Robbery Heat Map)



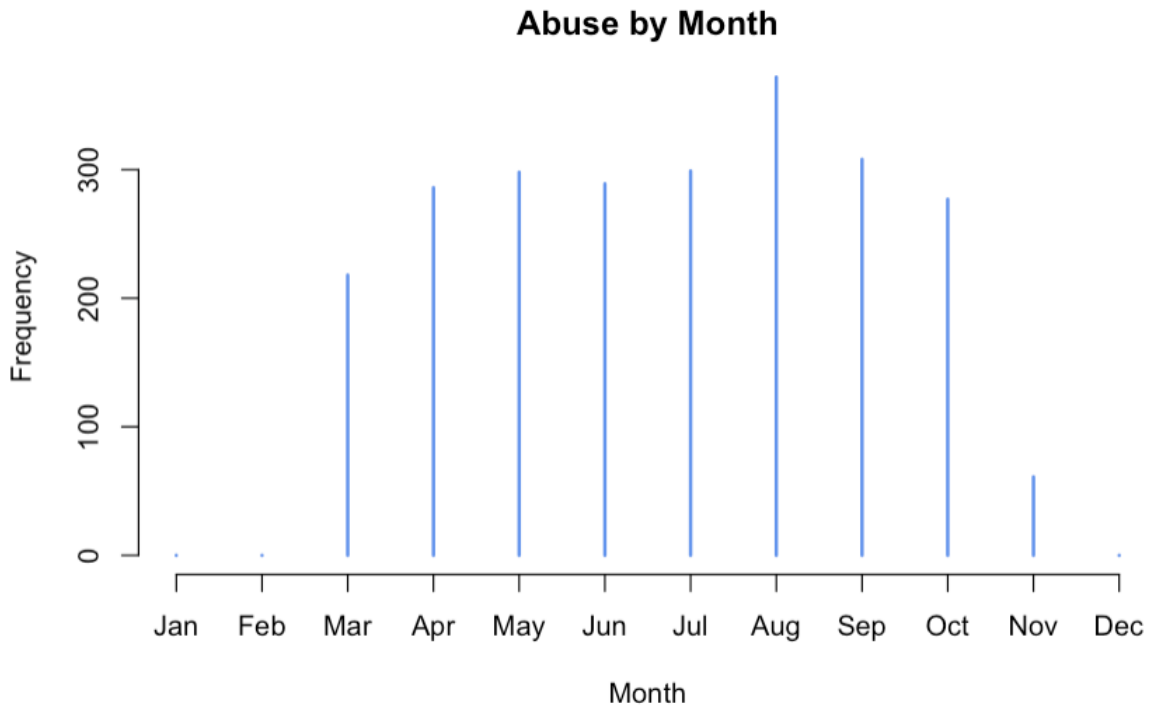
Map #9 (Theft Heat Map)



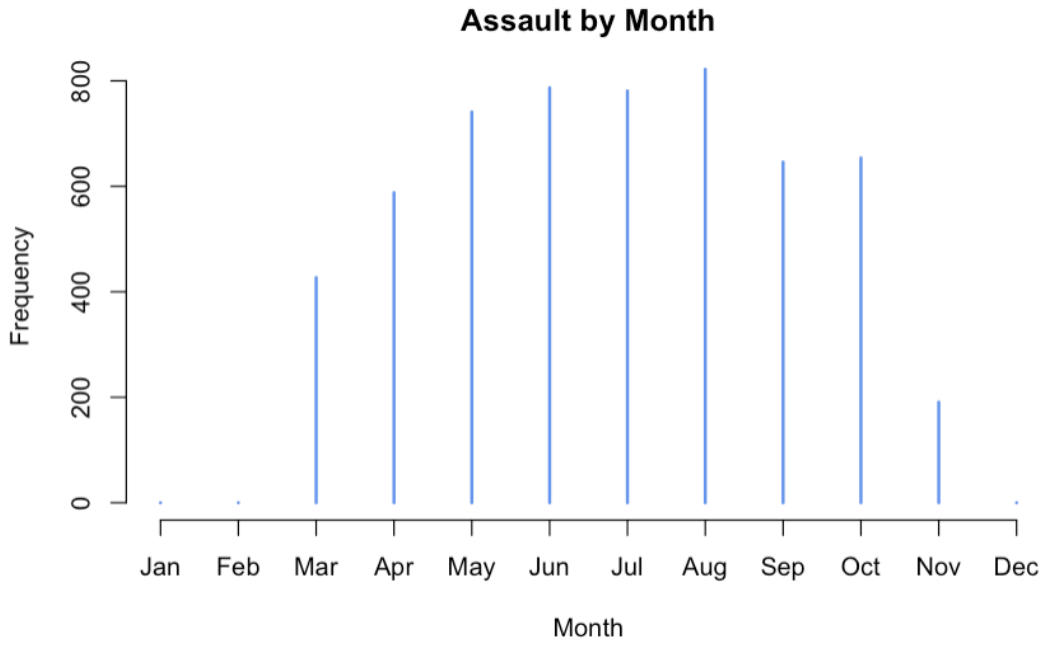
Appendix F (Covid-19 Pandemic Crime Category Frequency)

Months

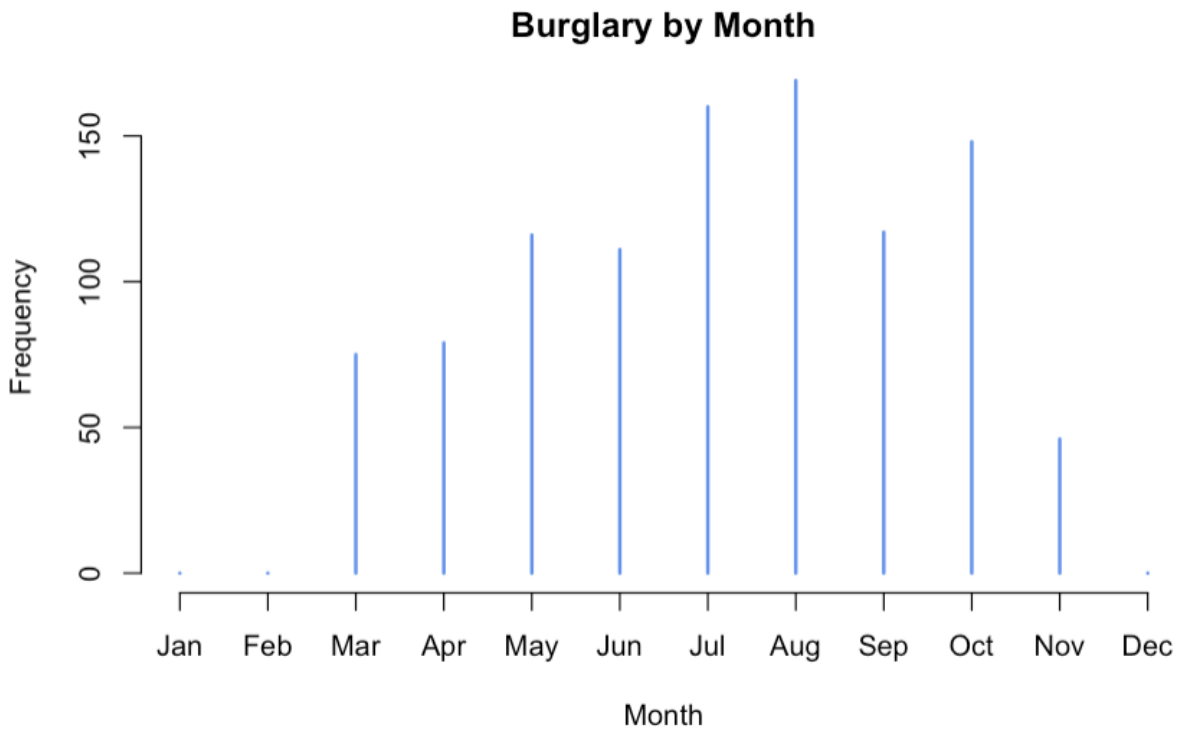
Plot #1



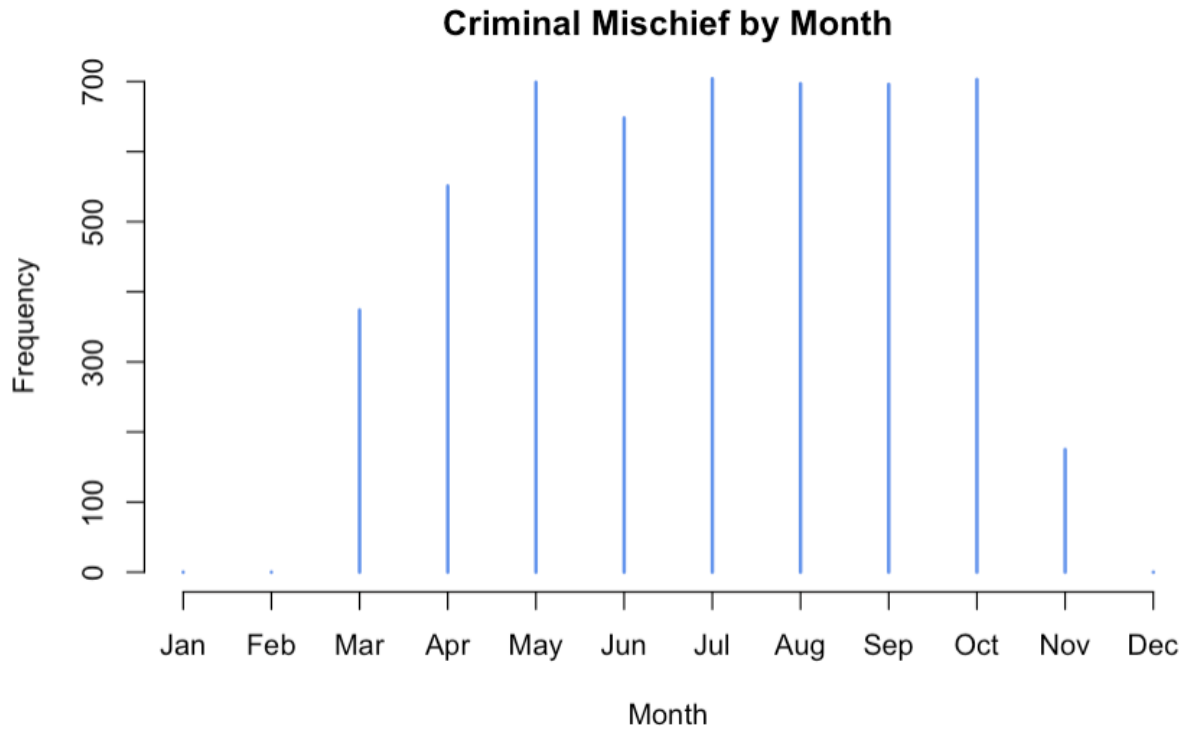
Plot #2



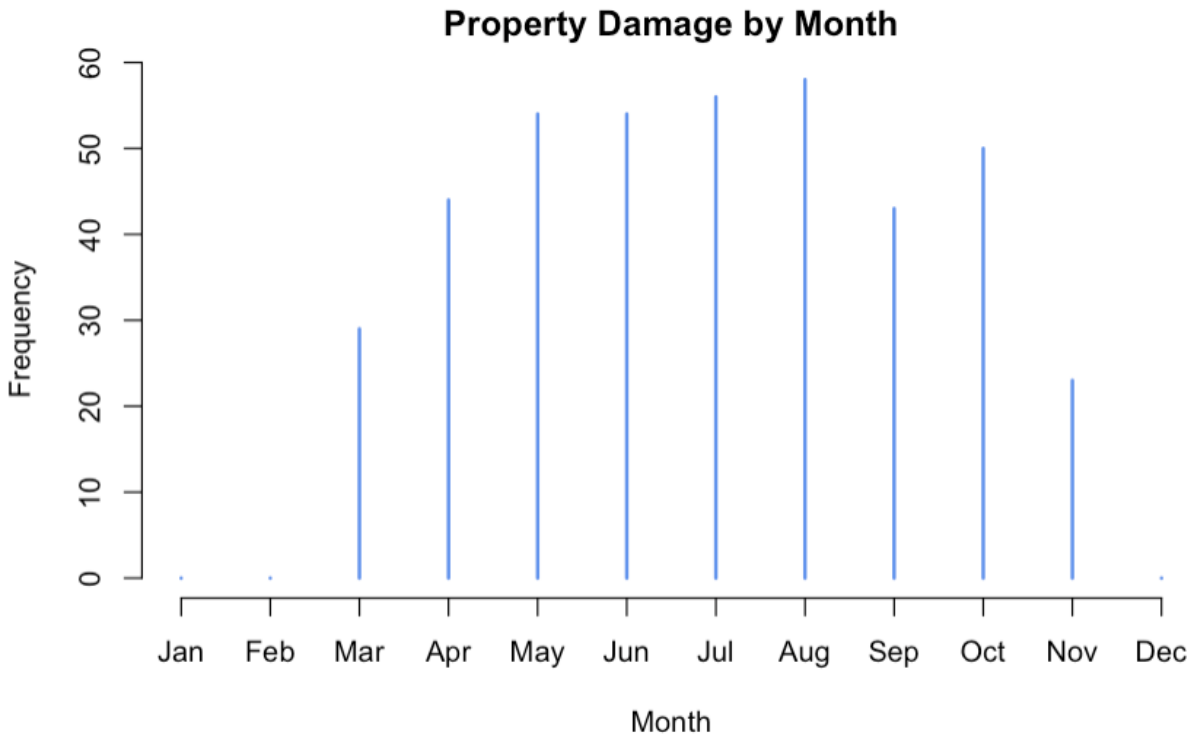
Plot #3


Burglary by Month
Frequency
0
50
100
150
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

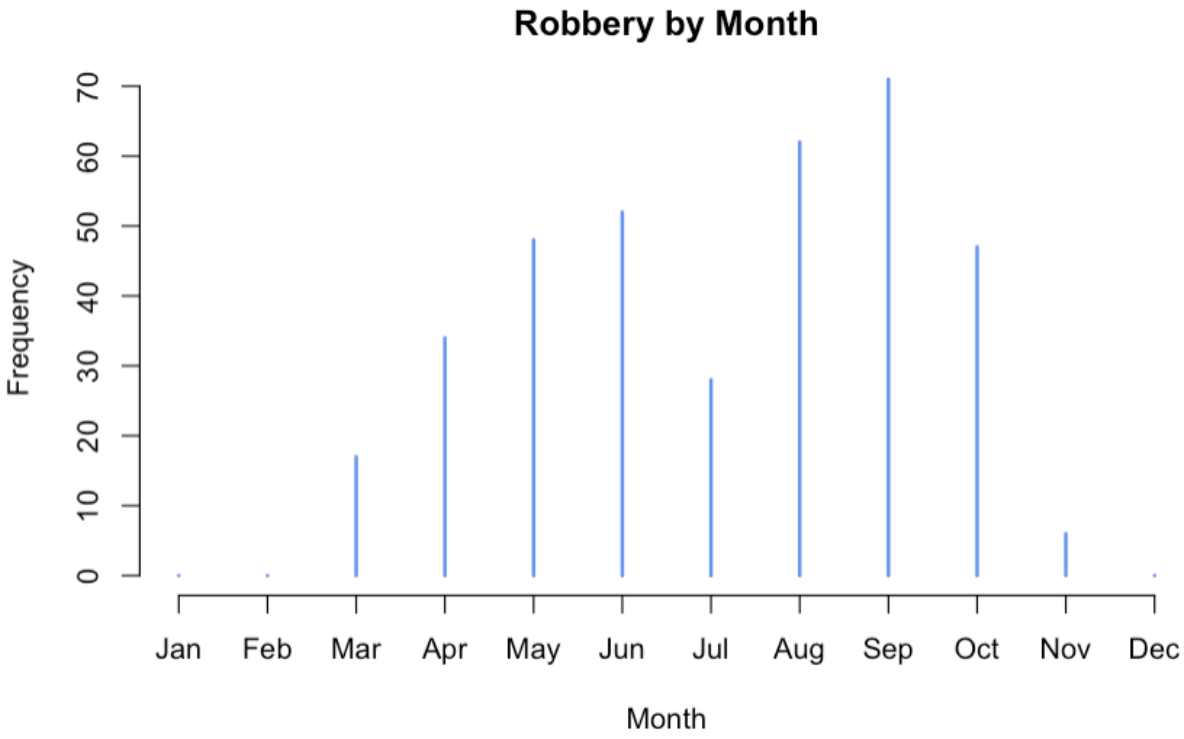
Plot #4


Criminal Mischief by Month
Frequency
0
100
300
500
700
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

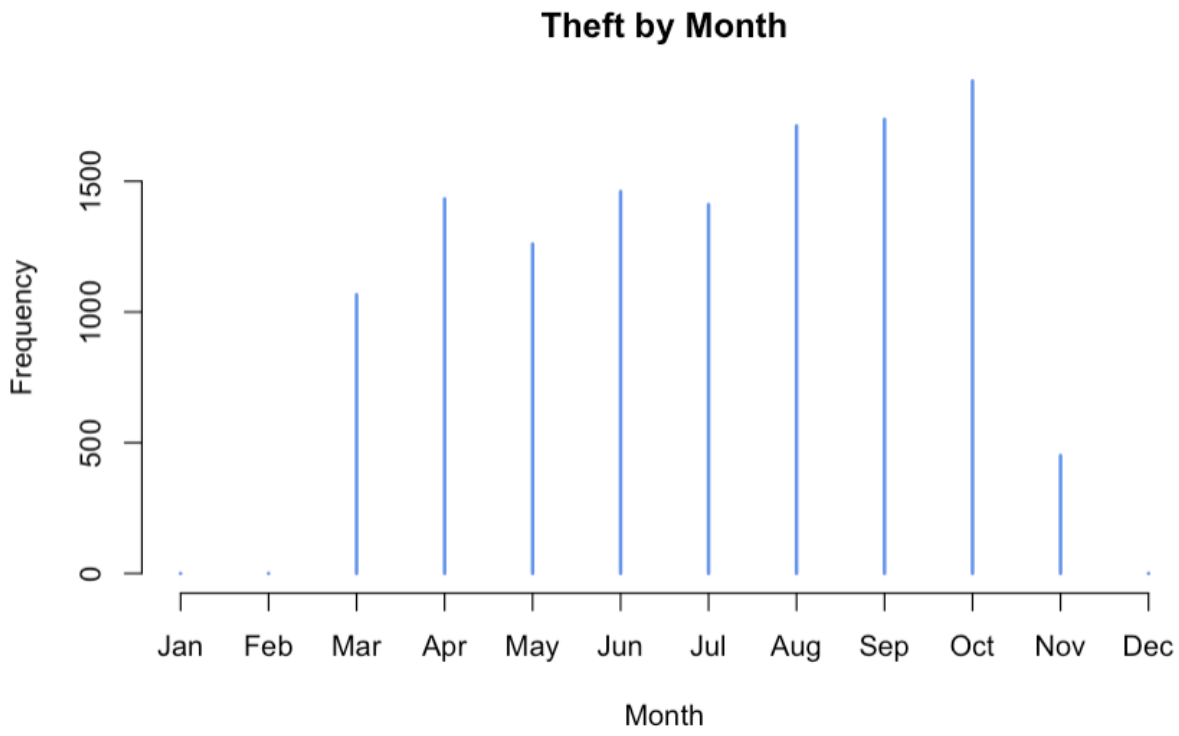
Plot #5


Property Damage by Month
Frequency
0
10
20
30
40
50
60
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Plot #6

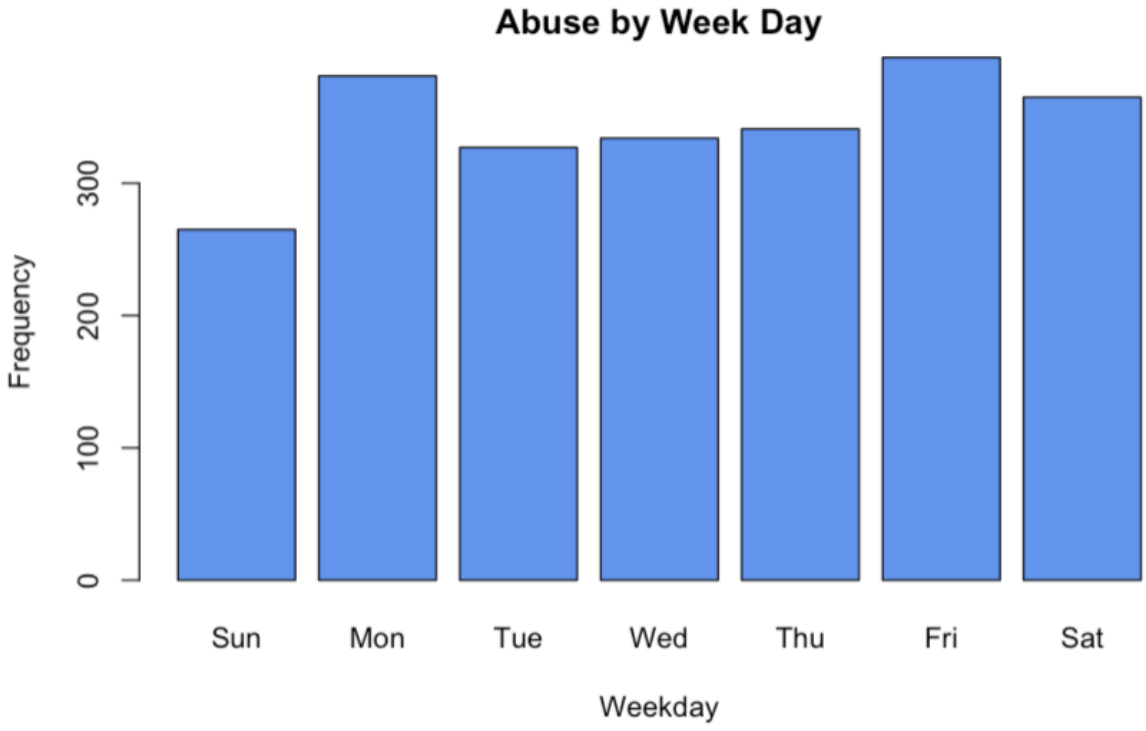

Robbery by Month
Frequency
0
10
20
30
40
50
60
70
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Plot #7

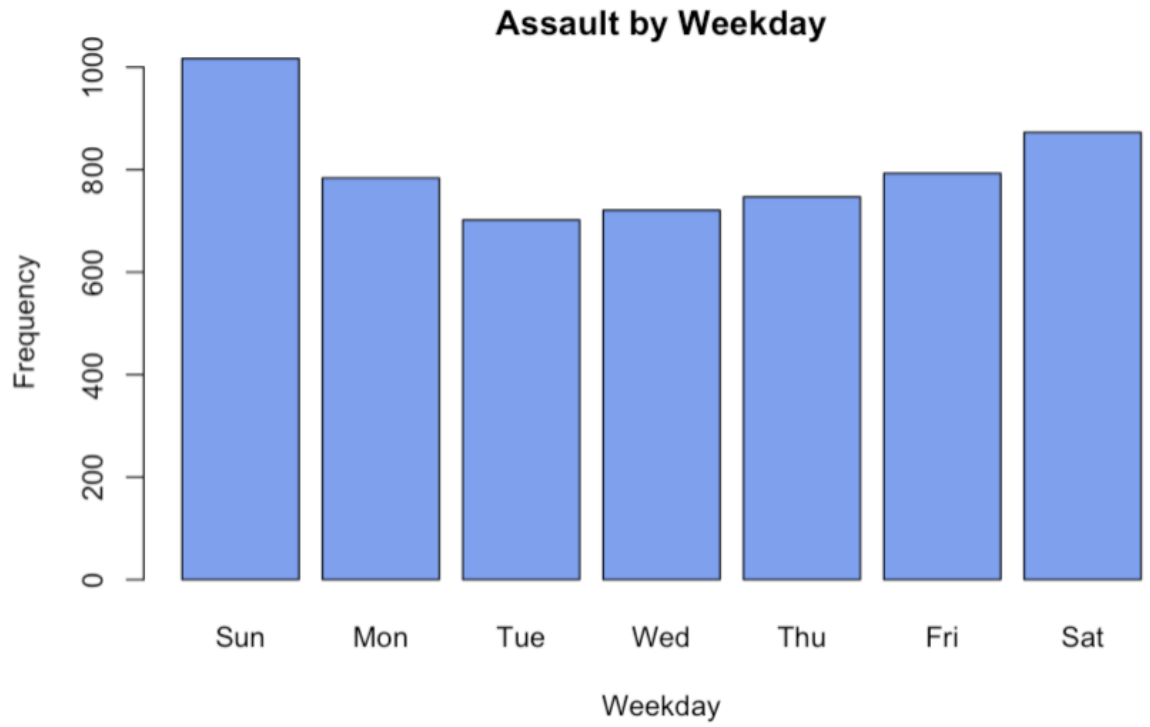


Weekdays

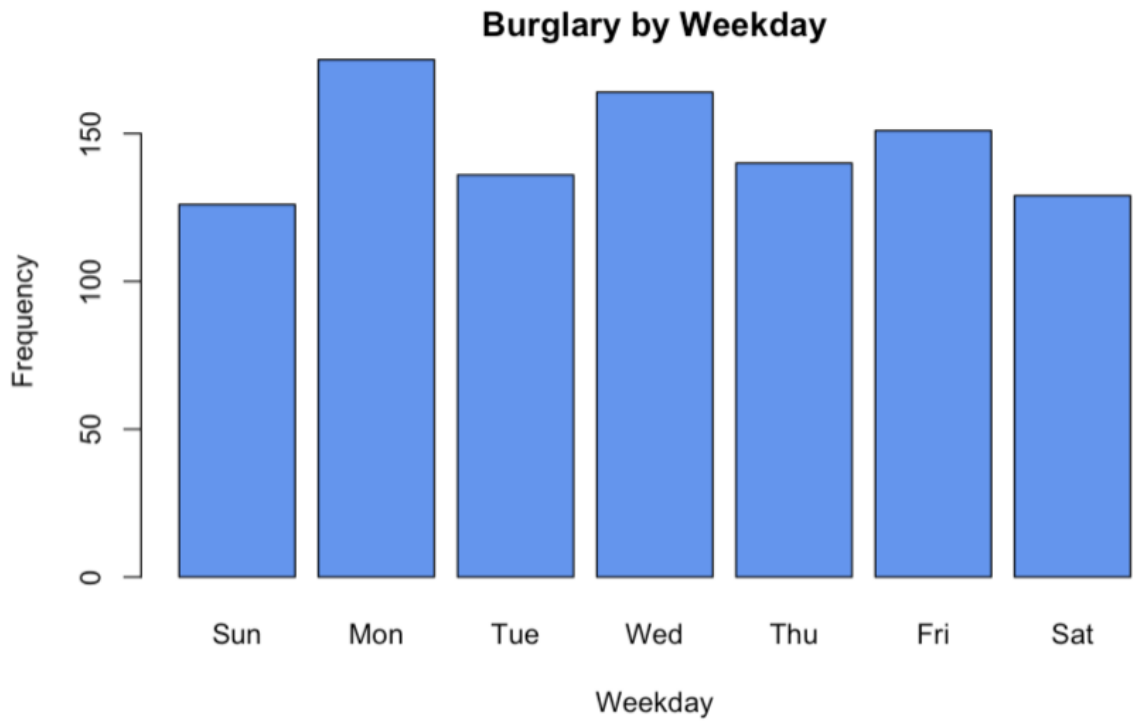
Plot #8



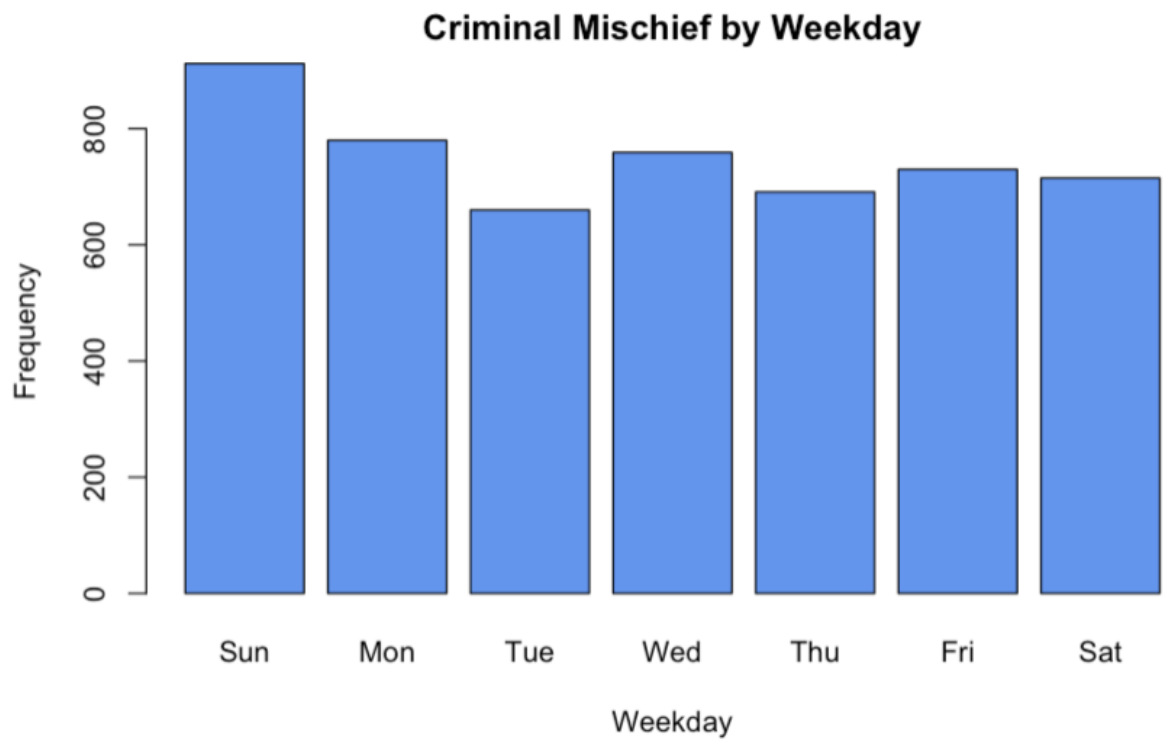
Plot #9


Assault by Weekday
Frequency
0
200
400
600
800
1000
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday

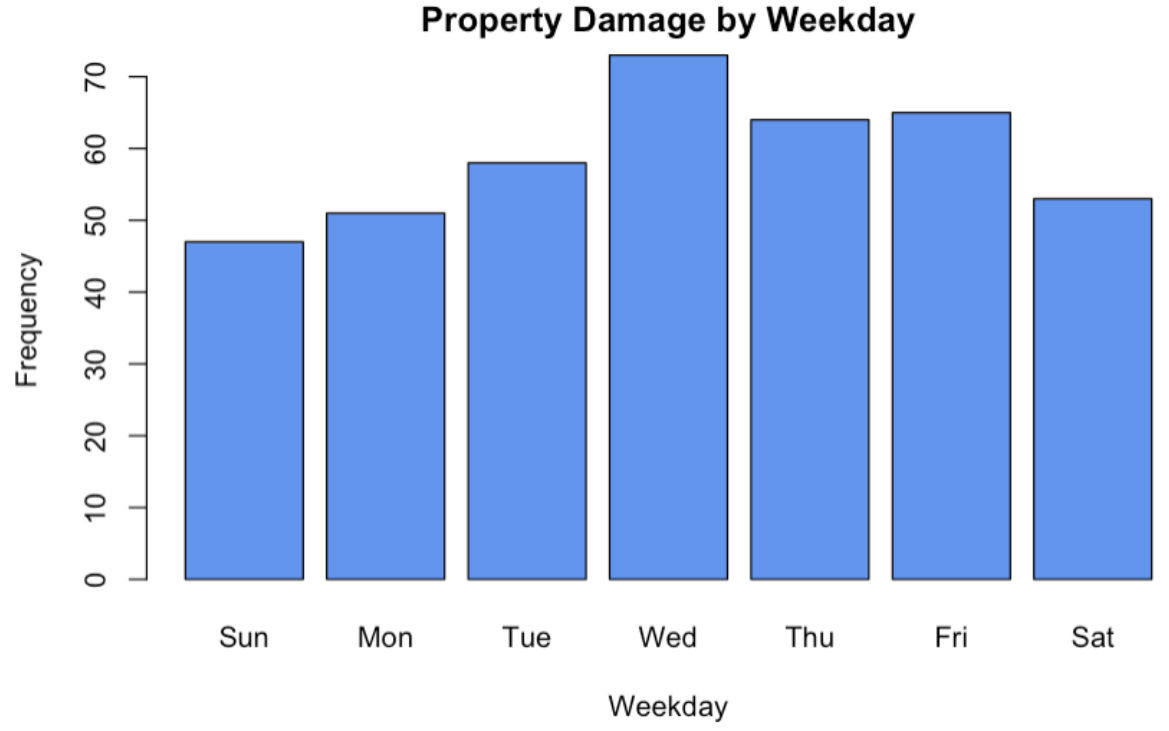
Plot #10


Burglary by Weekday
Frequency
0
50
100
150
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday

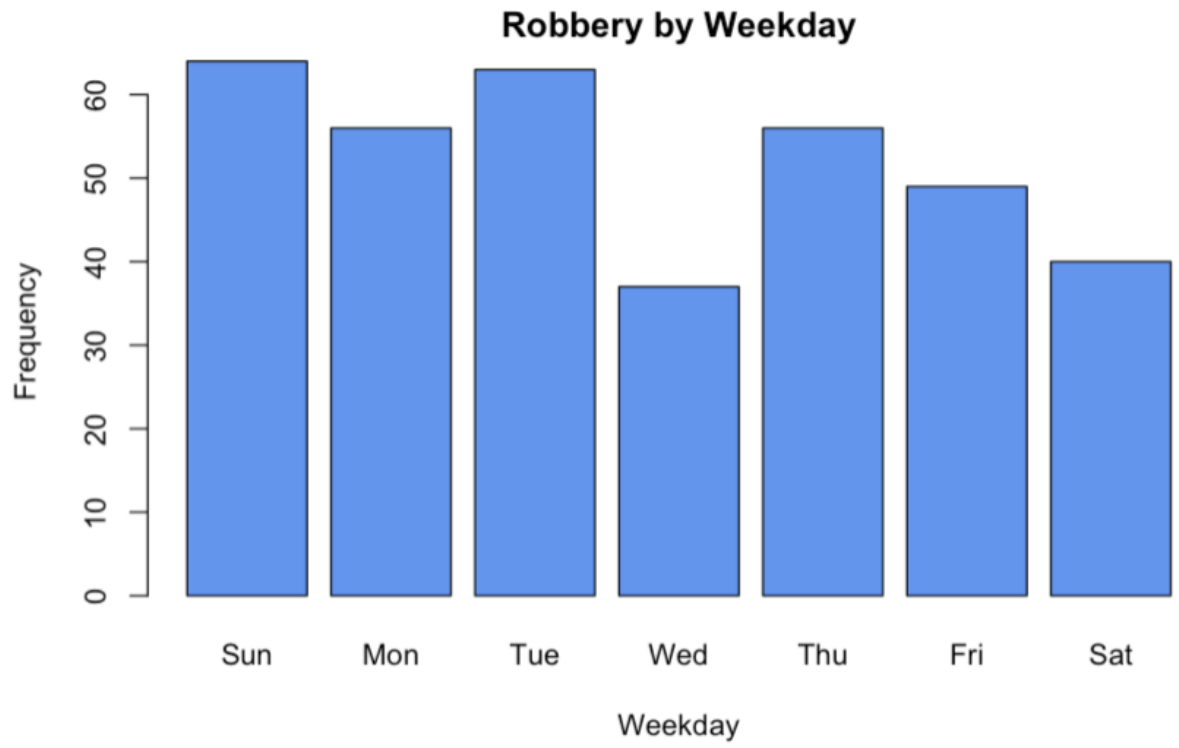
Plot #11



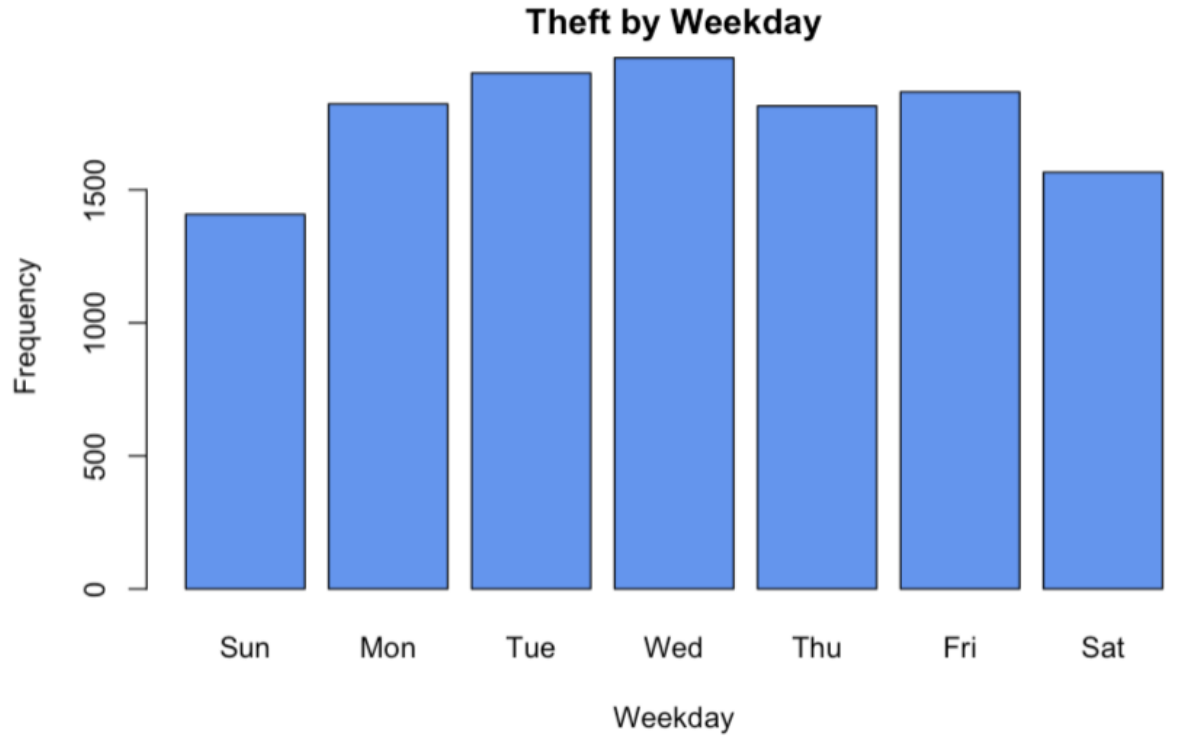
Plot #12



Plot #13



Plot #14



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