Spatial Analysis of Crime Incidents in the Ottawa Nepean Region 2005-2006 using Crime Stat

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GEOB 479
March 2018

Introduction

The following analysis required the use of Crime Stat to analyze the spatial distribution in the Ottawa Nepean area for crime incidents between January 2005 and March 2006. The data was retrieved from the Ottawa Police Department, Statistics Canada, and DMTI. The various analyses below aimed to process, analyze and visualize spatial distribution, clustering and/or hot spots of different crimes across the study of area. The outputs that can be useful in designing and targeting policy making in regards to crime reduction and analysis.

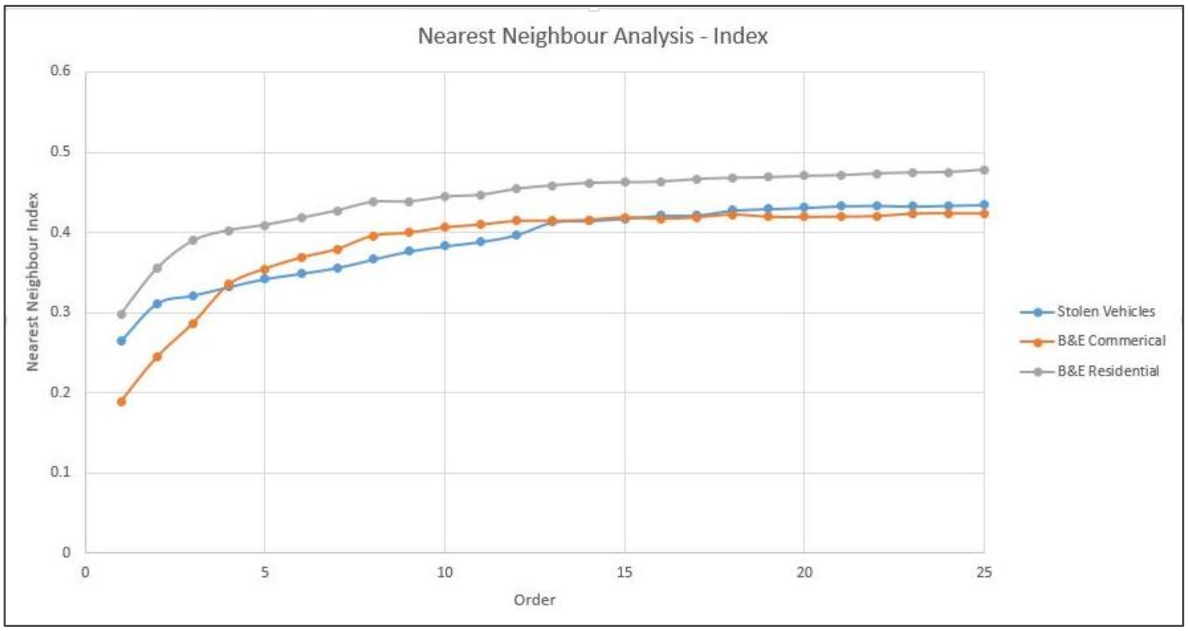
Nearest Neighbor Index

The nearest neighbor index is a distance statistics that is a test for first order nearest neighbor randomness. It compares the distances between nearest points and the distance that would be expected from chance. If the observed average distance is similar to that of the mean random distance, the ratio will be close to 1. However, if the observed average distance is smaller than the mean random distance, this means that points are closer together than would be expected from change, and the index will be less than 1.0. A value lower than 1.0 would therefore be an indicator of spatial clustering and spatial aggregation; The lower the index the more spatial aggregation. On the other hand, dispersal would be observed with an index above 1.

On the graph below, the index value have been plotted along the y axis and the order value on the x-axis. The results show that the data is more spatially aggregated than expected (index values are lower than 1), the distance between crime incidents are closer than what would be expected in random situations.

As observed on the graph, commercial break and enter and stolen vehicles are relatively similar, and have similar index values meaning they are similarly spatially aggregated,. However, break and enter residential has higher index value which means that crimes within that category are slightly less spatially aggregated/ slightly less clustered in its distribution pattern. Yet overall this tells that crimes tend to be spatially clustered in Ottawa.

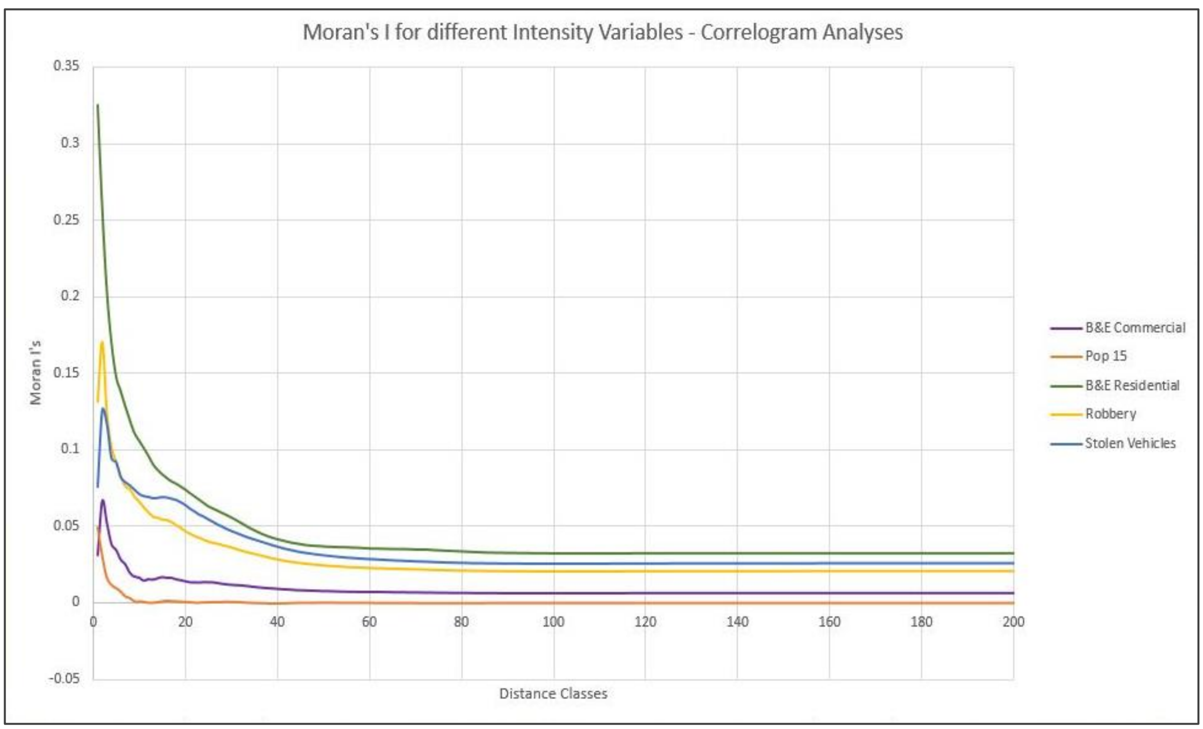
This means that residential crimes are more evenly distributed across the city. Which seem to be logical as residential areas are distributed over the city while commercial areas are more densely located around certain areas, where cars are also more concentrated in parking areas. In addition, it can also be observed on the graph that the first 10 neighbors are the most spatially aggregated.



Moran’s I

Moran’s I analyzes spatial distribution of incidents by analyzing the spatial autocorrelation of the intensity of crimes within each dissemination areas where values of 0 are not autocorrelated and values towards 1 are autocorrelated. The graph below shows the output for the Moran’s I correlogram for the different distances classes (lower classes represent dissemination areas that are closer together. The output of this analysis is interesting at it looks at the distribution of intensity of incidents rather than looking at individual events.

The results of the correlograms show positive values for the 4 different types of crime, which means that the distribution of crime intensities are spatially autocorrelated. Contrastingly, as observed on the graph below, the results for the population show that, beyond 10 distance classes the data is not autocorrelated. However, the non-zero values of the 4 crime type results show that crime intensity distribution has trends that can be explained by other factors than population density. In addition, the results also show that the closer the dissemination areas are the more likely crime intensities are to be spatially autocorrelated. Interestingly, the results also show that residential break-ins seem to have the highest spatial autocorrelation - which is interesting considering the fact that under the nearest neighbor analysis it was the least aggregated compared to other crimes.

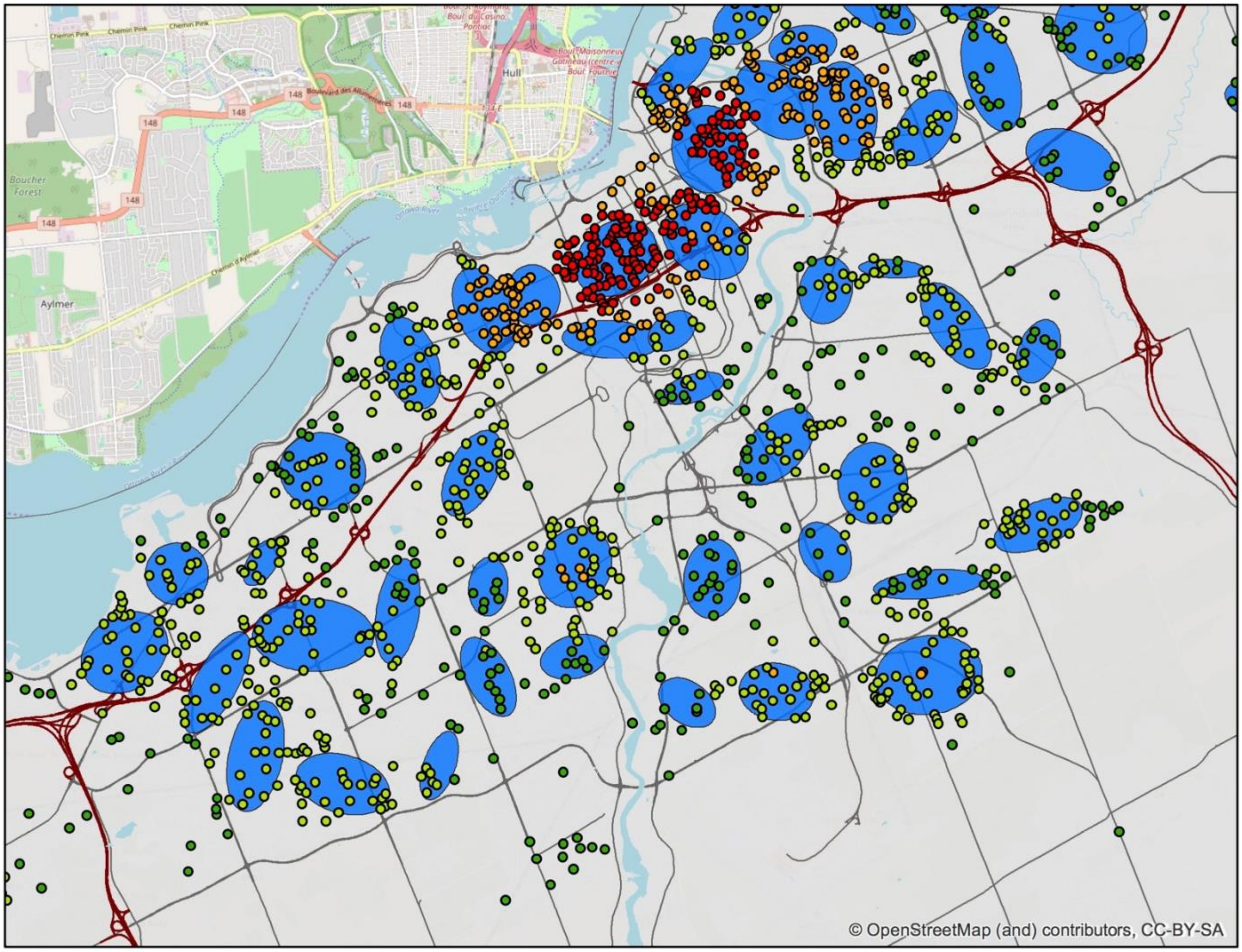


Fuzzy mode and Nearest neighbor hierarchical spatial clustering

The fuzzy mode within hot spot analysis represent individual clusters of points. The red points on the map on the following page represent crime areas with 152-247 number of crimes within 1000 meters. Areas of clustered points represent spatial aggregation and autocorrelation.

The nearest neighbor hierarchical spatial clustering represents hot spot areas (clusters of crime) instead of individual points clustered together. Both are represented on the map below where it can be observed that both type of clusters – points and area – have similar results, as could be expected. Indeed, most of the points fall within clusters. The outcome of these hot spot analysis are useful in isolating the areas in the city (represented by the distribution of clusters) which are source to crime incidents, and thus can help in developing policies.

Nearest Neighbour Analysis of Residential Break and Enters, Ottawa Nepean, Ontario (2005-2006)



Frequency of Crime

- 1 - 33
- 34 - 81
- 82 - 151
- 152 - 247

Highway

Main Roads

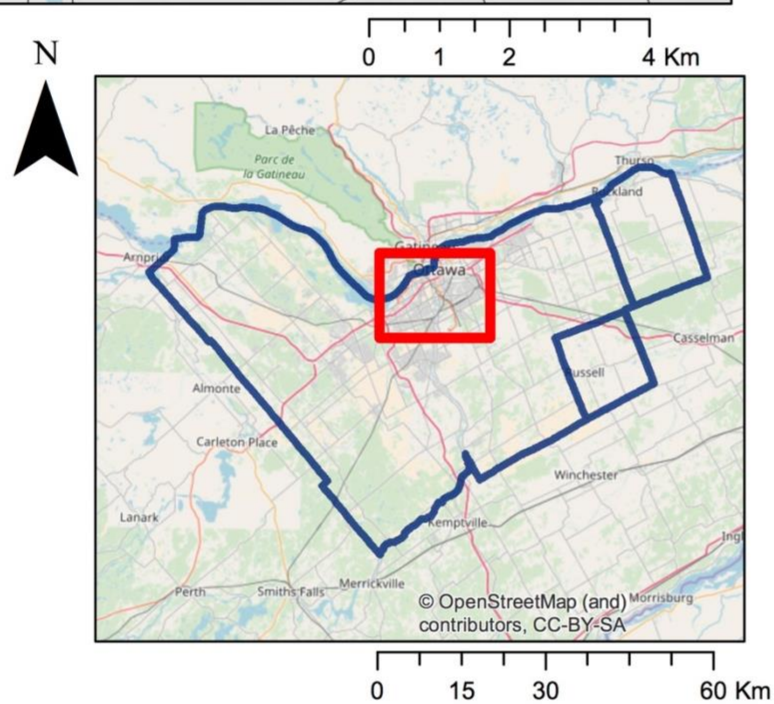
Water body

Ottawa-Nepean

Non-Adjusted Nearest Neighbor Cluster

Ottawa-Nepean

Area of focus



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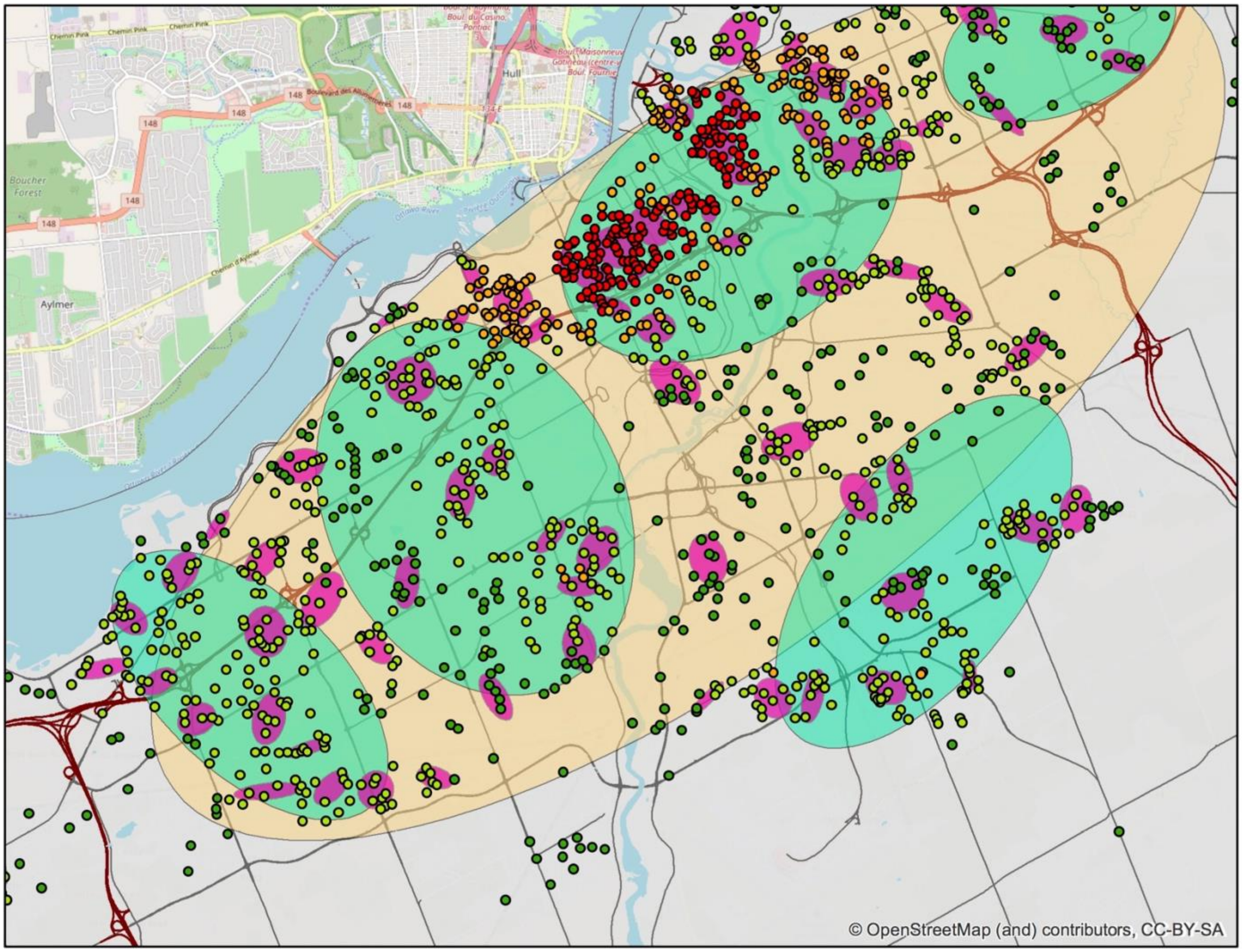
Data Source: Ottawa Police Department, Stats Canada & DTMI
Coordinate System: NAD783 UTM Zone 18
Projection: Transverse Mercator

Standard nearest neighbor hierarchical spatial clustering versus risk-adjusted results

The nearest neighbor hierarchical spatial clustering results showed clusters of crime across Ottawa. However, those results did not take into account the population of the areas. Taking into account for the population is relevant if wanting to analyze the relative risks of different areas. Indeed, areas with less population and high crimes are considered more dangerous than another area with the same number of crime but with much higher population.

The risk adjusted nearest neighbor analysis portrays, as can be observed on the following page, the areas in Ottawa that have the higher risk of crime occurrence of residential break and enter. There are three different orders of clusters. The first order cluster which can be compared to the previous map for non-adjusted nearest neighbors clusters. It is possible to observe that their clusters are different due to the fact that population has been taken into account. In addition, there is also a second order clusters and third order clusters, which are clusters of clusters. The third order cluster results in one single cluster whereby all incidents fall within that cluster.

Risk-Adjusted Nearest Neighbour Analysis of Residential Break and Enters, Ottawa Nepean, Ontario (2005-2006)



Frequency of Crime
- 1 - 33
- 34 - 81
- 82 - 151
- 152 - 247

Rist Adjusted - 1st Order Cluster

Rist Adjusted - 2nd Order Cluster

Rist Adjusted - 3rd Order Cluster

Ottawa-Nepean

Area of focus

Highway

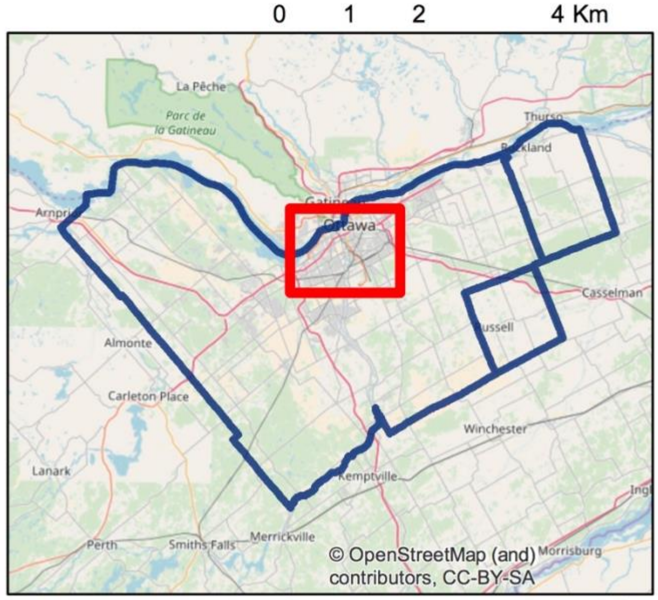
Main Roads

Water body

Ottawa-Nepean

N

0 1 2 4 Km



0 15 30 60 Km

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Projection: Transverse Mercator

The Knox Index

The Knox index is used to analyze the relationship between space and time - it is a simple comparison of the relationship between incidents in terms of distance (space) and time, in other words it is a measure of space-time clustering. This index is especially interesting in regards to crime data as crime incidents are often clustered together during short time periods. In addition, the interaction between time and space is compounded in the Chi Statistics, which the analysis calculated to be 94.01612. This result, according to the manual of Crime Stat reflects high spatial interaction between time and space.

The Know Index in this case was used to determine if there was both spatial and temporal clustering in crime incidents related to stolen vehicles, by examining car thefts event within 6 hours and 5 kilometers. The analysis classified the relationships of the calculated incidents into 4 relationships, close in time and space, close in time and not close in space, close in space and not close in time, and not close in space nor time. The output of the analysis (shown in Appendix A) show that the dominating relationship is incidents that are close in time and not close in space - thus showing that car thefts incidents are mostly clustered according to their time of occurrence.

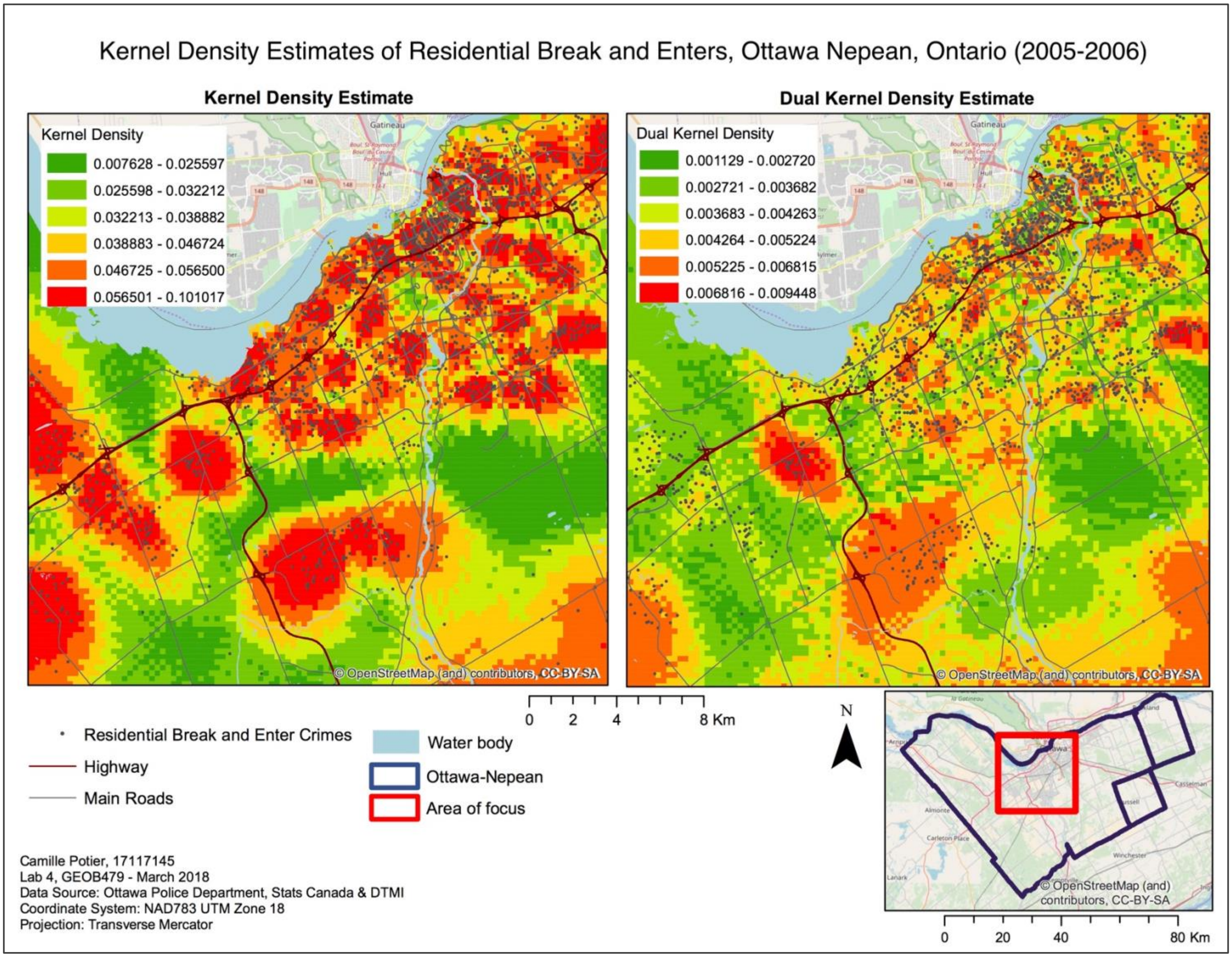
Kernel Density Interpolation

The kernel density interpolation method is one of the most popular methods of spatial statistical techniques (Chapter 10). In this case it is used to represent the estimated/expected intensity of crime incidents for the entire area of Ottawa Nepean. Its output provides a spatial representation of hot spots in crime data for residential break and enters. This output can be used for policy making as it enables one to focus on areas with high intensity of crime, as seen by the areas in red on the map below. The use of this techniques enable for the visualization of a broad region, such as the Ottawa - Nepean region. Indeed, the kernel density estimate analysis is used to study entire regions of study as it generalizes incident locations for an entire area, showing areas with high or low crime occurrences. The results are a grid interpretation of the data, area with higher densities are shown in red whilst areas of low densities of crime are shown in green.

The dual kernel density is applied to two distributions where the two variables can be related together. Whilst the kernel density evaluate residential break and enters, the dual kernel is adjusted for population data, which results in the portrayal of risk over the region.

The kernel density estimates generalize incident locations to an entire area whereas spatial distribution and hotspots statistics provide statistical summaries for each of the data incidents – interpolation techniques such as the kernel analysis generalizes those data incidents to the entire study region as they provide density/intensity of crime estimates. Kernel looks at entire area to compute statistically clustering while fuzzy analysis and hot spots look at each data point individually.

Furthermore, it is expected that there should be a correspondence between the identified risk adjusted clusters and the dual kernel interpolation of the crime incidents since both account for population density, and are thus both adjusted for risk of crime.


Kernel Density Estimates of Residential Break and Enters, Ottawa Nepean, Ontario (2005-2006)
Kernel Density Estimate
Kernel Density
0.007628 - 0.025597
0.025598 - 0.032212
0.032213 - 0.038882
0.038883 - 0.046724
0.046725 - 0.056500
0.056501 - 0.101017
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Dual Kernel Density Estimate
Dual Kernel Density
0.001129 - 0.002720
0.002721 - 0.003682
0.003683 - 0.004263
0.004264 - 0.005224
0.005225 - 0.006815
0.006816 - 0.009448
© OpenStreetMap (and) contributors, CC-BY-SA
0 2 4 8 Km
N
Residential Break and Enter Crimes
Highway
Main Roads
Water body
Ottawa-Nepean
Area of focus
© OpenStreetMap (and) contributors, CC-BY-SA
0 20 40 80 Km
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Data Source: Ottawa Police Department, Stats Canada & DTMI
Coordinate System: NAD783 UTM Zone 18
Projection: Transverse Mercator

Appendix A - Knox Index

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Knox Index: Interaction of Space and Time
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    Sample size ...........:  2152
    Measurement type ......:  Direct
    Input units .... ......:  Meters
    Time units ............:  Hours
    Simulation runs .......:  19
    Start time ............:  02:59:51 PM, 03/07/2018

    "Close" time ........:           6.00000 hours
    "Close" distance ....:        5000.00000 m

                         | Close in space(1)  | Not close in space(0) |
    ---------------------+--------------------+-----------------------+-----------------
    Close in time(1)     |             325473 |                986929 |        1312402
    Not close in time(0) |             242964 |                759110 |        1002074
    ---------------------+--------------------+-----------------------+-----------------
                         |             568437 |               1746039 |        2314476

    Expected:
                         | Close in space(1)  | Not close in space(0) |
    ---------------------+--------------------+-----------------------+-----------------
    Close in time(1)     |       322326.89199 |          990075.10801 | 1312402.00000
    Not close in time(0) |       246110.10801 |          755963.89199 | 1002074.00000
    ---------------------+--------------------+-----------------------+-----------------
                         |       568437.00000 |         1746039.00000 | 2314476.00000

    Chi-square ..........:          94.01612
    P value of Chi-square:           0.00010

    End time ..............:  02:59:51 PM, 03/07/2018

    Distribution of simulated index (percentile):
    Percentile      Chi-square
    ---------- ---------------
           min         0.00078
           0.5         0.00078
           1.0         0.00078
           2.5         0.00078
           5.0         0.00078
          10.0         0.00440
          90.0         2.56587
          95.0         3.40126
          97.5         3.40126
          99.0         3.40126
          99.5         3.40126
           max         3.40126

    Simulation ended ......:  02:59:54 PM, 03/07/2018
```