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Neighbourhood Characteristics and the Distribution of Crime on the Island of Montréal

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Neighbourhood characteristics and the distribution of crime on the Island of Montréal

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Table of contents

Acknowledgements 4

Abstract 6

Background 7

Findings **9**
- Montréal in context 9
- Distribution of crime on the Island of Montréal 10
- Distribution of crime in 2004 15
- Persons accused in crime incidents in 2001 19
- Neighbourhood characteristics and crime 28

Discussion **39**

Limitations and opportunities **43**

Methodology **45**
- Data sources 45
- Description of variables 46
- Geocoding 53

Endnotes **57**

Bibliography **58**

Appendix **63**

Cumulative Index **78**

Abstract

This research paper explores the spatial distribution of crime on the Island of Montréal and various social, economic and physical neighbourhood characteristics of this region. The analysis is based on data from the 2001 Census, police-reported crime data from the Incident-based Uniform Crime Reporting Survey and land use data from the Communauté métropolitaine de Montréal.

The results lend support to the notion that crime does not occur randomly in cities but is associated with demographic, socio-economic and land use factors. The research findings are consistent with those of other studies, in particular those focusing on Winnipeg (Fitzgerald, Wisener and Savoie 2004) and Regina (Wallace, Wisener and Collins 2006, forthcoming). However, in 2001 the distribution of crime in Montréal stood out clearly from that in other Canadian cities; property crime was highly concentrated in the city centre, while violent crime was distributed over various points throughout the area.

Bivariate results show several differences in the characteristics of high- and low-crime neighbourhoods. They suggest that crime is more prevalent in neighbourhoods where residents have less access to socio-economic resources. These neighbourhoods are characterized by an economically disadvantaged population with a lower proportion of highly educated people. They are also more likely to have a larger number of single persons, lone-parent families and recent immigrants, and to exhibit greater residential instability, fewer owner-occupants and a larger proportion of the population spending more than 30% of their budget on housing. Neighbourhoods with the highest crime rates also tend to have a greater portion of their land set aside for commercial or multi-family uses.

When all other factors are taken into account, a limited number of factors are found to be linked to the variation in the crime rate at the neighbourhood level. The set of explanatory factors varies in a specific way according to the type of crime, violent or property. However, three key factors are involved in both types of crime: low income, the proportion of single people and commercial land use.

The study shows that the vast majority of persons charged in criminal incidents that occurred in 2001 lived on the Island of Montréal. The results show that the distances travelled by the persons charged are relatively short, and that these distances vary with the type of offence, the age of the persons charged and their relationship with the victim. The findings are consistent with those from other countries, including the United Kingdom and the United States.

Background

This study is Statistics Canada's second examination of crime data using Geographic Information System (GIS) technology. The study, which was funded by the National Crime Prevention Centre at Public Security Canada, examines crime distribution on the Island of Montréal and the characteristics of charged persons' travel-to-offence patterns in 2001. Crime maps provide a visual representation of areas of concentrated crime and characteristics related to that concentration, and they can be an important tool for the development and implementation of crime reduction strategies.

The various mapping studies undertaken by the Canadian Centre for Justice Statistics (CCJS) fit into the theoretical framework of the ecology of crime, especially as regards to social disorganization and opportunities for crime. Since the 1940s, ecological studies of crime have found that crime is not distributed equally in cities; rather, it is often concentrated in specific neighbourhoods, and the route followed by the accused toward the target is relatively short and strongly influenced by daily activities. In the Canadian context, the study of neighbourhood characteristics and the distribution of crime in Winnipeg (Fitzgerald, Wisener and Savoie, 2004) showed that crime was concentrated in the city centre, which occupies a relatively small proportion of the total geographic area of that city. The results of the Winnipeg study also point to significant differences in the characteristics of high- and low-crime neighbourhoods. For instance, high-crime neighbourhoods were characterized by reduced access to socio-economic resources, lower residential stability, higher population density and land use patterns that can increase opportunities for crime. After taking into account all other factors, it was found that the level of socio-economic disadvantage of the residential population in a neighbourhood was the factor most strongly associated with the higher rates of both violent and property crime seen in some neighbourhoods.

This second study provides a description and explanation of the spatial models of crime on the Island of Montréal in relation to the social, economic and physical characteristics of its different neighbourhoods. A descriptive analysis of charged persons' travel patterns to the location of the offences, using GIS technology, is provided for Montréal for the first time. The following questions are raised in this study: How are police-reported criminal incidents distributed among the city's neighbourhoods? Is the crime rate in a neighbourhood associated with factors that are specific to that neighbourhood, such as its demographic, socio-economic, housing and land use characteristics? Is the crime rate in a neighbourhood affected by nearby neighbourhoods? What are the characteristics of charged persons' travel-to-offence patterns? These questions are explored using data from the 2001 Census of Population, the 2001 and 2004 Incident-based Crime Reporting Survey (UCR2), and land use data (2005) provided by the Communauté métropolitaine de Montréal.

It should be kept in mind that this study makes use of police-reported data, which provide a specific view of the nature and extent of crime. Specifically, police-

reported data measure only those crimes that are known to the police. Many factors can influence the police-reported crime rate, including the willingness of the public to report crimes to the police; reporting by police to the Uniform Crime Reporting Survey; and changes in legislation, policies or enforcement practices.

According to the 2004 General Social Survey (GSS) on victimization, 34% of victimization incidents were reported to the police in Canada. Specifically, police services were informed of 31% of all personal victimizations and 37% of all household crimes. This proportion varies throughout Canada, with the percentage of incidents reported being highest in Quebec, at 40%. A similar proportion of residents of the Montréal Census Metropolitan Area reported incidents to police. However, the data collected by the GSS are not available at the neighbourhood level because the sample size does not permit this.

The Census of Population is conducted by Statistics Canada every five years, most recently in 2001. In order to achieve the highest degree of compatibility between neighbourhood characteristics derived from the census and crime information, this study draws on police and census data, both from the year 2001.

Findings

Montréal in context

The analytical series "Trends and conditions in census metropolitan areas" uses census data to show that the 27 census metropolitan areas (CMA) differ greatly from each other with respect to a number of indicators (Heisz 2005). Montréal, the second largest CMA in Canada, stands out for its economic and social diversity. The strategies and policies adopted for its cities must take this into account.

In 2001, the Montréal CMA was the second largest CMA in Canada; it had a population of 3,426,350. The population of the Montréal CMA had grown 3% (99,903 inhabitants) since 1996, an increase similar to the average change (4%) of the other 26 CMAs during the same period. In 2001, some 47% of the Quebec population was living in the Montréal CMA, which extended over an area of 4,047 km^2.

The Island of Montréal, which is the focus of this study, falls within the larger CMA boundary and covers approximately 500 km^2, with a perimeter of 231.9 kilometres encompassing 521 neighbourhoods or census tracts (CT) (see definition in the census tract and neighbourhoods text box). The residential population of the study area was 1,812,723. The area is served entirely by the Montréal police department, which in 2001 employed a force of 4,082 officers operating out of 49 neighbourhood police stations.

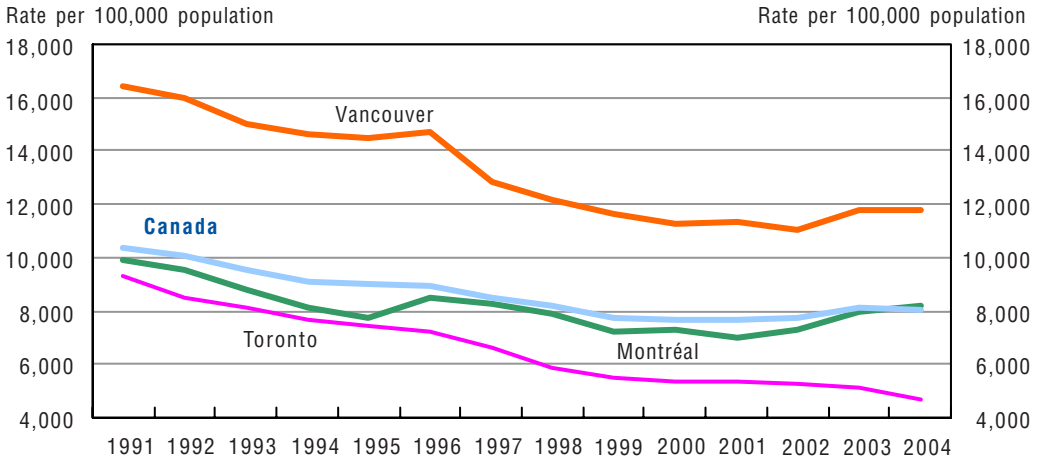
In Montréal, land use breaks down approximately as follows: 31% public areas (including streets, railways, port areas, airport, parking lots); 19% other public areas (parks, golf courses, vacant areas, etc.); 17% single-family housing; 12% multiple-family housing and other types of residential areas; 10% industrial buildings; 6% institutional buildings; and 5% commercial buildings.

Since the early 1990s, the aggregated crime rates reported by the Montréal CMA have followed a general downward trend, dropping 18% between 1991 and 2004. Figure 1 shows crime rates for Montréal and for Canada as a whole from 1991 to 2004. The rates for the CMA were slightly lower than the Canadian average, except in 2004, when the CMA ranked slightly above, with 8,173 *Criminal Code* offences per 100 000 population, excluding traffic offences. During the same period, the Toronto CMA reported lower crime rates while the Vancouver CMA recorded crime rates that were significantly higher than those of the Montréal CMA.

In the 2004 General Social Survey (GSS), the victimization rates reported by residents of the Montréal CMA were among the lowest of any CMA (Gannon and Mihorean 2005), at 64 violent incidents per 1,000 inhabitants aged 15 and older; 175 household victimization incidents per 1,000 households; and 72 thefts of personal property per 1,000 inhabitants aged 15 and older. Residents of the cities of Toronto (107, 222 and 107, respectively) and Vancouver (107, 462 and 136, respectively) reported much higher rates of all types of victimization.

Figure 1

Crime rates[1] in major census metropolitan areas, Canada, 1991 to 2004



1. Rates based on count of total *Criminal Code* incidents excluding traffic offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Uniform Crime Reporting Survey, 1991 to 2004.

Offence categories included in this study are: violent, property, drug, prostitution, offensive weapons, and gaming and betting offences. In 2001, the Montréal police department reported 136,000 of these offences, the vast majority of which were property crimes (78%), followed by violent offences (19%) and other offences (3%) including prostitution, drug-related offences, offensive weapons-related crimes, and gaming and betting offences. This distribution is similar to the one noted at the national level (79%, 17% and 4%, respectively). The Toronto and Vancouver police services present a slightly different crime composition; the Toronto Police Service has a slightly higher proportion of violent offences (72%, 24% and 4%), while the Vancouver Police Department has a lower proportion of these violent offences (84%, 11% and 5%).

Distribution of crime on the Island of Montréal

While incidents were reported in 520 of the 521 CTs on the Island, a closer look at the distribution of incidents reveals that reported crime is not evenly dispersed across the island (Table 1). Map 1 shows the spatial distribution of criminal incidents on the Island, each point representing a criminal incident. This map shows a concentration of criminal incidents in some areas of the Island, such as the city centre, whereas in other areas, criminal incidents are quite rare. This map also provides a first indication of the relationship between crime and land use. In fact, some of the areas where there are few criminal offences, such as Pierre-Elliot-Trudeau Airport and the lands occupied by petroleum industries in the east end of the Island, are relatively inaccessible and in some cases access is controlled.

Table 1A

Number and rate of incidents reported by police in Montréal neighbourhoods, 2001

Offences	Count of incidents[1]			
	CT average	CT minimum	CT maximum	Total all CTs
Total incidents[3]	**252**	**0**	**3,819**	**131,102**
Total violent incidents[3]	48	0	437	**25,000**
Total property incidents[3]	194	0	3,341	**101,213**
Drug incidents[3]	6	0	249	**2,924**
Other[3,4]	4	0	99	**1,965**
Selected offences				
Arson[5]	2	0	12	**911**
Assault (levels 1,2,3)[5]	25	0	152	**13,048**
Breaking and entering[5]	43	0	411	**22,157**
Car theft[5]	30	0	390	**15,823**
Drug incidents[5]	6	0	249	**2,924**
Homicide[5,6]	0	0	3	**147**
Mischief[5]	25	0	176	**12,967**
Prostitution[5]	1	0	82	**498**
Robbery[5]	8	0	177	**4,159**
All sexual offences[5,7]	2	0	14	**1,174**
Shoplifting[5]	9	0	583	**4,708**
Theft under $5,000 (without car theft)[5]	78	0	2,324	**40,478**
Theft over $5,000 (without car theft)[5]	4	0	138	**1,832**

Offences	Rate of incidents per 1,000 residential population[2]		
	CT average	CT minimum	CT maximum
Total incidents[3]	**117**	**10**	**13,034**
Total violent incidents[3]	19	1	1,491
Total property incidents[3]	94	8	11,403
Drug incidents[3]	2	0	182
Other[3,4]	2	0	96
Selected offences			
Arson[5]	1	0	17
Assault (levels 1,2,3)[5]	9	0	519
Breaking and entering[5]	16	2	679
Car theft[5]	12	0	608
Drug incidents[5]	2	0	182
Homicide[5,6]	0	0	7
Mischief[5]	10	1	601
Prostitution[5]	0	0	41
Robbery[5]	4	0	604
All sexual offences[5,7]	1	0	34
Shoplifting[5]	6	0	1,990
Theft under $5,000 (without car theft)[5]	47	2	7,932
Theft over $5,000 (without car theft)[5]	2	0	471

Table 1A – concluded

Number and rate of incidents reported by police in Montréal neighbourhoods, 2001

Offences	Rate of incidents per 1,000 residential and employed population[2]		
	CT average	CT minimum	CT maximum
Total incidents[3]	**49**	**9**	**369**
Total violent incidents[3]	10	1	65
Total property incidents[3]	37	7	239
Drug incidents[3]	1	0	69
Other[3,4]	1	0	21
Selected offences			
Arson[5]	0	0	5
Assault (levels 1,2,3)[5]	5	0	33
Breaking and entering[5]	9	1	39
Car theft[5]	6	0	25
Drug incidents[5]	1	0	69
Homicide[5,6]	0	0	1
Mischief[5]	5	0	22
Prostitution[5]	0	0	20
Robbery[5]	0	2	16
All sexual offences[5,7]	0	0	3
Shoplifting[5]	1	0	27
Theft under $5,000 (without car theft)[5]	14	2	159
Theft over $5,000 (without car theft)[5]	1	0	7

1. Total count based on 521 Census Tracts (CTs).
2. Rate based on the 506 CTs where the total residential population was over 250 people.
3. Includes most serious violation in each incident only.
4. Includes Prostitution, Offensive Weapons, Gaming and Betting, Indecent Acts, Child Pornography offences, Obstructing a Public/Peace Officer and Trespass at Night.
5. Includes all recorded violations in each incident.
6. Includes Attempted Murder and Conspiracy to Commit Murder.
7. Includes Sexual Assault (levels 1, 2, 3) and other sexual violations.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census Division, 2001.

Table 1B

Count of police-reported crime incidents in Montréal neighbourhoods, 2004

Offences	Count of incidents[1]			
	CT average	CT minimum	CT maximum	Total all CTs
Total incidents[2]	**235**	**0**	**3,214**	**122,552**
Total violent incidents[2]	44	0	277	**23,019**
Total property incidents[2]	180	0	2,866	**93,802**
Drug incidents[2]	6	0	147	**2,968**
Other[2,3]	5	0	251	**2,763**
Selected offences				
Arson[4]	0	0	1	**2**
Assault (levels 1,2,3)[4]	22	0	118	**11,653**
Breaking and entering[4]	37	0	355	**19,128**
Car theft[4]	25	0	332	**13,109**
Drug incidents[4]	6	0	149	**3,004**
Homicide[4,5]	0	0	5	**125**
Mischief[4]	27	0	170	**13,998**
Prostitution[4]	3	0	249	**1,491**
Robbery[4]	8	0	83	**4,009**
All sexual offences[4,6]	2	0	29	**1,301**
Shoplifting[4]	9	0	492	**4,736**
Theft under $5,000 (without car theft)[4]	66	0	1,481	**34,517**
Theft over $5,000 (without car theft)[4]	5	0	118	**2,497**

1. Total count based on 521 Census Tracts (CTs).
2. Includes most serious violation in each incident only.
3. Includes Prostitution, Offensive Weapons, Gaming and Betting, Indecent Acts, Child Pornography offences, Obstructing a Public/Peace Officer and Trespass at Night.
4. Includes all recorded violations in each incident.
5. Includes Attempted Murder and Conspiracy to Commit Murder.
6. Includes Sexual Assault (levels 1, 2, 3) and other sexual violations.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 1

Distribution of crime incidents, Montréal, 2001

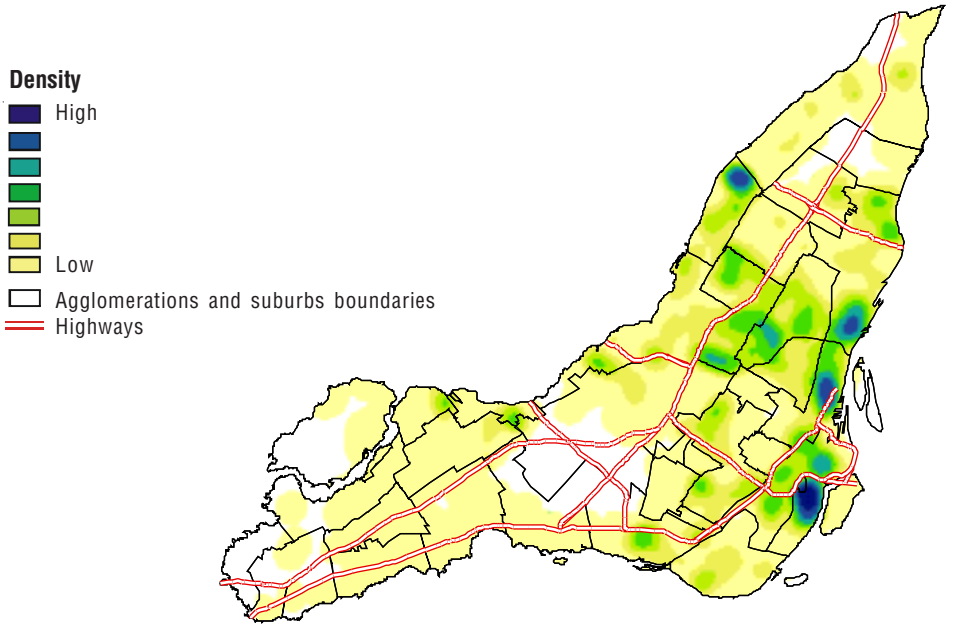
Based on 131,102 crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 2 and Map 3 show the location of clusters of violent and property incidents, or crime "hot spots". The first map shows that the neighbourhoods with the highest relative densities of violent crime are in the city centre, Verdun, Mercier–Hochelaga–Maisonneuve, Montréal-Nord, Rosemont–La-Petite-Patrie and Villeray–St-Michel–Parc–Extension. Property crimes are highly and almost exclusively concentrated in the city centre. Hot spots outside the city centre are located in the Island's large shopping malls and at Pierre-Elliot-Trudeau Airport. Maps showing the location of hot spots within the city for selected types of offences are provided in Appendix A.

Map 2

Kernel density distribution of violent crime incidents and population at risk, Montréal, 2001

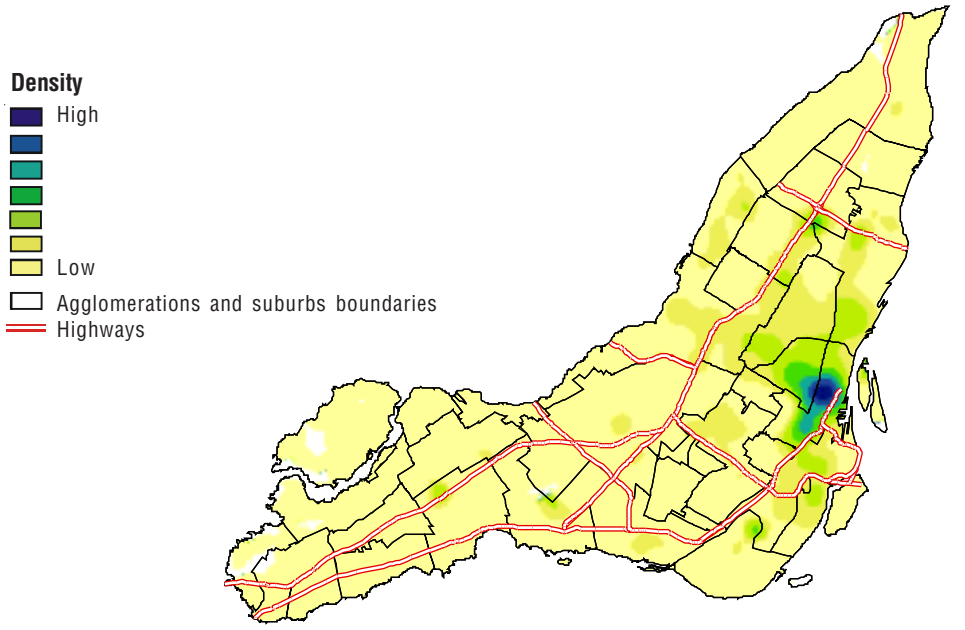


Based on 25,000 violent crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 3

Kernel density distribution of property crime incidents and population at risk, Montréal, 2001



Based on 101,213 property incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Crime on the Island is concentrated in a relatively small number of neighbourhoods. In fact, about 20% of violent crime incidents reported in 2001 took place in 7% of the CTs, and 20% of reported property crime incidents occurred in 4% of the CTs. Other studies have also noted this concentration (Sherman, Gartin and Buerger 1989; Brantingham and Brantingham 1982; Fitzgerald, Wisener and Savoie 2004; Wallace 2006). However, the distribution of the major offence categories in Montréal exhibits a general pattern that is different from what was observed in Winnipeg and Regina, where violent offences were highly concentrated in the city centre and property offences occurred in a number of hot spots. Montréal has several pockets of poverty, in contrast to the Western Canadian cities, where poverty is highly concentrated in the city centre (Heisz 2005). This finding underlines the importance of studying the specific dynamics of each community. The multivariate analysis presented further on in this report explores more fully the role of poverty in the spatial distribution of crime in Montréal.

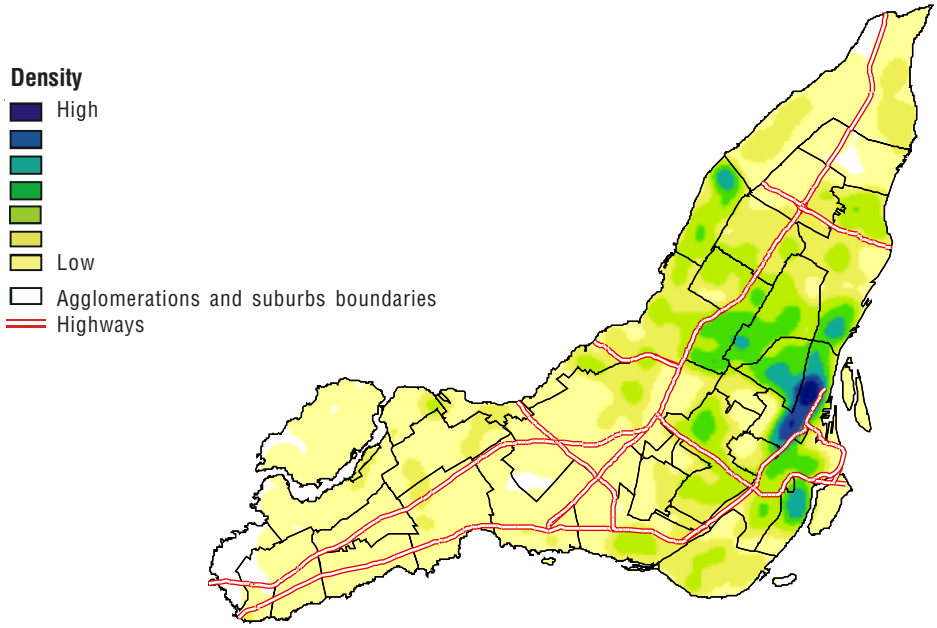
Distribution of crime in 2004

An analysis of the spatial distribution of crime over time[1] suggests that population data must be available in order to take demographic fluctuations into account in determining crime rates. Census data available at the CT geographic level for the Island of Montréal are from 2001. Accordingly, the analysis presented in this report uses single kernel density distributions to determine whether the relative frequency of crime distribution on the Island of Montréal changed between 2001 and 2004.

Overall between 2001 and 2004, the Montréal police department reported a slight decrease in violent crime, the rate going from 1,168 per 100,000 population to 1,066 in 2004. A comparable decrease was also noted for property offences (4,923 in 2001 to 4,456 in 2004). Map 4 and Map 5 show relative frequency distributions of violent incidents in 2001 and 2004. These distributions indicate that, overall, the relative frequency of crime in a CT compared to the Island as a whole for the same year exhibited a very similar pattern for the years 2001 and 2004.

Map 4

Kernel density distribution of violent crime incidents, Montréal, 2001



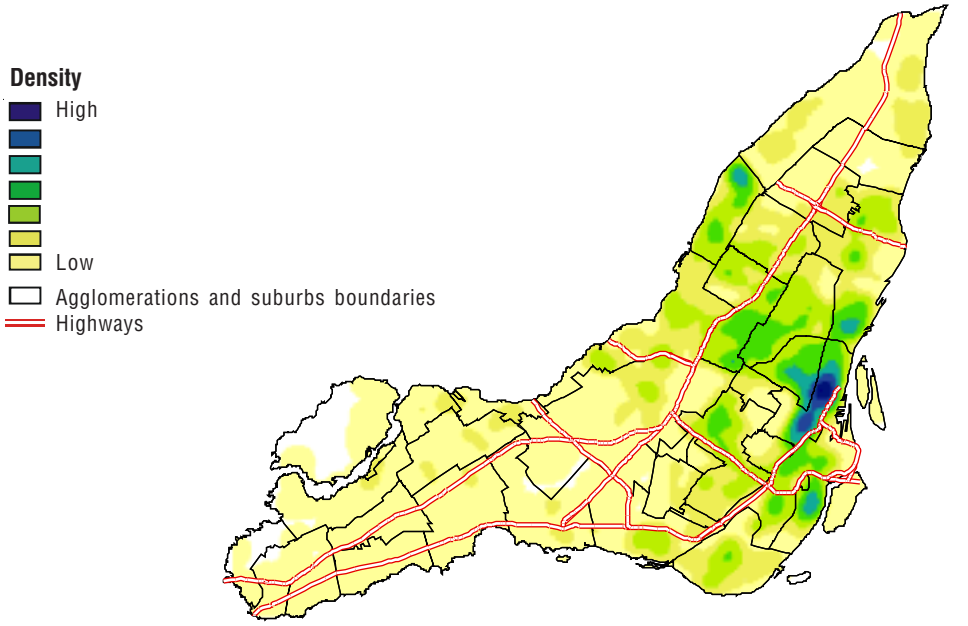
Based on 25,000 violent crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 6 and Map 7 illustrate the relative distributions of property offences in 2001 and 2004. The spatial distribution of the relative frequency of property crime incidents remained remarkably stable between 2001 and 2004.

Map 5

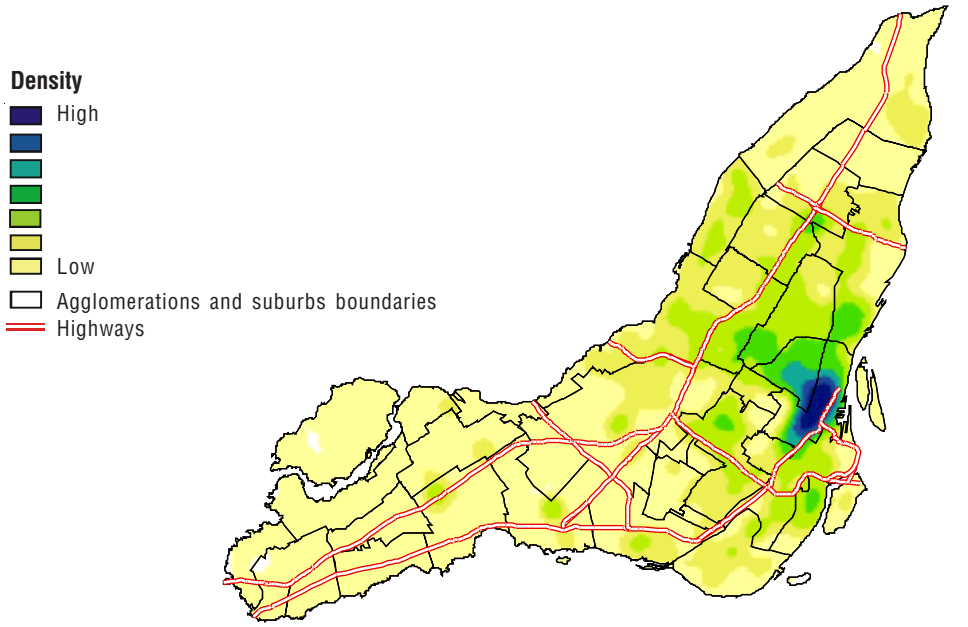
Kernel density distribution of violent crime incidents, Montréal, 2004



Based on 23,019 violent crime incidents.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 6

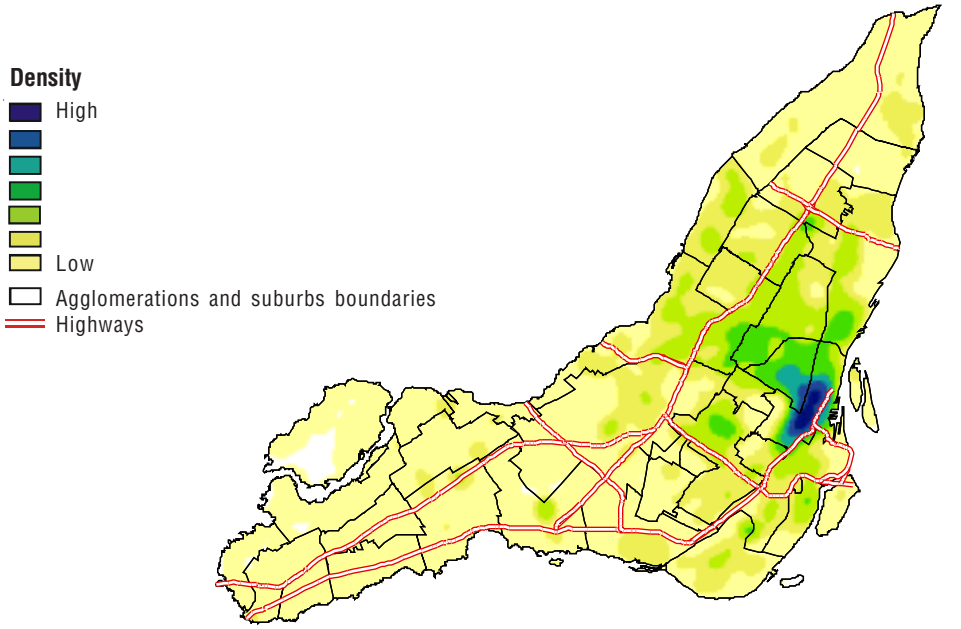
Kernel density distribution of property crime incidents, Montréal, 2001



Based on 101,213 property crime incidents.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 7

Kernel density distribution of property crime incidents, Montréal, 2004



Based on 93,802 property crime incidents.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

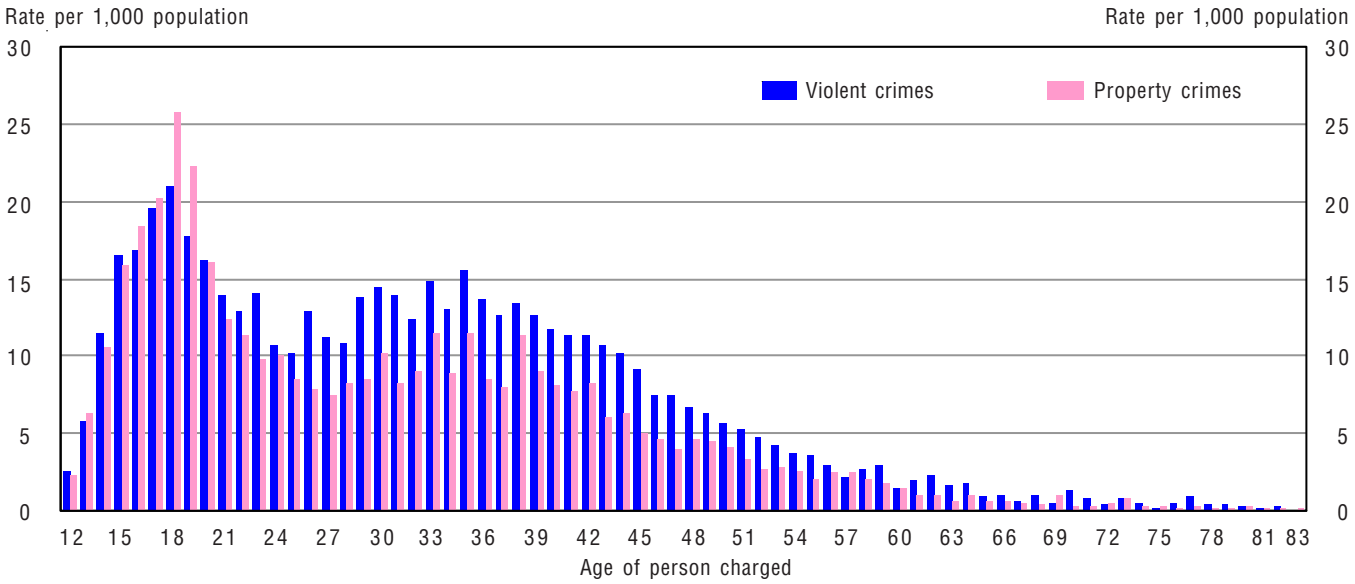
Persons accused in crime incidents in 2001

Social ecology recognizes that a better knowledge of the characteristics of persons accused in criminal incidents also serves to inform and guide the development of strategies for combating crime. In the paragraphs below, special attention is paid to the characteristics of persons accused of and charged with criminal offences committed on the Island of Montréal in 2001.

Approximately one-third of the criminal incidents reported in 2001, or nearly 43,600 of them, were solved, and one or more accused were identified. The age-specific delinquency rate peaked for 15- to 19-year olds, which is largely consistent with the national picture seen annually. Of this number, more than two-thirds were charged. The charge rate by age showed a pattern quite similar to the age-specific delinquency rate (Figure 2). In Montréal in 2001, the vast majority of persons charged were men (77%). Women accounted for 12%, male youth aged 12 to 17, for 9%, and female youth, for 2%. The pattern emerging from the geocoded data provided a very similar picture, and no statistically significant difference was noted (based on T-test, $p<0.001$).

Figure 2

Age structure of person charged, Montréal, 2001



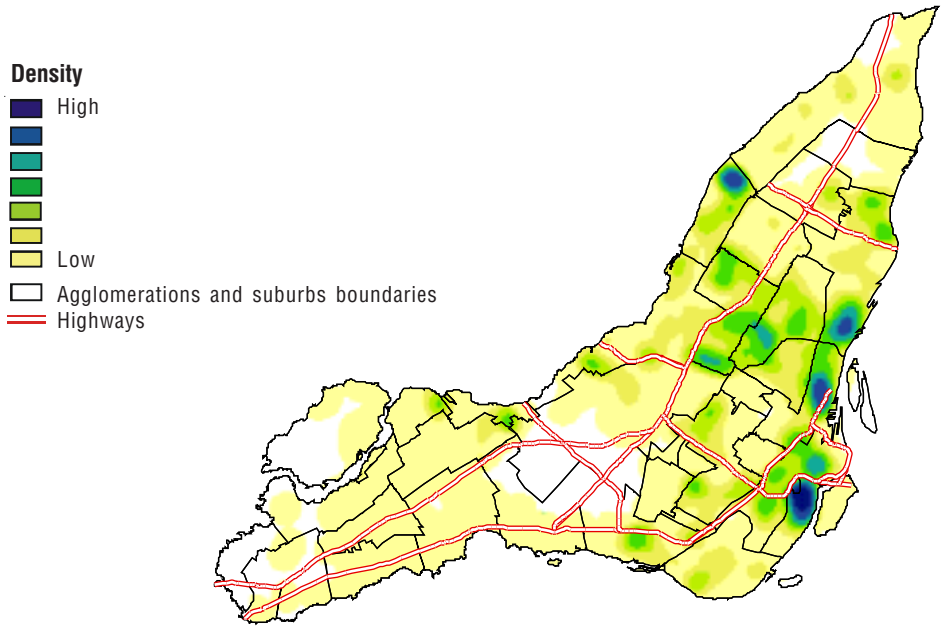
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, 2001.

Place of residence of persons charged

Map 8 and Map 9 display the place of residence of charged persons reporting a residential address on the Island of Montréal by type of offence committed in 2001. These maps show that charged persons come from various neighbourhoods. The place of origin of persons charged with violent offences (10,096 persons charged) is more diverse than that of those charged with property offences (7,744 persons charged), and it is also less concentrated. The points of origin of persons charged with property offences are more concentrated in the CTs that comprise the boroughs of Mercier–Hochelaga–Maisonneuve, Montréal-Nord, Sud-Ouest, Verdun and Ville-Marie. Charged persons who live outside of Montréal (9% or 1,973 persons charged) largely come from the Island's suburbs[2]: Laval (468 persons charged), Longueuil (186), Saint-Hubert (60), Brossard (55) and Terrebonne (55). Among charged persons residing off the Island, 32% had committed violent offences and 44% property offences.

Map 8

Kernel density distribution of place of residence of persons charged with violent offences and the residential population, Montréal, 2001

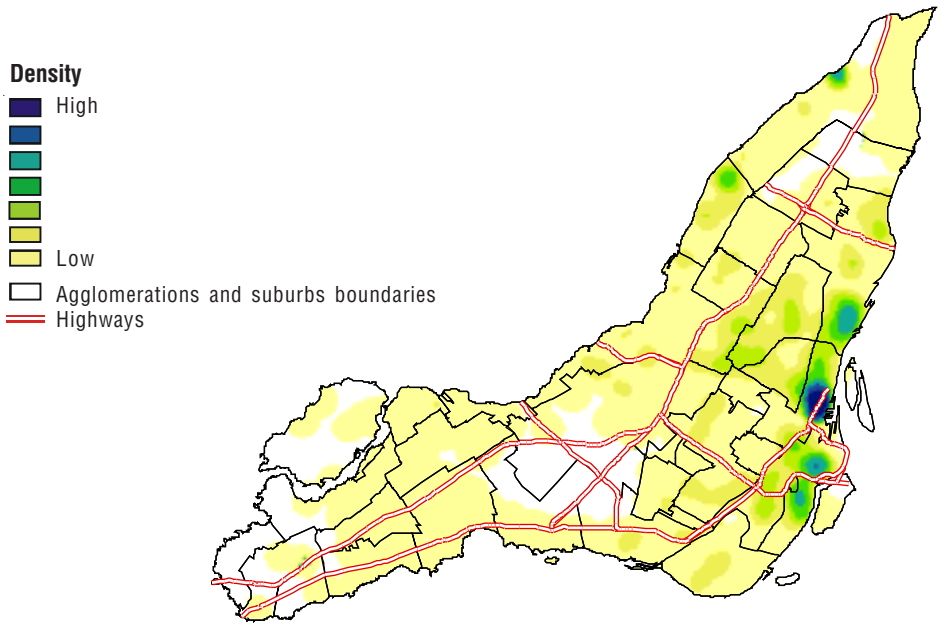


Based on 10,096 persons charged.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 9

Kernel density distribution of place of residence of persons charged with property offences and the residential population, Montréal, 2001



Based on 7,744 persons charged.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Distance travelled by persons charged

Using the location of criminal incidents and the place of residence of persons charged, it is possible to calculate the distance travelled by the person charged (see *Methods* section). Since analyses of distance travelled cover all charged persons residing on the Island of Montréal and elsewhere in Canada, the median distance is chosen as a better measure of central tendency than the mean, since it is not affected by extreme values.

Since Map 10 and Map 11 show simple density distributions, they do not take the residential population into account. These maps can be used to compare density distributions of places of origin and destination for all violent offences. At first glance, these maps show few differences between the general patterns in the distribution of relative frequencies, since the places of origin and destination appear quite similar. The fact is that persons charged with violent offences do not travel far; they travel a median distance of less than 1 kilometre (0.9 km) (Table 2). However, a more detailed examination reveals that the median distance travelled varies according to the type of violent offence. Persons charged with assault (0.4 km) travel the least, while those identified in sexual assault incidents cover a median distance of 1.3 kilometres. Persons charged with robbery in 2001 had travelled the greatest median distance, at more than 3 kilometres. The number of persons charged with homicide (21) is too small to draw conclusions regarding the distance covered.

Table 2

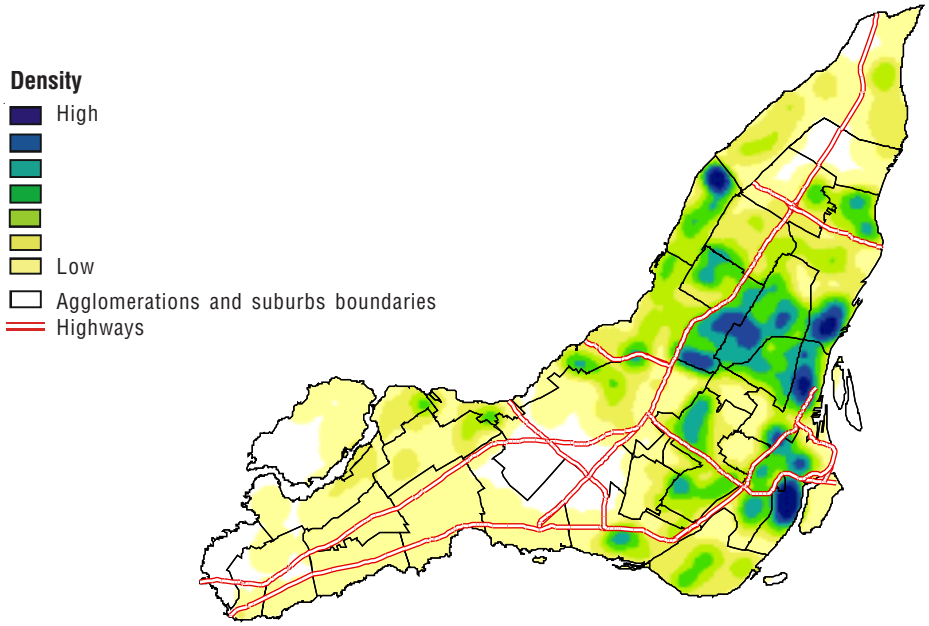
Median distances travelled by charged persons by type of offence, Montréal, 2001

	Median distances in kilometers		
	Street network	Euclidian	Number of cases
Violent offences	0.89	0.68	10,009
Assaults	0.35	0.26	6,913
Sexual assaults	1.29	1.07	201
Robbery	3.11	2.52	958
Utter threats to person	1.41	1.08	1,347
Property offences	4.16	3.38	7,744
Break and Enter	3.3	2.65	1,079
Theft over and under $5,000	4.38	3.61	4,550
Shoplifting	4.1	3.46	2,897
Car theft	6.53	5.67	565
Total of offences	**2.55**	**2.03**	**21,382**

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 10

Kernel density distribution of place of residence of persons charged with violent offences, Montréal, 2001

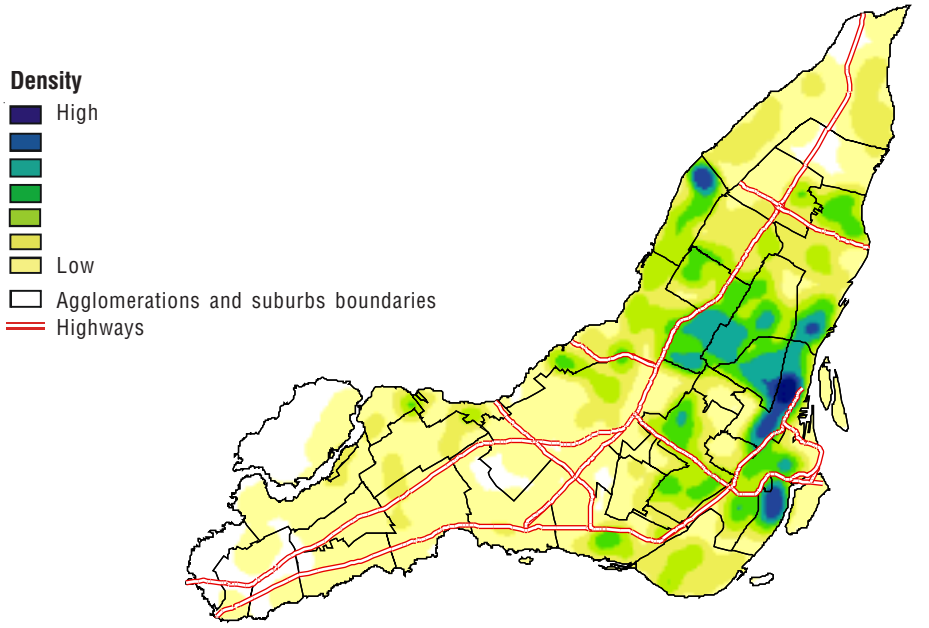


Based on 10,096 persons charged.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 11

Kernel density distribution of solved violent offences for which the charged person's place of residence is known, Montréal, 2001



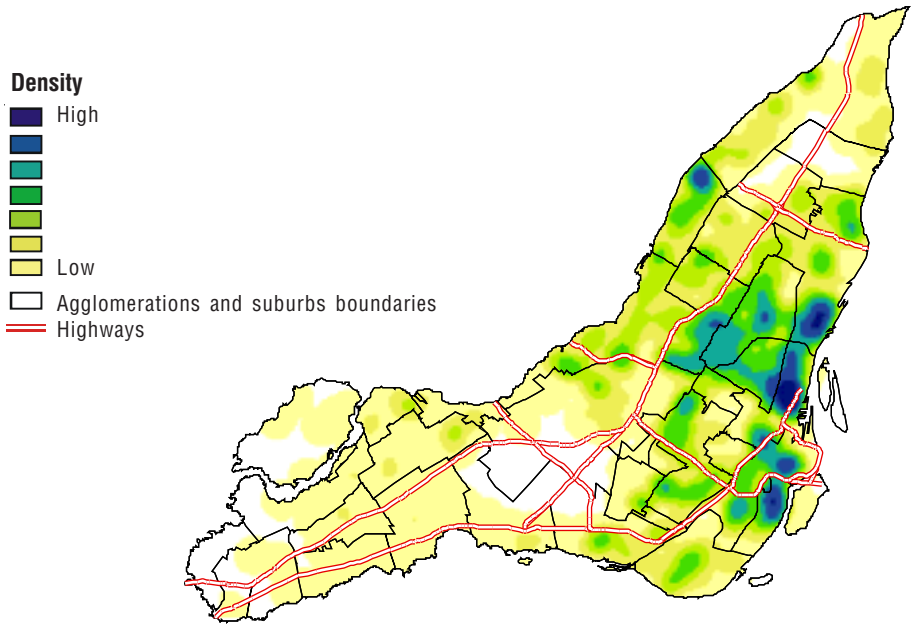
Based on 10,096 violent crime offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 12 and Map 13 illustrate the relative distribution of the points of origin of persons charged with property offences and the location of the criminal incident. Those charged with property crimes show greater diversity in their place of origin and more concentrated destination points. The CTs with the main point-of-origin hot spots are located in the boroughs of Verdun, Mercier–Hochelaga–Maisonneuve, Ville-Marie and Montréal-Nord, whereas the destination points are much more limited—they are concentrated in the city centre and the Island's main shopping malls. This dissimilarity indicates that persons charged in property crime incidents, who travel a median distance of more than 4 kilometres, generally cover a greater distance than those charged with violent offences. This distance also varies with the type of offence. In 2001, persons charged with breaking and entering had the shortest distance of all persons charged with property offences, at 3.3 kilometres, followed by theft $5,000 and under and theft over $5,000 (4.4 km). The longest distances travelled were for car thefts, at more than 6.5 km.

Map 12

Kernel density distribution of place of residence of persons charged with property offences, Montréal, 2001

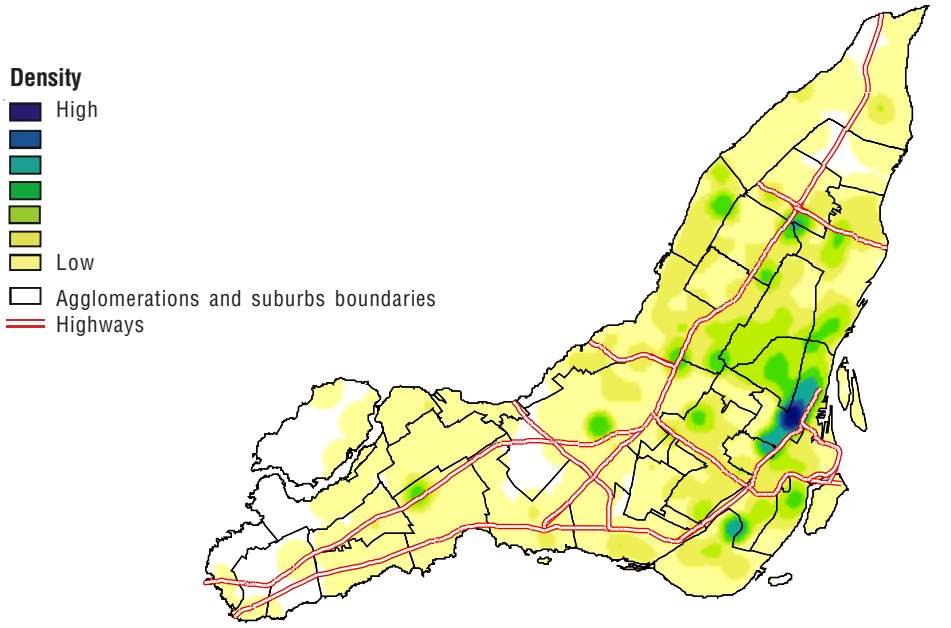


Based on 7,744 persons charged.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 13

Kernel density distribution of solved property offences for which the place of residence of a person charged is known, Montréal, 2001

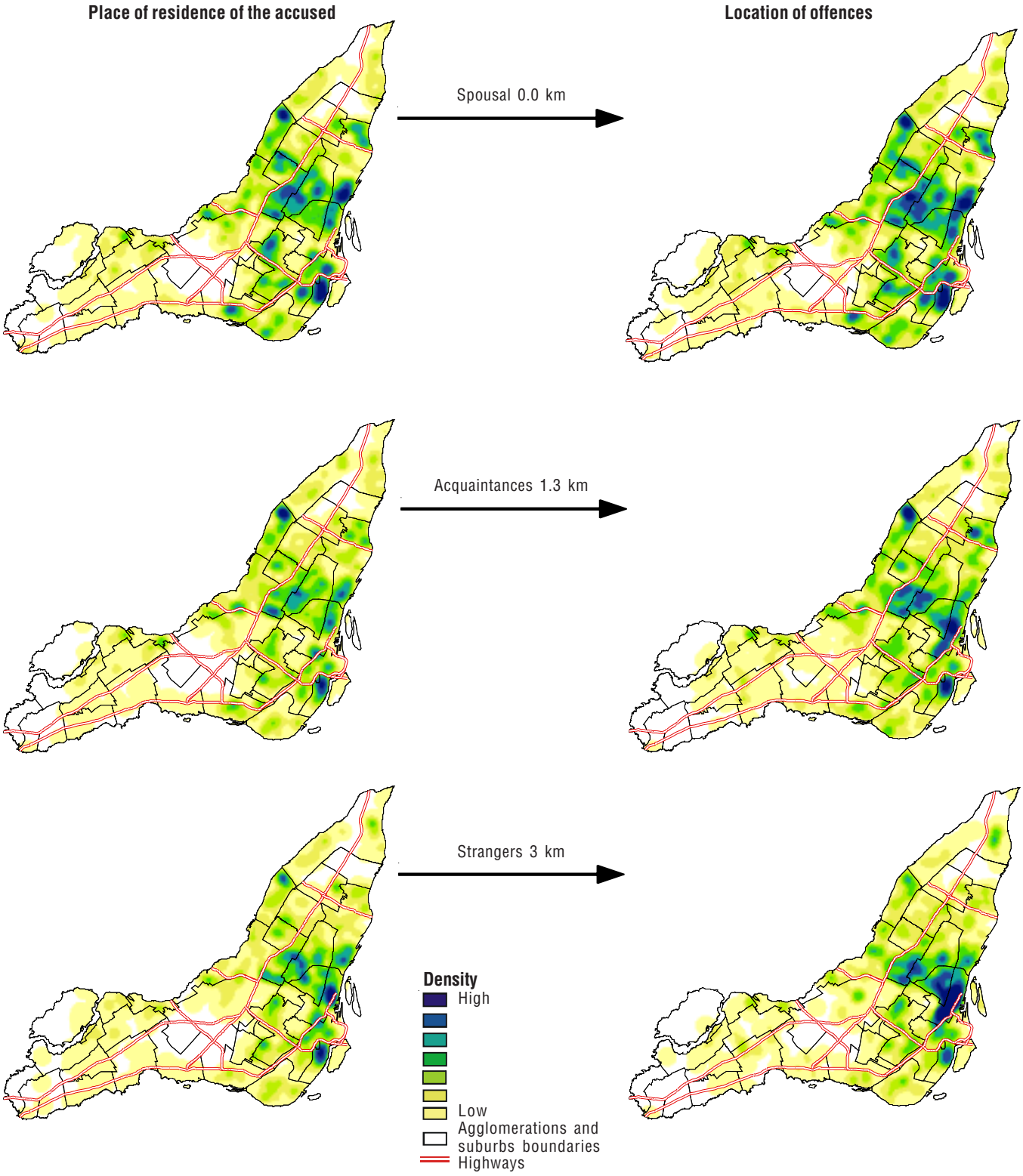


Based on 7,744 property crime offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

The distance also varies according to the charged person's relationship with the victim. Figure 3 shows charged persons' origin and the various distances they travel according to their relationship with the victim (one relationship is counted per person charged, namely the one showing the closest link with the victim). Median distances travelled vary according to the closeness of the relationship between persons charged and their victims. Not surprisingly, the data show that spouses did not travel, the address in most cases being the same, that is, the same block face. Ex-spouses travelled a median distance of 2.1 kilometres. Charged persons who knew the victim covered a median distance of 1.3 kilometres, while charged persons who did not know their victim travelled the longest distance, namely 3 kilometres, and most of them headed for the city centre of Montréal. However, few differences are noted in the kernel distribution of charged persons' origin according to their relationship with the victim.

Figure 3

Place of origin of charged persons and variation in their destination according to relationship with victim, Montréal, 2001

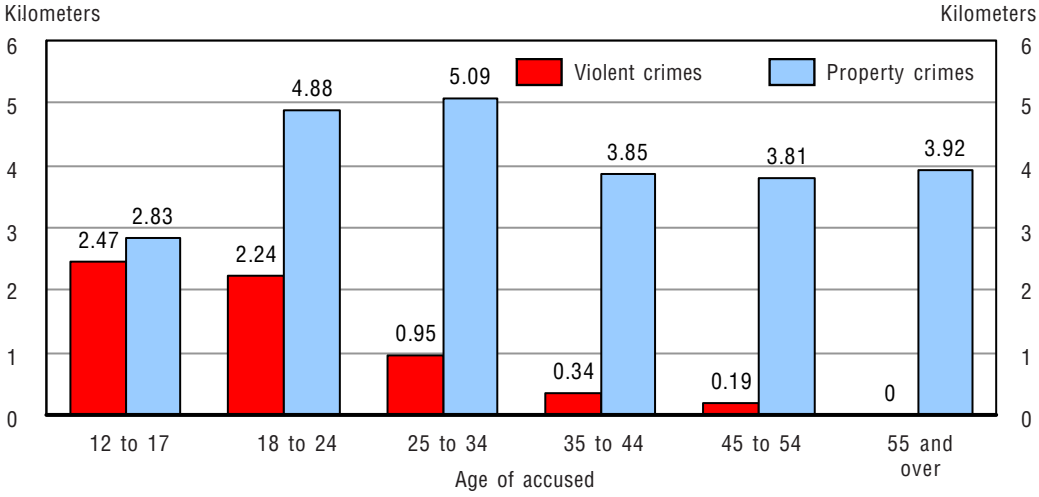


Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

The median distance travelled by charged persons also varies according to age (Figure 4). In the case of violent offences, the distance travelled is greater in adolescence, that is, between 12 and 17 years of age, and diminishes with age. This variation is attributable to the fact that young persons aged 12 to 17 are more likely to target acquaintances (51% of their victims) and strangers (40%) than persons with whom they have any other type of relationship. Starting at age 25, charged persons were consistently more likely to target their spouse (between 26% and 29%), followed by acquaintances (between 24% and 34%) and ex-spouses (between 12% and 16%). Charged persons aged 18 to 24 were the most likely to attack strangers (representing 43% of their victims). By comparison, distance travelled in the case of property offences was shortest for male and female youth and peaked between 18 and 34 years of age, after which it stabilized. This pattern may be related to access to various modes of transportation.

Figure 4

Median distances[1] travelled by charged persons by age, Montréal, 2001



1. Distances measured using the street network.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Groff and McEwen (2005), who examined the statistical relationship between Euclidian distance and street network distance, concluded that there was an almost perfect linear relationship between these two measures (R^2=0.997). In Table 2, distances measured using the street network are consistently longer than straight-line (Euclidian) distances. However, the two measures yield the same general assessment of the trip length according to the characteristics of the person charged and the type of offence. A simple linear regression applied to the Montréal situation shows that the relationship between the two measures is perfectly linear (R^2=1.000) in the case of violent offences and almost perfectly linear (R^2=0.998) in the case of property offences. For example, the street network distance travelled by a person charged with a violent offence is 119% plus 0.008 kilometres that of the Euclidian distance. Euclidian distance may thus be considered an excellent measure of the distance travelled by charged persons on the Island of Montréal.[3]

Neighbourhood characteristics and crime[4]

Since the 1940s (Shaw and McKay 1942), numerous studies have documented the relationship between neighbourhood characteristics and crime rates. However, these studies have differed with respect to the importance they place on factors such as low income, residential mobility, ethno-cultural composition, opportunities for criminal behaviour, collective efficacy (or the level of trust and reciprocity in a neighbourhood), and social disorganization (or a decrease in the influence of social rules over behaviour) (Cohen and Felson 1979; Brantingham and Brantingham 1982; Ronek and Maier 1991; Sampson and Lauritsen 1994; Sampson et al. 1997).

This section explores the relationship between many of these factors and 2001 rates of violent and property crime in Montréal neighbourhoods. The analysis makes use of total violent and property crime rates rather than rates for individual offence types to maximize the number of incidents being considered. For reasons of data confidentiality and reliability, Statistics Canada requires that when using individual, family or household income data, the population size for any Canadian geographic area being considered must be least 250 people living in at least 40 private households. As a result, only 506 of the 521 CTs are included. A map is appended showing the coverage of the 506 CTs over the territory of the Island of Montréal.

Characteristics considered in this analysis are taken from the 2001 Census and land use data of the Communauté métropolitaine de Montréal. They are outlined in the section entitled *Description of variables*.

Descriptive results: a comparison of high- and low-crime neighbourhoods

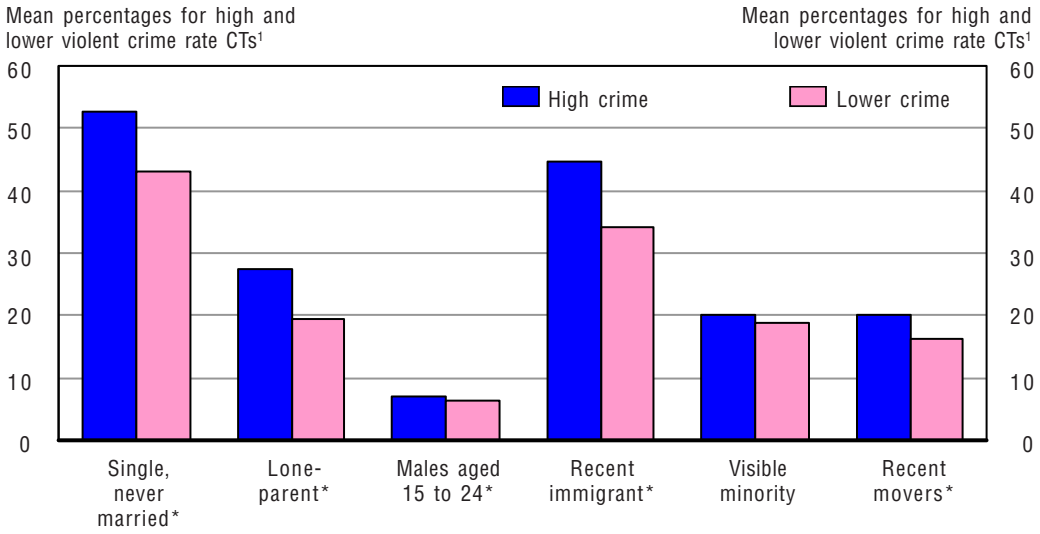
To examine the relationship between violent and property crime rates and selected neighbourhood characteristics, the 506 CTs have been divided into two groups for each crime type. The first group contains the 126 CTs that recorded the highest property and violent crime rates (25%), and the second group contains the remaining 380 CTs, representing 75% of the total.[5]

Before controlling for other factors, significant differences are noted in selected characteristics when comparing neighbourhoods with higher crime rates with their lower crime rate counterparts. These differences in crime rates are consistent across a number of socio-economic, demographic, land use and dwelling characteristics for both violent and property crimes.

Figure 5 shows that when compared with census tracts that recorded fewer violent incidents, census tracts with the highest rates had, on average, a significantly greater proportion of single residents (53% and 43%), lone-parent families (27% and 19%) and greater residential mobility (20% and 16%, respectively), meaning that a larger proportion of people were not living at the same address one year prior to the 2001 Census. The percentages were also higher for recent immigrants, meaning those who arrived in Canada between 1991 and 2001 (45% and 34%, respectively), in high-crime neighbourhoods. Another difference, small but statistically significant, was that neighbourhoods with high levels of violent crime had a higher male-to-female ratio and a larger proportion of young males aged 15 to 24. Figure 6 shows similar differences with respect to property crimes.

Figure 5

Demographic characteristics in neighbourhoods with high and lower rates of violent crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: p<0.001

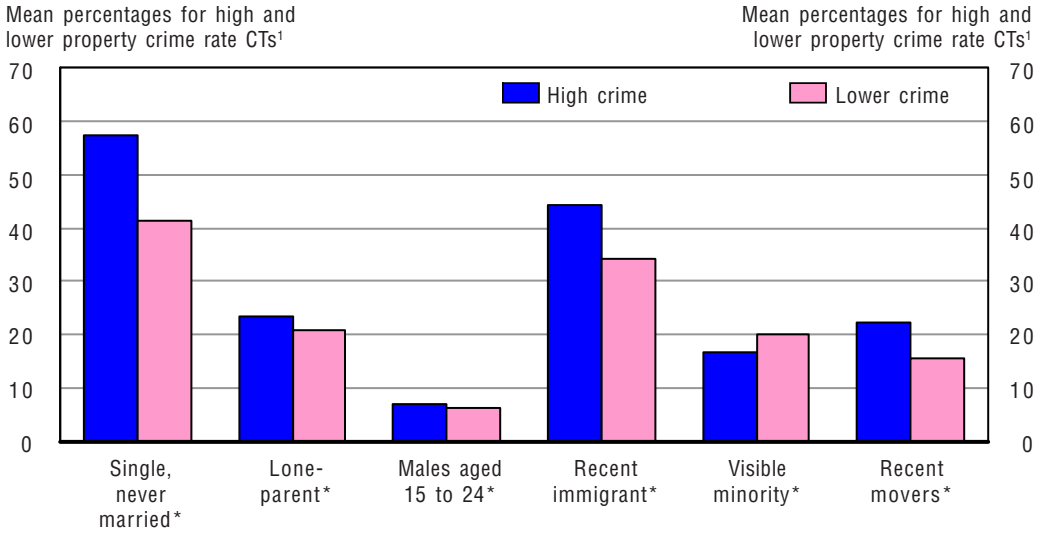
1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.

Note: N = 506 Census Tracts.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census, 2001.

Figure 6

Demographic characteristics in neighbourhoods with high and lower rates of property crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: p<0.001

1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.

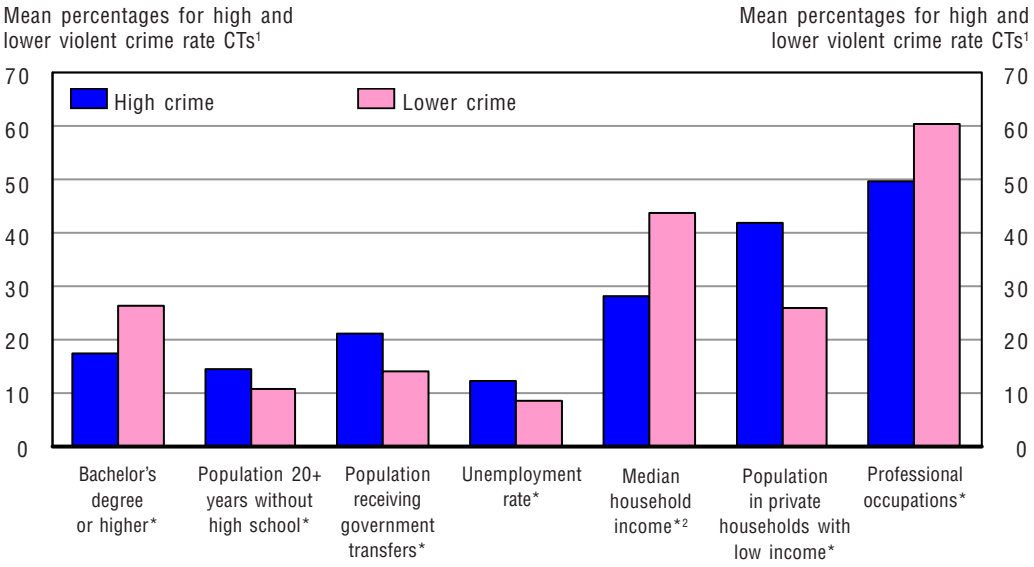
Note: N = 506 Census Tracts.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census, 2001.

Finally, Figure 7 and Figure 8 show that there are many disparities in the socio-economic variables in neighbourhoods with higher violent and property crime rates. These disparities reflect much larger proportions of residents who have incomes below the low-income cut-off (42% vs. 26%), receive government transfers (21% vs. 14%) or are unemployed (12% vs. 9%). Also, these neighbourhoods have a substantially lower median household income than CTs with low violent crime rates ($28,000 vs. $44,000). The proportion of persons aged 20 and over who have a bachelor's degree is significantly different, namely 26% in neighbourhoods with low violent crime compared to 17%. A similar observation may be made with respect to the proportion of persons in professional occupations, which is higher in neighbourhoods where violent crime is low (61%) than in those with high crime (50%).

Figure 7

Socio-economic characteristics in neighbourhoods with high and lower rates of violent crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: $p<0.001$

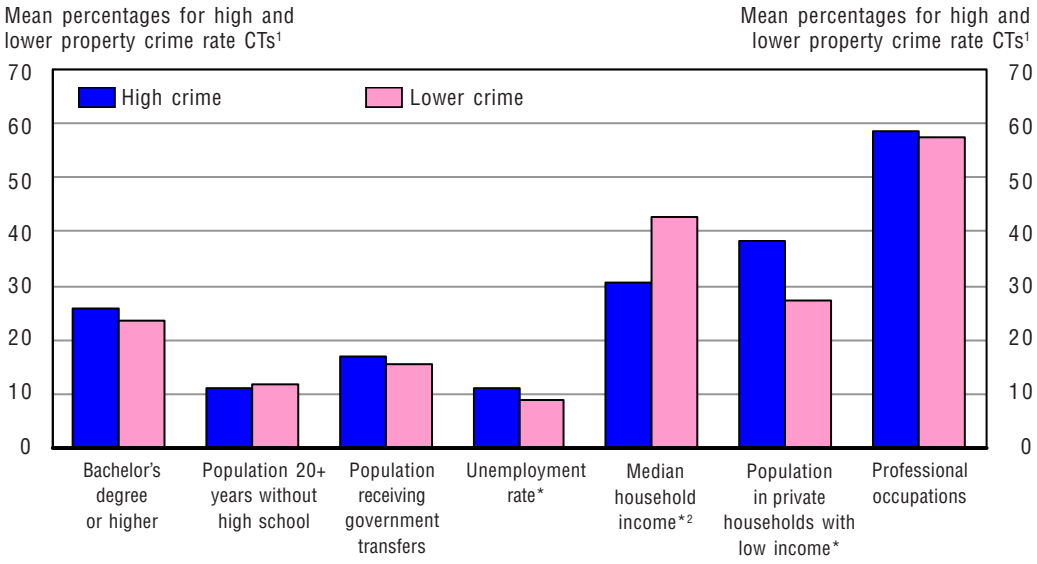
1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.
2. Median household income in $1,000s.

Note: N = 506 Census Tracts.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census, 2001.

Figure 8

Socio-economic characteristics in neighbourhoods with high and lower rates of property crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: p<0.001

1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.
2. Median household income in $1,000s.

Note: N = 506 Census Tracts.

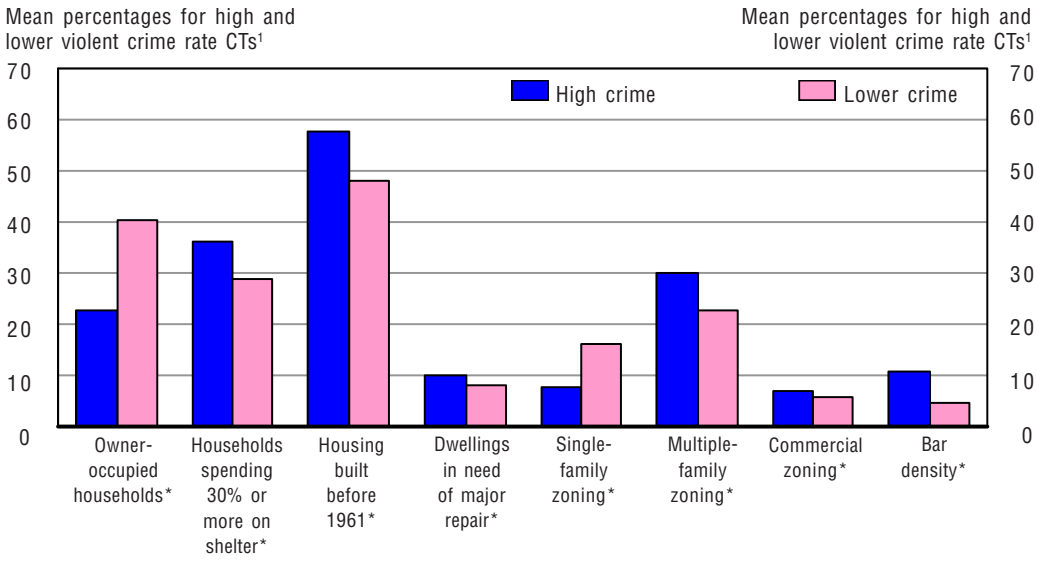
Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001 and Census, 2001.

Figure 8 indicates similar results for property crime rates, except for the proportion of persons holding a bachelor's degree and the proportion with a professional occupation, which are not statistically significant. The Winnipeg study showed that there was a significant difference in the percentages of persons with no high school diploma in low-crime and high-crime neighbourhoods (Fitzgerald, Wisener and Savoie 2004). This difference is not statistically significant in Montréal neighbourhoods in the case of property crime.

The differences in land use and housing characteristics were greater in the case of property offences than in that of violent offences (Figure 9 and Figure 10). The proportion of commercial zoning was greater in neighbourhoods with higher property crime rates than in other neighbourhoods (10% and 5% respectively); the proportion of multi-family zoning was also greater in the former neighbourhoods (29% vs. 23%), while the proportion in single-family zoning was smaller (7% vs. 17%) (Figure 10). The density of bars was much greater in neighbourhoods with high property crime, at 14 per km^2 compared to 3 per km^2. Neighbourhoods where the property crime rate was higher also recorded a larger proportion of dwellings constructed before 1961 (59% vs. 48%). There were also lower proportions of owner-occupied dwellings in these same high property crime neighbourhoods (22% vs. 41%), and greater proportions of unaffordable housing, represented by households spending more than 30% of their income on shelter (35% vs. 29%). Figure 9 shows similar differences in the case of violent crimes.

Figure 9

Land-use and housing characteristics in neighbourhoods with high and lower rates of violent crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: p<0.001

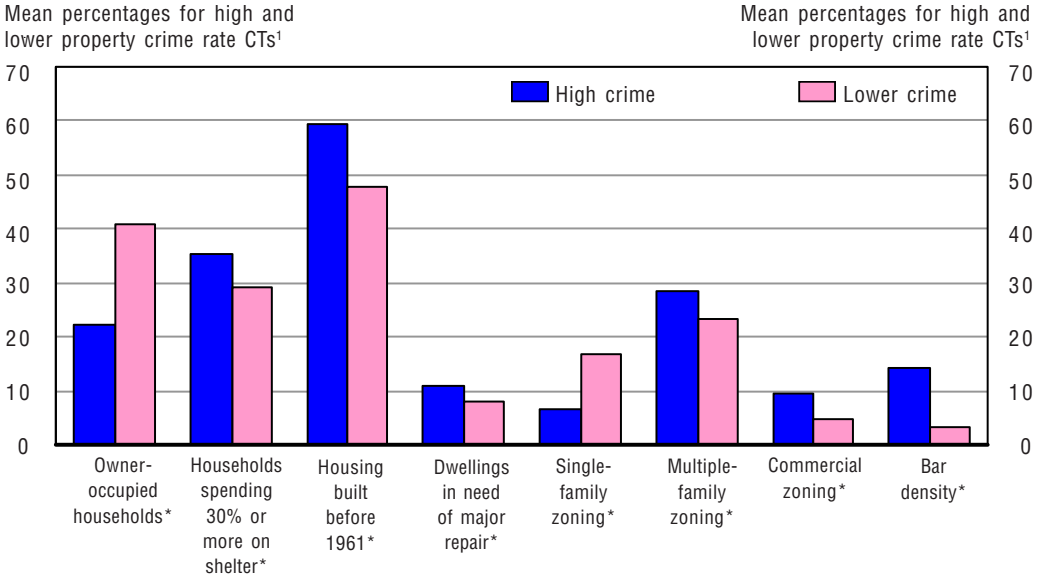
1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.

Note: N = 506 Census Tracts.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001, Census, 2001 and Communauté métropolitaine de Montréal, land use data, 2005.

Figure 10

Land-use and housing characteristics in neighbourhoods with high and lower rates of property crime, Montréal, 2001



* differences between high-crime and lower-crime means are statistically significant at: p<0.001

1. High-crime = CTs falling into the highest 25% (126) of violent crime rate neighbourhoods; lower-crime = remaining 75% (380). Rate per 1,000 residential and employed population.

Note: N = 506 Census Tracts.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001, Census, 2001 and Communauté métropolitaine de Montréal, land use data, 2005.

Results of multivariate analysis

When considered individually, the neighbourhood characteristics discussed above are associated with higher rates of violent and property crime, but the strength of this association can vary when multiple characteristics are considered together. Multivariate analysis in this section is used to examine the interrelationships among variables and to observe how they relate to the level of crime after taking other factors into account. Ordinary least squares (OLS) regression is used to examine the distribution of violent and property crime rates as a function of the set of explanatory factors. The use of this method requires a continuous or quantitative outcome variable that has a normal distribution, in this case the crime rate. Since the distribution of crime rates is often skewed, with a small proportion of neighbourhoods accounting for a larger proportion of reported incidents, it was necessary to log transform the crime variables.

Many of the neighbourhood characteristics in this study are highly correlated with each other or convey essentially the same information. This multicollinearity between factors stems from the strong association among many factors that are individually linked to crime (Land, McCall and Cohen 1990).

To avoid the problem of multicollinearity, which may distort the results, highly correlated variables were eliminated from the analysis.[6] Thus, Table 3 shows that median household income (r=-0.76), the proportion of persons receiving government transfers (r=0.74) and the percentages of persons unemployed (r=0.76), owner-occupied dwellings (r=-0.80) and unaffordable housing (r=0.79) are all highly correlated with the low income cut-off, and hence had to be eliminated. Table 3 shows that the proportion of people with a bachelor's degree is closely related to occupation. Therefore the occupation variable, which was also highly correlated with median household income, was dropped from the analysis.

Table 3

Bivariate correlations of independent variables, Montréal neighbourhoods, 2001[1]

		1	2	3	4	5	6	7	8	9	10	11
1	Ratio of males to females	1.00	...	...	...	...	...	...	...	...	...	...
2	Percent males aged 15 to 24	0.41**	1.00	...	...	...	...	...	...	...	...	...
3	Percent population aged 65 years and above	-0.44**	-0.48**	1.00	...	...	...	...	...	...	...	...
4	Percent population single, never married	0.46**	0.39**	-0.40**	1.00	...	...	...	...	...	...	...
5	Percent lone-parent families	-0.05	0.13**	-0.15**	0.36**	1.00	...	...	...	...	...	...
6	Percent population with a Bachelor's degree or higher	0.10*	0.10*	-0.09*	0.14**	-0.50**	1.00	...	...	...	...	...
7	Percent Aboriginal population	0.05	0.04	-0.02	0.18**	0.19**	-0.10*	1.00	...	...	...	...
8	Percent visible minority population	-0.01	0.22**	-0.11*	-0.21**	0.18**	-0.14**	-0.18**	1.00	...	...	...
9	Percent recent immigrants, 1991 to 2001	0.18**	0.22**	-0.20**	0.46**	0.37**	-0.03	0.17**	0.25**	1.00	...	...
10	Percent recent movers (past year different address)	0.38**	0.41**	-0.24**	0.75**	0.27**	0.11*	0.21**	0.03	0.54**	1.00	...
11	Percent population receiving government transfers	-0.12**	-0.03	0.26**	0.00	0.64**	-0.69**	0.08	0.41**	0.25**	0.09	1.00
12	Unemployment rate	0.19**	0.25**	-0.12**	0.20**	0.50**	-0.34**	0.05	0.53**	0.44**	0.32**	0.69**
13	Percent population 20+ years without high school diploma	-0.15**	-0.12**	0.13**	-0.12**	0.53**	-0.81**	0.21**	0.14**	0.12**	-0.03	0.66**
14	Median household income (000's)	-0.08	-0.14**	-0.04	-0.44**	-0.61**	0.53**	-0.12**	-0.26**	-0.44**	-0.48**	-0.65**
15	Percent of population in private households with low income	0.21**	0.34**	-0.11*	0.47**	0.68**	-0.38**	0.14**	0.48**	0.57**	0.55**	0.74**
16	Percent households spending 30% or more on shelter	0.13**	0.27**	0.11*	0.39**	0.44**	-0.24**	0.15**	0.29**	0.47**	0.58**	0.57**
17	Percent owner-occupied households	-0.10*	-0.19**	-0.01	-0.61**	-0.61**	0.23**	-0.14**	-0.21**	-0.59**	-0.65**	-0.56**
18	Percent housing built before 1961	0.10*	0.10*	-0.14**	0.51**	0.23**	0.25**	0.13**	-0.20**	0.26**	0.31**	0.00
19	Percent dwellings in need of major repair	0.16*	0.29**	-0.27	0.50**	0.32**	0.07	0.17	0.03**	0.32**	0.42**	0.12**
20	Percent commercial zoning	0.27**	0.12**	0.03	0.17**	-0.06	0.04	0.01	0.11*	0.11*	0.26**	0.02
21	Percent single-family zoning	-0.12**	-0.06	0.04	-0.49**	-0.46**	0.27**	-0.10*	-0.11*	-0.40**	-0.50**	-0.41**
22	Percent multiple-family zoning	-0.06	-0.01	-0.08	0.44**	0.40**	-0.14**	0.00	0.04	0.39**	0.32**	0.28**
23	Bar density	0.30**	0.17**	-0.05	0.43**	-0.05	0.14**	0.04	-0.03	0.17**	0.36**	0.02

Table 3 – concluded

Bivariate correlations of independent variables, Montréal neighbourhoods, 2001[1]

		12	13	14	15	16	17	18	19	20	21	22
1	Ratio of males to females	...	...	...	...	...	...	...	...	...	...	...
2	Percent males aged 15 to 24	...	...	...	...	...	...	...	...	...	...	...
3	Percent population aged 65 years and above	...	...	...	...	...	...	...	...	...	...	...
4	Percent population single, never married	...	...	...	...	...	...	...	...	...	...	...
5	Percent lone-parent families	...	...	...	...	...	...	...	...	...	...	...
6	Percent population with a Bachelor's degree or higher	...	...	...	...	...	...	...	...	...	...	...
7	Percent Aboriginal population	...	...	...	...	...	...	...	...	...	...	...
8	Percent visible minority population	...	...	...	...	...	...	...	...	...	...	...
9	Percent recent immigrants, 1991 to 2001	...	...	...	...	...	...	...	...	...	...	...
10	Percent recent movers (past year different address)	...	...	...	...	...	...	...	...	...	...	...
11	Percent population receiving government transfers	...	...	...	...	...	...	...	...	...	...	...
12	Unemployment rate	1.00	...	...	...	...	...	...	...	...	...	...
13	Percent population 20+ years without high school diploma	0.36**	1.00	...	...	...	...	...	...	...	...	...
14	Median household income (000's)	-0.56**	-0.47**	1.00	...	...	...	...	...	...	...	...
15	Percent of population in private households with low income	0.76**	0.42**	-0.76**	1.00	...	...	...	...	...	...	...
16	Percent households spending 30% or more on shelter	0.58**	0.31**	-0.72**	0.79**	1.00	...	...	...	...	...	...
17	Percent owner-occupied households	-0.57**	-0.28**	0.79**	-0.80**	-0.79**	1.00	...	...	...	...	...
18	Percent housing built before 1961	0.05	-0.10*	-0.15**	0.18**	0.15**	-0.34**	1.00	...	...	...	...
19	Percent dwellings in need of major repair	0.17**	0.03*	-0.32**	0.37**	0.36**	-0.43**	0.60**	1.00	...	...	...
20	Percent commercial zoning	0.08	-0.06	-0.17**	0.16**	0.21**	-0.21**	-0.09*	-0.05	1.00	...	...
21	Percent single-family zoning	-0.38**	-0.27**	0.58**	-0.57**	-0.53**	0.71**	-0.20**	-0.12**	-0.24**	1.00	...
22	Percent multiple-family zoning	0.26**	0.10*	-0.50**	0.42**	0.42**	-0.65**	0.34**	0.30**	-0.04	-0.49**	1.00
23	Bar density	0.12**	-0.16**	-0.21**	0.25**	0.27**	-0.26**	0.18**	-0.03	0.34**	-0.20**	0.23**

... not applicable
* $p<0.05$, two tailed
** $p<0.01$, two tailed
1. Based on the 506 CTs where the total residential population was over 250 people.
Sources: Statistics Canada, Census Division, 2001 and CUM 2005 Zoning Data.

Another aspect that must be taken into account in a spatial analysis of data such as crime data is spatial autocorrelation (see the modelling and spatial autocorrelation text box). The presence of a strong autocorrelation is detected in the residuals of the OLS regression models for Montréal, that is a Moran's *I* statistic of 0.14 ($p<0.001$) in the case of violent crimes and 0.24 ($p<0.001$) in the case of property crime. Therefore, in modelling relationships between neighbourhoods, it is appropriate to take their relative geographic position into account. The use of a spatial autoregressive model is required.

To assess the relative contribution of neighbourhood characteristics to the explanation of crime, the set of variables was regressed separately on violent and property crime rates. The results are shown in Table 4. The modeling process reveals a set of six explanatory variables for the variation in violent crimes and a set of five variables in the case of property crimes. The spatial autoregressive model gives a squared correlation coefficient of 0.60 ($p<0.05$) between actual values for the neighbourhood crime rates and the predicted values in the case of violent crimes, and of 0.61 ($p<0.05$) in the case of property crimes. The estimated regression coefficients provide an indication of the relative contribution of each variable after controlling for the other variables in the model.[7]

Table 4

Spatial autoregressive model for violent and property offence rates, Montréal neighbourhoods, 2001

	Unstandardized regression coefficients	
	Violent crime rate[3]	Property crime rate[3]
Neighbourhood characteristics[2]	**b**	**b**
Percent population in private households with low income	0.20***	0.10***
Percent population with a Bachelor's degree or higher	-0.22***	...
Percent population single, never married	0.16***	0.11***
Percent visible minority population	...	-0.05**
Percent commercial zoning	0.07***	0.12***
Percent single-family zoning	0.11***	...
Percent multiple-family zoning	0.10***	...
Bar density	...	0.05**
Spatial lag	0.24***	0.43***

... not applicable
** $p<0.01$
*** $p<0.001$

1. Police reported violent and property crime rates per residential and employed population (log transformed). Based on the 506 CTs where the total residential population was at least 250 people.
2. Variables are standardized z-scores.
3. Regression models include intercept.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001, Census Division, 2001 and CUM 2005 Zoning Data.

The violent crime rate model shows that the proportion of neighbourhood residents aged 20 and older with a bachelor's degree has the greatest explanatory power when the other variables are held constant. Thus the violent crime rates are lower in neighbourhoods where a larger proportion of residents aged 20 and older have a bachelor's degree (b=-0.22). This factor appears to offer protection with respect to violent crime. In contrast, violent crime rates are highest where the proportions of low-income persons (b=0.20) and single persons (b=0.16) are highest. The reported rate of violent crime also increases in residential neighbourhoods, whether the housing be single-family (b=0.11) or multi-family (b=0.10). The proportion of a neighbourhood that is zoned commercial also contributes to the explanatory model, although its contribution is smaller (b=0.07).

The results of the spatial regressive model applied to property crime provide a slightly different picture. Commercial land use on the Island of Montréal has the greatest explanatory power for the variation in property crime (b=0.12). Property crime rates are also the highest where the proportions of low income persons (b=0.10) and single persons (b=0.11) are the largest. Drinking place density is also related to higher crime (b=0.05), but its contribution to the explanatory model is the smallest. To a lesser but statistically significant degree, the percentage of the neighbourhood population belonging to a visible minority (b=-0.5) is a protection factor in the case of property crime. In other words, the greater the proportion of persons belonging to a visible minority, the lower the level of property crime.

Modelling and spatial autocorrelation

Spatial autocorrelation reflects a relationship or dependence between two different units of observation owing to their geographic location (Anselin and Bera 1998). The presence of spatial autocorrelation substantially changes the properties of the OLS estimators and the statistical inference based on these estimators. If spatial autocorrelation is present, these estimators may be biased or inefficient. In detecting autocorrelation in geographic data, the task is to model the relationships between the units taking account of their relative position in the geographic area being studied.

In the spatial analysis of crime, spatial autocorrelation is characterized by the geographic clustering of similar crime rates, and it may also be a result of how natural neighbourhoods are defined. Map 4 and Map 6 illustrate the concentration of crime hot spots in selected areas of the Island of Montréal, these data having been aggregated to the CT level in order to model them. The spatial modelling of crime at the level of neighbourhoods requires that hot spots (high density nodes) be distributed randomly among the CTs and have no influence or spillover effect on neighbouring CTs. Thus, where neighbouring CTs have similar levels of crime, it is possible that the key characteristic in the distribution of crime is location or proximity to another CT with a high density of crime (or other characteristics of the CT), rather than characteristics that are specific to it (Anselin, Cohen, Cook and Tita 2000).

To determine the presence of spatial dependence in the data, a statistical test, Moran's I, is performed to determine whether the data are distributed randomly over the area studied. For computing Moran's I, neighbouring locations were defined as sharing a common boundary, point or vector. The significance of the Moran's I test is determined by a permutation approach, where a significant result indicates that there is spatial autocorrelation in the data. The value of the Moran's I statistic ranges between 1 and -1. A value approaching 1 indicates the presence of positive autocorrelation whereas a negative value indicates the presence of negative autocorrelation, and a value of zero, the absence of spatial autocorrelation. The value of the Moran's I statistic is 0.47 ($p<0.001$) in the case of violent offences and 0.61 ($p<0.001$) for property offence rates, indicating a spatially dependent structure in the data.

After spatial autocorrelation is observed in the data, the residual values from the OLS regression models are analysed to determine whether the characteristics of the different sets of variables served to eliminate the autocorrelation. Once again the Moran's I test indicates the presence of spatial autocorrelation in the residuals. The value of this test is 0.14 ($p<0.001$) for the violent offences model and 0.24 ($p<0.001$) for property offences. These results indicate that explanatory variables or neighbourhood characteristics do not explain the entire spatial structure in the data and that therefore the location of the neighbourhood is having an underlying effect. When autocorrelation is present in the residuals of a regression model, the use of a spatial autoregressive model is strongly recommended to ensure that the regression coefficients and their associated variances are valid.

The spatial autoregressive model offers the same explanatory analysis of neighbourhood characteristics as the standard linear model, but it controls for the effect of location. To do this, an extra variable called the spatial lag, representing the average crime rate from all neighbouring locations, is added to the other variables in the standard linear model and thus the spatial effects are filtered out of the model. The use of coefficient of determination (R2) in spatial autoregressive models is not recommended, since the variation introduced by the location effect cannot be separated from the variation in the predicted values and error terms. Alternatively, the squared correlation coefficient between actual crime rate values at the neighbourhood level and the values predicted using the coefficients of the spatial autoregressive model can be used. The squared correlation coefficient also allows comparison between different communities.

Additionally, the coefficient of the spatial lag variable is not interpreted in the same way as those of other variables in the autoregressive model. The value of this parameter represents in part the effect of location in the area, but it also takes account of measurement error in the way the neighbourhoods are defined. Thus the spatial lag cannot be interpreted directly; it is only retained in the model to make the results accurate. Even with these two distinctions, the results of the spatial autoregressive model are essentially the same as those of other regressive models. For example, in Table 4, regression coefficients of the neighbourhood characteristics represent their relative contributions to the explanatory model for crime.

The residuals from the Montréal spatial autoregressive models are again checked for the presence of spatial autocorrelation using Moran's I. They indicate a value of 0.02 ($p>0.1$), which is not statistically significant, both in the set of violent offence variables and the set of property offence variables. Thus, the models have succeeded in controlling for the effect of spatial autocorrelation, and the parameter estimates are therefore of greater accuracy and free of biases caused by the location of the neighbourhood.

Discussion

This report has presented information from the second Statistics Canada study on the spatial distribution of crime in a Canadian city using a combination of statistical analyses and crime mapping based on Geographic Information System (GIS) technology. Results from the examination of Montréal data are in agreement with those from other studies in Canada and abroad indicating that crime is not randomly distributed across cities, but is concentrated in certain neighbourhoods where demographic, socio-economic and urban land use factors have an impact.

Similar to what the Winnipeg and Regina studies have shown, there is, in Montréal, a concentration of crime in a limited number of neighbourhoods. However, this concentration exhibits a different pattern from that observed in the Western Canadian cities. Property offences are essentially concentrated in neighbourhoods in the city centre, while violent offences are distributed among a number of hot spots.

Bivariate results show significant differences with respect to some characteristics when neighbourhoods with high crime rates are compared with those with low crime rates. The results suggest that crime is more prevalent in neighbourhoods where residents have less access to social and economic resources. These neighbourhoods are characterized by a population that is economically more disadvantaged and includes a lower proportion of highly educated people. These neighbourhoods are also more likely to have a larger number of single persons, lone-parent families and recent immigrants. They also exhibit greater residential instability, a smaller number of owner-occupants and a larger proportion of the population that spends more than 30% of their budget on housing. More commercial and multi-family land use is also seen in neighbourhoods where the highest rates are reported. Nevertheless, it must be remembered that these are crime rates that are measured at the neighbourhood level and not the delinquency rates of their residents. It is therefore important not to make generalisations.

This study has shown that many of these individual factors are closely related. These are, for example, the proportion of the neighbourhood's residents in a low income household, which is in close statistical association with the unemployment rate; government transfers; the proportion of tenants in a neighbourhood; and the proportion of single-parent families and recent immigrants in a neighbourhood. Thus, when the variables were held constant through the use of a multivariate technique, a few key factors were shown to be most highly related to both property and violent crime rates. These variables suggest that there are unique dynamics in the study area, the Island of Montréal.

After taking these other variables into account and screening out the effect of the location of the neighbourhood, it becomes clear that the proportion of persons with a university degree stands out for its greater power to explain the variation in violent crime rates: the larger the proportion of persons with a degree in a

neighbourhood, the lower the level of violent crime. At first glance, the considerable proportion of highly educated persons appears to offer some protection against violent crime at the neighbourhood level, whereas low income and single status contribute the most to explaining high violent crime rates in neighbourhoods. The type of land use also contributes to the explanation of crime; an especially important factor is residential zoning (multi-family and single-family) and, to a lesser extent, commercial zoning.

The results for property crime are somewhat different. Commercial zoning is the factor that offers the greatest explanatory power for the variation in property crime rates. Low income and single status also play a role in explaining crime at the neighbourhood level. When all other variables are held constant, bar density is found to be a significant factor associated with property crime, whereas this was not the case for violent crime.

The research results obtained at the neighbourhood level in Montréal support Sampson and Raudenbush's (1999) hypothesis, which proposes that violent crime varies according to the level of social capital or related concepts such as collective efficacy. Social capital is defined as social interactions and standards which facilitate decisions toward formal and informal collective measures in the interest of individuals and the community. Several characteristics of the human capital of residents in a neighbourhood, such as education, training and socio-economic status, are key to the development of social capital and better collective efficacy.

Compared to Winnipeg or Regina, Montréal has several separate clusters of low-income neighbourhoods (e.g., Lachine, Sud-Ouest, Hochelaga–Maisonneuve, Côte-des-Neiges, Parc–Extension, Montréal-Nord) surrounding a relatively well-off city centre. With the revitalisation of low income neighbourhoods (e.g., Plateau Mont-Royal, Vieux-Montréal), low income intensity in the urban core is being reduced (Heisz 2005). There would thus appear to be several hot spots of violent crime with less of a concentration than seen in the Winnipeg and Regina studies. The most at risk demographic groups facing low income also differ regionally. In the Montréal region, recent immigrants and lone-parent families are the most at risk, representing 14 % and 19 % respectively of the low income population in 2000. These same demographic groups represented 6% and 27% respectively of the low income population in Winnipeg, and 2% and 27% in Regina. Compared to Montréal (0.5%), a higher proportion of the low income population can be found among aboriginals in Winnipeg (24 %) and Regina (26 %) (Heisz and McLeod, 2004).

In Montréal, neighbourhoods with the highest proportion of lone-parent families, recent immigrants and single status seem to have a lower collective efficacy. The low income situation of these demographic groups, which is associated with areas having higher residential mobility and the existence of more commercial and multi-dwelling zoning, decreases the informal social control function. According to Sampson and Raudenbush (1999), residential stability has long been considered a key element in strong urban social organization, and its absence is seen as a lost opportunity for residents to contribute to the community. Clifford and Hope (2004) contend that measures to encourage the residential revitalization of neighbourhoods serve to halt and reverse social disorganization and help maintain a diverse population that is more able to take on a surveillance role.

As regards the protective effect against property crime afforded by a higher proportion of visible minorities in a neighbourhood, the results of the 2004 General Social Survey can shed light on this relationship. The protective effect of this variable

appears to be due to the economic disadvantage faced by visible minorities rather than to any real advantage. The fact is that the risks of victimization of households increase with household income (Gannon and Mihorean 2005). Hou and Picot (2003), who studied visible minority enclaves and labour market outcomes of immigrants in large Canadian cities, found that in Montréal neighbourhoods where blacks had a dominant presence, the proportions of unemployed and low income persons were also very high. Moreover, their analysis showed a significant association between exposure to members of the same group and lower income among black immigrants, even when the effects of low income in the neighbourhood were taken into account. Sampson and Raudenbush (1999) stressed that the relationship between disadvantage and crime is so close that other "symptoms" that characterize high crime neighbourhoods actually result from socio-economic disadvantage.

The study also showed that persons charged in criminal incidents that occurred in 2001 came primarily from the Island of Montréal. They came from a larger number of neighbourhoods in the case of violent incidents and were less concentrated than in the case of property crimes. Descriptive analyses of the median distance travelled by charged persons led to the finding that distances travelled vary depending on the type of offence, the age of the persons charged and their relationship with the victim. Overall, persons charged in violent incidents travelled less (0.9 km) than those charged in property incidents (4 km). Other research papers have also shown that persons accused of violent offences travel shorter distances than those accused of property crimes (LeBeau 1987; Turner 1969). This study also found that distances travelled vary depending on the age of the persons charged. The youngest travel the most in violent incidents and the least in incidents involving property. A number of foreign studies have produced similar results (Groff and McEwen 2005; Wiles and Costello 2000; Chapin and Brazil 1969; Harries 1999). The median distance travelled also varies according to the closeness of the relationship between the person charged and the victim. Charged persons who know their victim travel little, while those who do not cover a greater distance and converge toward the city centre.

Results from the Montréal study support British research findings indicating that most offender movements are relatively short, and that travel associated with crime is driven by opportunities presenting themselves during daily activities rather than plans to offend (Felson and Clark 1998; Wiles and Costello 2000). Offenders and their targets vary according to the initial reason for travelling—or not travelling, in the case of spousal violence. In this regard, trips initiated for work, school or recreation offer specific opportunities for crime (Felson and Clark 1998). The longer median travel distances recorded for auto theft incidents seem to be related to a more organized criminal effort.

Opportunities for crime increase when neighbourhood land use patterns are conducive to crime (Hayslett-McCall 2002). Land uses that have been associated with crime include mixed patterns of residential, commercial, industrial and vacant lands within neighbourhoods, as well as the presence of particular establishments, such as shopping malls and bars. Land use patterns can impact crime by inhibiting the social control or guardianship capacity of residents in a neighbourhood or by being a focal point for particular types of activities (e.g., consuming alcohol at a bar, selling or using drugs in abandoned structures) (Hayslett-McCall 2002).

The distribution of crime and the characteristics of charged persons' travel patterns on the Island evolve in a demographic, socio-economic and physical context that is unique to Montréal. These results underline the importance of targeting neighbourhoods' specific needs and recognizing the diversity of Canadian cities in developing strategies for combating crime. In Montréal, programs to improve residents' socio-economic conditions and to foster the development of social capital while taking the impact of zoning into account would be effective actions at the community level.

Limitations and opportunities

This study focuses on the distribution of crime, and demographic and socio-economic factors examined in the 2001 Census. It focuses on an initial point in time, and therefore it was not possible to examine the change over time in neighbourhood crime rates and related characteristics. The opportunities for analysis were limited by the data available. In the coming years, the new version of the Incident-Based Uniform Crime Reporting Survey (UCR2.2) will provide increased access to geocoded crime data, and spatiotemporal series will begin to accumulate. The 2006 Census will also yield new demographic and socio-economic data at the census tract level. In future studies of the Island of Montréal, these data will offer opportunities to focus on the change over time and hence on the causal nature of the factors involved. Poverty on the Island of Montréal has undergone a spatial shift in the past 20 years (Heisz 2005), but what is the situation with respect to crime? Some questions merit special attention: What factors were associated with the shift in poverty from some neighbourhoods to others? What is the impact of the polarization of poverty and its persistence at the neighbourhood level? Was this shift in poverty also accompanied by changes in the composition and levels of crime? Which neighbourhoods are at risk? Understanding factors related to change over time is also important for developing crime prevention and reduction strategies and for evaluating existing programs.

The study presented the first descriptive research on travel patterns of persons charged to their victims using GIS technology on the Island of Montréal. The results revealed that the distribution of concentrations of charged persons' homes differs only slightly according to the relationship with the victim. This raises the following question: Do these concentrations mean that there is a limited number of highly active individuals who move about for crime, or do they instead reflect hot spots attributable to a large number of offenders? In future studies, light could be shed on this question through the linkage of information on persons charged from the UCR2.2 Survey. Also, future studies will have to look at the triangle consisting of victim, person charged and offence location. Some research findings suggest that it is the same individuals who are victims and offenders (Hough and Mayhew 1983; Esbensen and Huizinga 1991; Lauritsen, Sampson, and Laub 1991). According to the General Social Survey, 40% of victims were targeted more than once (Gannon and Mihorean 2005). Multiple victimization cases are closely linked to opportunities for crime, which suggests that if the circumstances of multiple victimization were better understood, prevention strategies could be developed that would have a greater impact at the level of the community. In addition, the geocoded data available for 2001 represent persons charged only, not all accused persons. It would be interesting to compare these results with the spatial distribution of persons identified in criminal incidents and not formally charged.

This study, conducted using police data, provides a specific picture. To better understand the factors related to crime distribution, it would be necessary to have access to data sets from various sources. In the coming years, it would be useful to examine, at the neighbourhood level, the information collected in victim and offender surveys, which in turn would provide a picture conducive to developing new crime prevention strategies.

More research aimed at adressing the collective capacity to deploy human and social captial and to transform this into collective efficacy, would also be necessary. As the body of research grows in relation to crime mapping within the Canadian context, it would be interesting to examine the mechanism at play in neighbourhoods representing numerious risk factors without high crime rates. This would contribute to a better understanding of the dynamics of collective efficacy.

Methodology

Data sources

Incident-based Uniform Crime Reporting Survey

The Incident-Based Uniform Crime Reporting Survey (UCR2) collects detailed information on individual criminal incidents reported to the police, including characteristics of incidents, accused persons and victims. The Montréal police service has been reporting to the UCR2 Survey since 1992.

The UCR2 Survey allows a maximum of four offences per criminal incident to be recorded in the database. The selected offences are classified according to their level of seriousness, which is related to the maximum sentence that can be imposed under the *Criminal Code*.

Analyses of major offence categories (violent offences, property offences, drug-related offences and other *Criminal Code* offences) undertaken in this study are based on the most serious offence in each incident, as are the crime rates published annually by the CCJS. In this type of classification, a higher priority is given to violent offences than to non-violent offences. As a result, less serious offences may be under-represented when only the most serious offence is considered.

The majority of analyses in this study are based on major offence categories, such as violent offences and property offences, and take into account only the most serious offence in each incident. However, when the analysis is focused on individual offence types, all incidents in which the offence is reported are included, whatever the seriousness or the ranking of the offence in the incident. This method provides a more complete spatial representation of the different types of individual offences. For example, Table 1 provides information on selected individual offence types, such as theft $5,000 and under, theft over $5,000, vehicle theft, shoplifting, breaking and entering, drug offences, mischief, arson, prostitution, robbery, common assault, sexual assault, homicide and major assault. See Table 1A.

This study includes most *Criminal Code* offences and all offences under the *Controlled Drug and Substances Act*, but excludes offences under other federal and provincial statutes and municipal bylaws. Also excluded are *Criminal Code* offences for which there is either no expected pattern of spatial distribution or a lack of information about the actual location of the offence. For example, administrative offences including bail violations, failure to appear and breaches of probation are typically reported at court locations; threatening or harassing phone calls are often reported at the receiving end of the call; and impaired driving offences may be more likely to be related to the location of apprehension (for example, apprehensions

resulting from roadside stop programs). In total, more than 12,000 offences were excluded for 2001 and more than 13,000 offences for 2004.

Census of Population

On May 15, 2001, Statistics Canada conducted the Census of Population to produce a statistical portrait of Canada and its people. The Census of Population provides the population and dwelling counts not only for Canada but also for each province and territory, and for smaller geographic units, such as cities or districts within cities. The Census also provides information about Canada's demographic, social and economic characteristics.

The detailed socio-economic data used in this study are derived from the long form of the Census, which is completed by a 20% sample of households. These data exclude the institutional population, that is, individuals living in hospitals, nursing homes, prisons and other institutions.

Island of Montréal land use data

Land use data were utilized to calculate the proportions of neighbourhoods with commercial, multi-family residential and single-family residential zoning. Land use data show the actual utilization of urban lands, while zoning data reflect planned and legislated use. Land use parcels were aggregated to the neighbourhood level in order to calculate proportions. They cover 438 km^2, or 87.6% of the Island's 500 km^2. Land use data were taken from the most up-to-date version of the geomatics department database at the Communauté métropolitaine de Montréal, and they date from 2005. The 2001 land use data were not archived.

To round out the picture provided by land use data, zoning data were used. These data, which were obtained from the Montréal planning department, increased coverage by an additional 40 km^2. In all, land use data cover 96% of the Island territory. The census tracts (CTs) that remain uncovered are concentrated in the boroughs of Île-Bizard (CTs 550.2, 550.3 and 550.4) and in part of Pointe-Claire (CTs 450.0, 451.0 and 452.0).

The Business Register Division of Statistics Canada provided the addresses of all drinking places on the Island of Montréal in 2001 (code 7224 of the North American Industry Classification System). This code includes establishments known as bars, taverns or drinking places primarily engaged in preparing and serving alcoholic beverages for immediate consumption.

Description of variables

Crime variables

The distribution of criminal incidents across urban areas is often concentrated in or near the city centre, where residential populations are relatively low, but where there are high concentrations of people either working or engaging in other activities. Rates based on residential population alone will artificially inflate the crime rates in these urban core neighbourhoods, since the total population at risk in these areas has not been taken into account.

To more accurately gauge the risk of crime in CTs, crime rates are based on the population at risk. An approximation of the population at risk is obtained by adding the number of workers and the number of residents in each CT. Rates based on these combined populations more closely approximate the total number of people at risk of experiencing crime. This study uses the approach taken in the Winnipeg research project.[8]

- Violent offence rates. Violent offences include homicide, attempted murder, sexual assault, assault, violations resulting in the deprivation of freedom, robbery, extortion, criminal harassment, uttering threats, explosives causing death or bodily harm, and other violent crimes.
- Property offence rates. Property offences include arson, breaking and entering, theft $5,000 and under, theft over $5,000, vehicle theft, possession of stolen goods, fraud and mischief.
- Charge rates. Only the residential population is taken into account in analyses that focus on charged persons' place of residence and their travel-to-offence patterns. Census data on the residential population serve to establish the characteristics of the people living in neighbourhoods and to shed light on the socio-economic and demographic risk and protection factors related to crimes to which the individuals living in these neighbourhoods are exposed.

2001 Census of Population variables

Population characteristic variables

- Males aged 15 to 24 as a percentage of the total neighbourhood population. This age group is at highest risk of offending (Figure 2). In Montréal in 2001, about 33% of all identified accused were males aged 15 to 24, whereas they accounted for only 14% of the total population. These males had committed 28% of violent crimes and 33% of property crimes reported. See Figure 2
- Percentage of the neighbourhood population that is 65 years and older. Results from the GSS on victimization suggest that national rates of criminal victimization among the elderly are relatively low compared to the population as a whole, although elderly people report feeling less safe (Gannon and Mihorean 2005).
- Percentage of single persons in the neighbourhood, defined as single persons aged 15 and older who have never been married. According to the 2004 General Social Survey (GSS), single persons are more a risk of experiencing violence. This situation is partly due to the fact that single persons tend to participate more often in evening activities and are generally younger, and both these factors are strongly linked to a higher risk of victimization. In 2004, persons who participated in at least 30 evening activities every month also had the highest rates of violent victimization (174 per 1,000 population). This rate was four times higher than that noted for persons participating in fewer than 10 evening activities per month (44 incidents per 1,000 population).
- Percentage of the neighbourhood population immigrating to Canada between 1991 and 2001. Initially, immigration may hinder integration into society; however this drawback is lessened as the length of residence in the country increases (Breton 2003). Recent immigrants' social participation may be more limited, and consequently, they may not be able to benefit to the same extent from social capital or from relationships within the community. Numerous studies have demonstrated links between reduced levels of social participation and increased levels of crime (Morenoff et al. 2001; Sampson, Raudenbush and Earls 1997; Sampson 1997).
- Percentage of visible minority residents in the neighbourhood. Members of visible minorities "are persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour." In 2002, according to the Ethnic Diversity Survey, roughly 9% of Canadians who reported being victims of crime in the previous five years believed that the offence perpetrated against them could be considered a hate crime. Members of visible minorities were 1.5 times more likely than non-members of visible minorities to have been a victim of a hate crime (13 per 1,000 population and 20 per 1,000 population respectively) (Silver, Mihorean and Taylor-Butts 2004).

- Percentage of Aboriginal identity population living in the neighbourhood. Includes persons who reported identifying with at least one Aboriginal group, that is North American Indian, Métis or Inuit (Eskimo), who reported being a Treaty Indian or a Registered Indian as defined by the *Indian Act* of Canada, or who reported they were members of an Indian Band or First Nation. The Aboriginal population in Canada is over-represented with respect to victimization and offending (Statistics Canada, 2001a). Thus, according to the most recent cycle of the GSS, Aboriginal persons were three times more likely than non-Aboriginals to have been a victim of a violent incident (319 compared to 101 per 1,000 population), even when other factors such as age, sex and income were taken into account (Gannon and Mihorean, 2005).
- Percentage of lone-parent families among economic families living in private households.[9] Although the after-tax income of lone-parent families is increasing in Canada, these families continue to be among the lowest earners (Statistics Canada 2001c), and they are concentrated in the more disadvantaged areas of the city. Additionally, an increase in labour force participation among female lone-parents from 65% in 1995 to 82% in 2001 may be linked to decreased guardianship or supervision in neighbourhoods, which has been associated with higher crime rates (Cohen and Felson 1979).
- Percentage of persons who have moved. Includes persons who, on Census Day, resided at an address other than the one where they were living one year earlier. According to the 2004 GSS, persons who have occupied their residence for only a short time are more likely to have their household victimized (317 incidents per 1,000 population) than those who have lived there for 10 years (196). Residential mobility has been associated with higher crime rates through reduced guardianship or social involvement that is more typical of frequent movers. Studies of American cities also indicate that streets where neighbours know each other or feel responsible for their community have significantly lower rates of violent crime than those where social interaction is lower (Block 1979; Sampson 1993).

Dwelling characteristic variables

- Percentage of dwellings constructed before 1961. In combination with other variables related to signs of physical decay within urban neighbourhoods, the age of urban buildings may be associated with higher crime rates through a perception of increased physical disorder (Kelling and Coles 1998).
- Percentage of dwellings in need of major repairs. Refers to whether, in the judgement of the respondent, the dwelling requires any repairs (excluding desirable remodelling or additions). Major repairs refer to the repair of defective plumbing or electrical wiring, structural repairs to walls, floors or ceilings, etc. This variable may similarly be associated with higher crime rates through the perception of increased physical disorder in the neighbourhood (Kelling and Coles 1998).
- Percentage of households spending more than 30% of total household income on shelter, including both owner-occupied and tenant-occupied households. This is a measure of housing affordability. The 30% figure is based on research indicating that when the shelter costs of low income households exceed 30% of their income, their consumption of other life necessities is reduced. Shelter expenses include payments for electricity,

oil, gas, coal, wood or other fuels, water and other municipal services, mortgage payments, property taxes, condominium fees and rent. Decreased housing affordability within a neighbourhood is another indicator of socio-economic disadvantage.

- Percentage of owner-occupied dwellings in the neighbourhood. Collective dwellings are excluded from both the numerator and denominator. Renters have the highest victimization rates among households. In 2004, the victimization rate for renters was 267 incidents per 1,000 households, compared to 242 for owners (Gannon and Mihorean, 2005). Greater proportions of owner-occupied housing in a neighbourhood are linked to increased residential stability, social interaction among neighbours and a collective commitment to the neighbourhood. The 2003 GSS results show that people living in a neighbourhood for less than one year are less likely to know their neighbours (Schellenberg 2004).

Socio-economic variables

The results of the Winnipeg research project showed major differences between the socio-economic characteristics of high-crime neighbourhoods and those of low-crime neighbourhoods. High-crime neighbourhoods were characterized by reduced access to socio-economic resources (Fitzgerald, Wisener and Savoie 2004). A number of American studies have also demonstrated that inequality of socio-economic resources between neighbourhoods in American cities is strongly associated with the spatial distribution of crime (Morenoff, Sampson and Raudenbush 2001). In the present study, the following socio-economic variables are used:

- Percentage of population receiving government transfer payments, including employment insurance benefits; Old Age Security benefits, including the Guaranteed Income Supplement and the spouse's allowance; net federal supplements; Canada and Quebec pension plan benefits; the Canada Child Tax Benefit; New Brunswick, Quebec, Alberta and British Columbia family allowances; the goods and services tax credit; workers' compensation benefits; social assistance; and provincial or territorial refundable tax credits.
- Percentage of neighbourhood population aged 20 years and older without a secondary school diploma.
- Percentage of neighbourhood residents aged 20 and older who have obtained a bachelor's degree.
- Percentage of neighbourhood population in private households with low income in 2000. Low income refers to private households that spend 20% more of their disposable income than the average private household on food, shelter and clothing. Statistics Canada's low-income cut-offs (LICOs) are income thresholds that vary according to family and community size. Although LICOs are often referred to as poverty lines, they have no official status as such.
- Neighbourhood unemployment rate for population aged 15 and older participating in the labour force.

- Median household income in thousands of dollars or the dollar amount above and below which half the cases fall, namely the 50th percentile. Low household income increases the risk of violent victimization, while high income increases the risk of household victimization (Gannon and Mihorean 2005). It may be that potential thieves are more attracted to higher-income households since their members probably own more property or property of greater perceived value.

City land use variables

- Commercial zoning—the proportion of square area within a neighbourhood zoned for commercial land use. Types of land use falling under commercial zoning include stores, supermarkets, discount stores, furniture stores, banks, hotels, motels, restaurants, service garages, service stations, full-service auto dealers, car washes, residential/commercial split properties and commercial offices.
- Multi-family residential zoning—the proportion of square area within a neighbourhood zoned for multi-family, two-family (duplex) or transitional dwellings, which include short- and longer-term subsidized housing for those in need.
- Single-family residential zoning—the proportion of square area within a neighbourhood zoned for single-family dwellings.
- Bar density—number of bars over the area of a CT. Much research has been done on the role of alcohol and drugs in offending (Boles and Miotto 2003). According to the GSS, victims felt that alcohol or drug use had played a part in just over half (52%) of violent incidents (Gannon and Mihorean 2005). Bars attract a sizable number of potential offenders and victims to the same place. According to Roncek and Maier (1991), the presence of bars contributes more to the explanatory model of the variation in crime rates than do socio-economic variables of the neighbourhood residents.

Geocoding

Geocoding is the process of matching a particular address with a geographic location on the Earth's surface. In this study, the address corresponds to the location of an incident that was reported to the police, after aggregation to the block-face level—that is, to one side of a city block between two consecutive intersections. This is done by matching records in two databases, one containing a list of addresses, the other containing information about the street network and the address range within a given block. The geocoding tool will match the address with its unique position in the street network. Since the street network is geo-referenced (located in geographic space with reference to a coordinate system), it is possible to generate longitude and latitude values—or X and Y values—for each criminal incident. Where the incident location does not correspond to an address, geocoding is performed by creating a point on, say, an intersection of two streets, a subway station or the middle of a public park. X and Y values in the criminal incident database provide the spatial component that allows for points to be mapped, relative to the street or neighbourhood in which they occurred.

In 2001, the UCR2 Survey did not lend itself to collecting information on the geographic location of criminal incidents.[10] For the purposes of this study, the Montréal police department sent the CCJS the addresses of approximately 136,000 incidents selected, reported and entered in the UCR2 database in 2001 and approximately 140,000 incidents in 2004. The Montréal police department also provided information on the home address of nearly 32,500 accused persons identified in 2001 incidents. This information was resolved by the CCJS into a set of geographical coordinates (X and Y) for each address. These coordinates were rolled up to the mid-point of a block-face in the case of specific addresses, and to intersection points in the case of streets, parks and subway stations.

The geocoding exercise was successful for more than 96% of 2001 incident location data and for more than 95% of 2004 data. All addresses of criminal incidents that were reported more than five times but failed the automated geocoding process were geocoded manually so as to represent crime concentrations as accurately as possible. The low percentage of incidents that failed geocoding did not create a bias in offence trends. Incidents that failed geocoding contained information that was too vague, such as a bus number or the trans-Canada registration.[11] In fact, geocoded offences and offences prior to geocoding both account for the same proportion of overall crime.

In this project, the Montréal police department provided the addresses of accused persons that were entered in its information management system, without additional editing. This information therefore includes a number of missing and inaccurate address elements, which makes the geocoding process more difficult. The accused persons' home addresses supplied by the police service refer to persons against whom official charges were laid or recommended for offences in 2001, that is the persons charged. According to contacts at the Montréal police department, the information concerning the addresses of accused persons is of higher quality when the individual is formally charged, since a complete and valid address must be provided in the files submitted to the courts. Therefore the data do not take into account children under 12 years of age or adults whose case may have been processed informally by the police. The geocoded data on persons charged used in this study are a sample representing 75% of all persons charged in violent incidents, 73% of those charged with property offences, 78% of those charged with prostitution or gaming offences or offensive weapons-related crimes and 78% of those charged with drug-related offences, as reported by the Montréal police department to the UCR2 Survey. A comparison of the distribution of geocoded addresses of persons charged and the set of persons charged in the UCR2 database by age and sex shows no statistically significant difference based on T-test, $p<0.001$.

Mapping techniques

Two methods of presenting crime and other information are used in this study. The first method displays the total points for each CT (see description below). The second displays a pattern of points where each point corresponds to a criminal incident or the home address of a charged person. This method shows high-density crime locations or "hot spots."

Census tracts and natural neighbourhoods

Ecological studies recognize that the choice of neighbourhood boundaries can change how the distribution of neighbourhood characteristics is understood (Ouimet, 2000). The natural neighbourhoods used in this analysis correspond to CTs, which are delineated by Statistics Canada in conjunction with a committee of local experts (e.g., planners, social workers, health care workers and educators). The initial rules for delineation, in order of priority, are as follows:

1) The CT boundaries should follow permanent and easily recognizable physical features.

2) The population of the CT should be between 2,500 and 8,000 persons, preferably averaging around 4,000.

3) CTs should be as homogeneous as possible with respect to socio-economic characteristics.

In a study of the impact of neighbourhoods on health in Montréal, Ross, Tremblay and Graham (2004) found that analytical models using CTs as the geographic unit yielded results remarkably similar to the 'natural' neighbourhood model. These researchers concluded that the additional efforts invested in creating natural neighbourhoods other than CTs are not warranted "especially in studies where there are both a sufficient number of predefined geo-statistical units to draw from and where the units have some social meaning, as in the case of Canadian census tracts." (p. 1490)

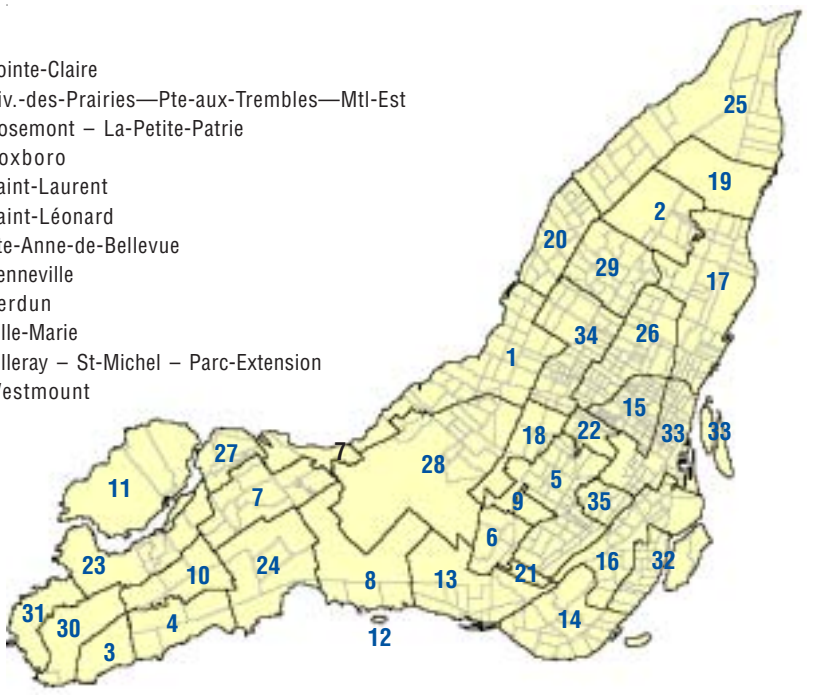
Thus, CTs are by definition smaller and more homogeneous geographic entities than the boroughs whose boundaries are those of the former municipalities of Montréal and the territories served by the different police stations on the Island. Since CTs are also used in many studies, this makes it possible to add layers of additional information (health, education, economic factors, etc.) for an integrated approach toward prevention in neighbourhoods with a number of risk factors.

Map 14

Boundaries of census tracts, Montréal, 2001

Agglomerations and suburbs

1. Ahuntsic – Cartierville
2. Anjou
3. Baie-d'Urfé
4. Beaconsfield
5. Côte-des-Neiges—Notre-Dame-de-Grâce
6. Côte-Saint-Luc
7. Dollard-des-Ormeaux
8. Dorval
9. Hampstead
10. Kirkland
11. L'Île-Bizard-Ste-Geneviève
12. L'Île-Dorval
13. Lachine
14. Lasalle
15. Le Plateau – Mont-Royal
16. Sud-Ouest
17. Mercier – Hochelaga – Maisonneuve
18. Mont-Royal
19. Montréal-Est
20. Montréal-Nord
21. Montréal-ouest
22. Outremont
23. Pierrefonds
24. Pointe-Claire
25. Riv.-des-Prairies—Pte-aux-Trembles—Mtl-Est
26. Rosemont – La-Petite-Patrie
27. Roxboro
28. Saint-Laurent
29. Saint-Léonard
30. Ste-Anne-de-Bellevue
31. Senneville
32. Verdun
33. Ville-Marie
34. Villeray – St-Michel – Parc-Extension
35. Westmount



Source: Statistics Canada, Census, 2001.

Of the 521 CTs that are part of the Island of Montréal, 520 were the location of at least one offence in 2001. However, the bivariate and multivariate analyses presented include only 506 CTs, namely those with more than 250 inhabitants. Statistics Canada suppresses income data for geographic areas under this threshold for reasons of confidentiality and data quality.

Mapping census tracts

By combining criminal incident codes with X and Y values, point distributions were generated for specific crime types. Using a geographic information system (GIS), point data were overlaid on top of CTs. The total number of criminal incidents was then calculated for each CT.

Mapping hot spots: kernel analysis

Kernel analysis is an alternative method of making sense of the spatial distribution of crime data. This method makes it possible to examine criminal incident point data across neighbourhood boundaries and to see natural distributions and the areas where these incidents are concentrated. The goal of kernel analysis is to estimate how the density of events varies across a study area based on a point pattern. Kernel estimation was originally developed to estimate probability density from a sample of observations (Bailey and Gatrell 1995). When applied to spatial data, kernel analysis creates a smooth map of density values in which the density at each location reflects the concentration of points in a given area.

In kernel estimation, a fine grid is overlaid on the study area. Distances are measured from the centre of a grid cell to each observation that falls within a predefined region of influence known as a bandwidth. Each observation contributes to the density value of that grid cell based on its distance from the centre of the cell. Nearby observations are given more weight in the density calculation than those farther away. In this study, the grid cell size is 100 square metres. The research radius used is 1,000 metres, and the higher the research radius, the smoother the image produced.

The product of the kernel estimation method is a simple dot matrix (raster image) displaying contours of varying density. Contour loops define the boundaries of hot spot areas. Hot spots may be irregular in shape, and they are not limited by neighbourhood or other boundaries. This method of analysis was applied using the Spatial Analyst software of the Environmental Systems Research Institute.

The dual kernel method is also used in this study to examine the distribution of two variables simultaneously. Use of the dual kernel serves to standardize the distribution of crime based on the population at risk (the sum of the number of persons who reside or work in a neighbourhood). The dual kernel is calculated using an in-house procedure that standardizes single kernel density distributions.

Measuring the distance travelled by persons charged

The coordinates generated by the geocoding process are used to calculate the distance travelled by persons charged to the place of the offence. In this study, two methods are explored for measuring the distance between the point of origin (address of the person charged) and the point of destination (the location of the offence). A first measure is taken by calculating the Euclidian (straight-line) distance between the coordinates. This first measure is used largely for its relative simplicity, since most GIS software includes this feature. However, this method does not take account of the street network and topography, which are likely to increase the distance travelled between the origin and destination points. The Euclidian method may underestimate distances travelled. A second way to measure the distance travelled is to use the national road network,[12] which yields a better estimate of the distance travelled, in that it takes account of obstacles to movement, such as a railway or stream. The distance is calculated by using the optimum trip length, that is, the shortest street route between the points of origin and destination. Despite the increased accuracy obtained by using the street network, the resulting measure of distances travelled is still an estimate; it is not possible to know whether the persons charged actually used the shortest route and whether the point of origin was their place of residence. According to research conducted in the United States (Groff and McEwen 2005; Rhodes and Conly 1981), these results must be considered as approximate measures of the area of activity of persons charged.

Endnotes

1. Change over time and the spatial analysis of crime were examined in depth in the Regina project. See Wallace, Wisener and Collins (2006, forthcoming).
2. Based on municipal boundaries prior to the amalgamations of 2001.
3. The results of the simple regression model for Euclidian and street network distances are shown in Appendix A.
4. It should not be concluded from the results this study that some neighbourhood characteristics are the cause of crime; rather the results show that these factors are associated with or co-occur with higher crime rates in neighbourhoods.
5. Dichotomous variables are used only for the descriptive or bivariate analysis. The multivariate analysis that follows is based on continuous dependent variables: violent and property crime rates. The differences are significant at $p<0.001$ unless otherwise indicated, based on a two sample T-test.
6. The correlation between two variables reflects the degree to which the variables are related. The most common measure of correlation is Pearson's correlation coefficient (r), which reflects the degree of linear relationship between two variables. It ranges from +1 to -1. A correlation of +1 means that there is a perfect positive linear relationship between variables, while a correlation of -1 means that there is a perfect negative relationship.
7. Since the independent variables are initially transformed into z-scores, the unstandardized regression coefficients provide a means of assessing the relative importance of the different predictor variables in the multiple regression models. The coefficients indicate the expected change, in standard deviation units, of the dependent variable per one standard deviation unit increase in the independent variable, after controlling for the other variables. The maximum possible values are +1 and -1, with coefficient values closer to 0 indicating a weaker contribution to the explanation of the dependent variable.
8. For more information on populations at risk and how they are calculated, see Fitzgerald, Wisener and Savoie, 2004.
9. An economic family is a group of two or more persons who live in the same dwelling and are related to each other by blood, marriage, common-law or adoption.
10. In January 2005, the CCJS implemented the UCR2.2 Survey, a revised version of the UCR2 Survey. The UCR2.2 Survey will collect information on the geographic location of every criminal incident as well as on hate crimes, organized crime and cybercrime.
11. For more information on the geocoding of UCR2 data in special projects, see: Josée Savoie, 2005, Geocoding Crime Data: Feasibility Study on Collecting Data from Police Forces, Ottawa, Canadian Centre for Justice Statistics, unpublished report.
12. Available at no charge on the GeoBase website: www.geobase.ca/geobase/en/data/nrnc1.html.

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Appendix A

Modelling Euclidian Distance

Violent offences

Model	R	R square	Adjusted R square	Standard deviation of the estimate
1	1.000 (a)	1.000	1.000	1.350

a Predictors: (Constant), EuclDistKm

Model		Non-standardized coefficients		Standardized coefficients	t	Sig.
		B	Standard deviation	Beta		
1	(Constant)	0.008	0.014		0.593	0.553
	EuclDistKm	1.188	0.000	1.000	4612.377	0.000

a Dependent variable: NetworkDistKm

Property offences

Model	R	R square	Adjusted R square	Standard deviation of the estimate
1	.999 (a)	.998	.998	2.546

a Predictors: (Constant), EuclDistKm

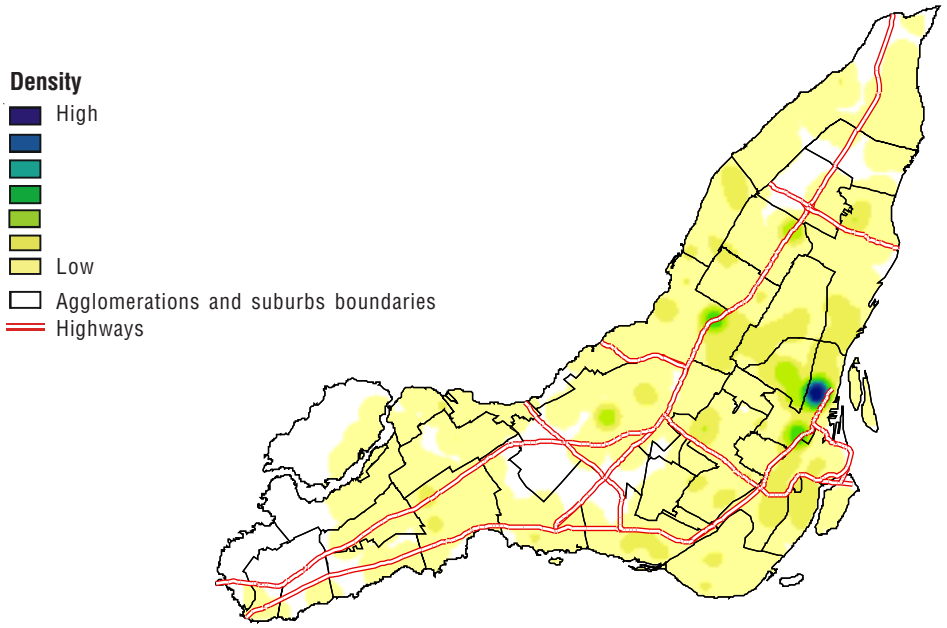
Model		Non-standardized coefficients		Standardized coefficients	t	Sig.
		B	Standard deviation	Beta		
1	(Constant)	.007	.030		.228	.820
	EuclDistKm	1.191	.001	.999	2215.810	.000

a Dependent variable: NetworkDistKm

Appendix B

Map 15

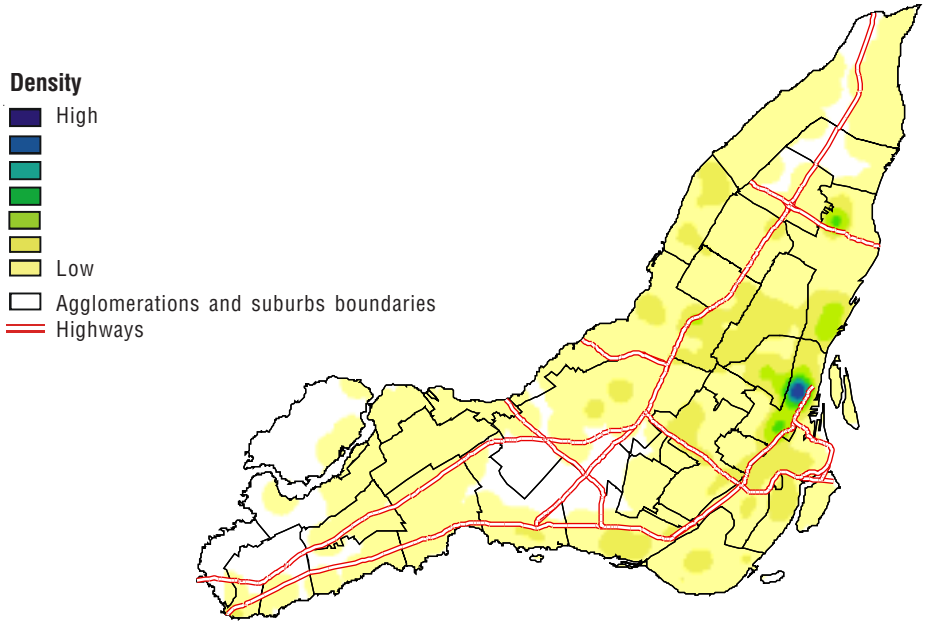
Kernel density distribution of drugs offences, Montréal, 2001



Based on 2,924 drugs offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 16

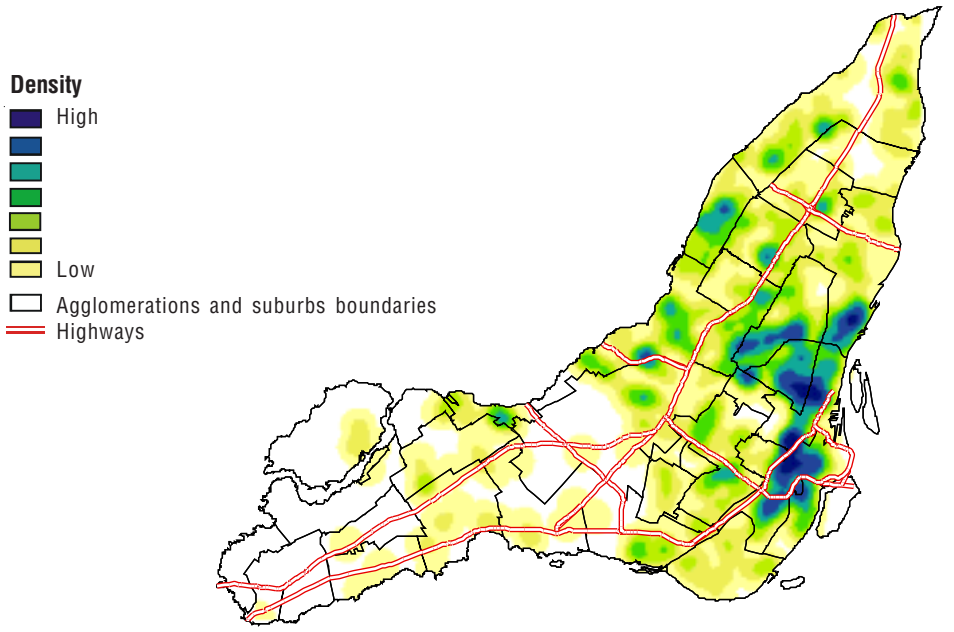
Kernel density distribution of drugs offences, Montréal, 2004



Based on 3,004 drugs offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 17

Kernel density distribution of arson offences, Montréal, 2001

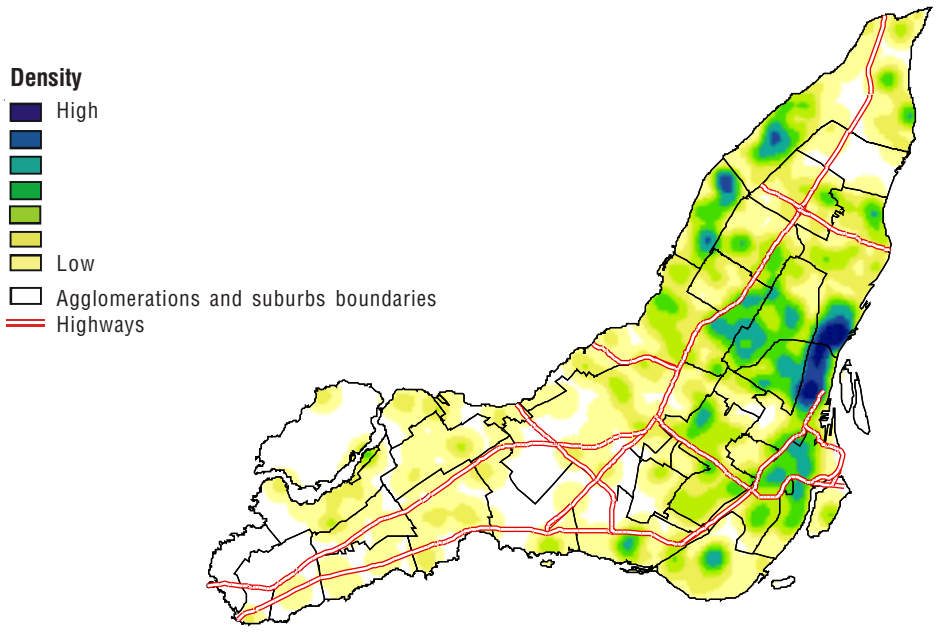


Based on 934 arson offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 18

Kernel density distribution of arson offences, Montréal, 2004

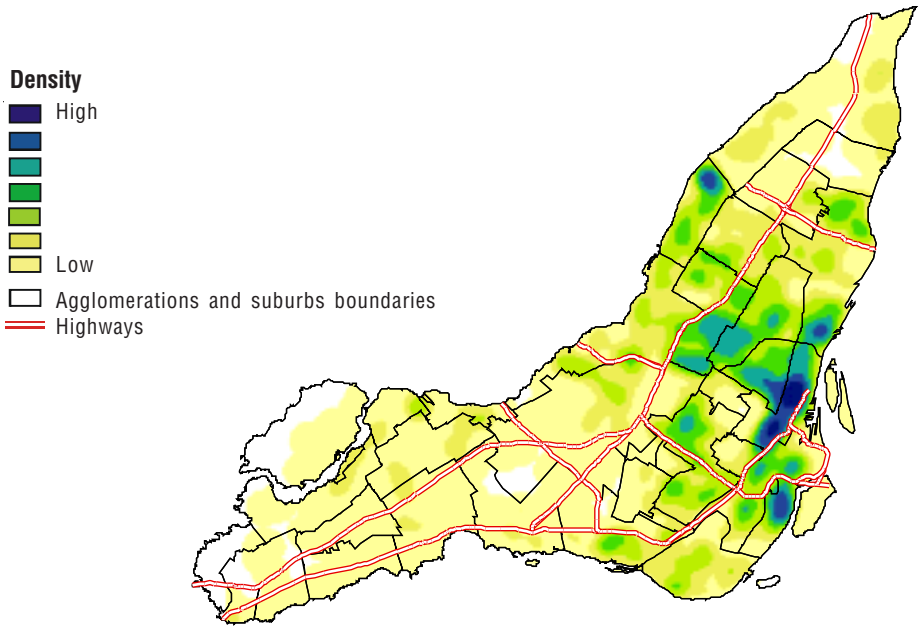


Based on 887 arson offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 19

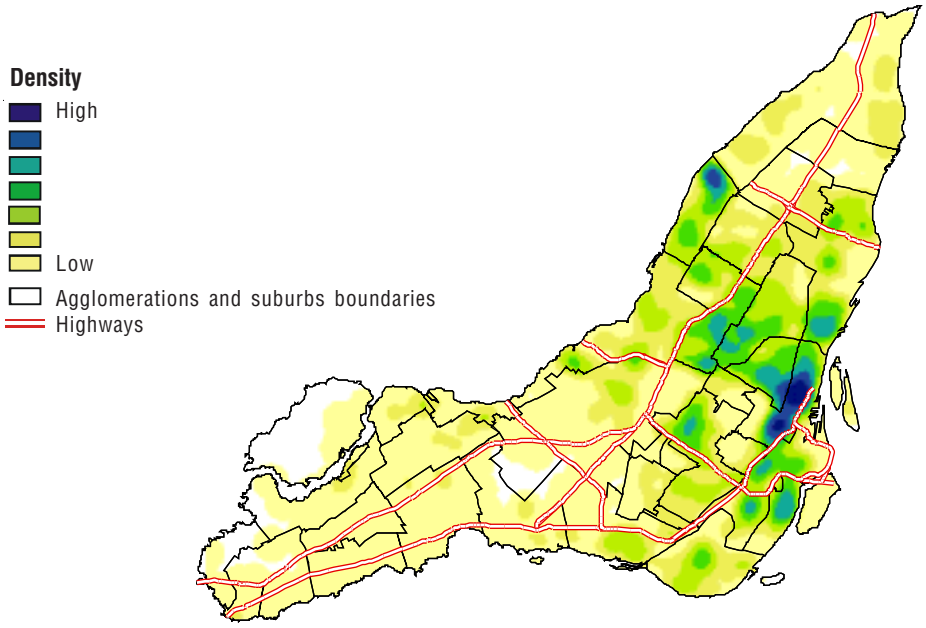
Kernel density distribution of assault offences, Montréal, 2001



Based on 13,195 assault offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 20

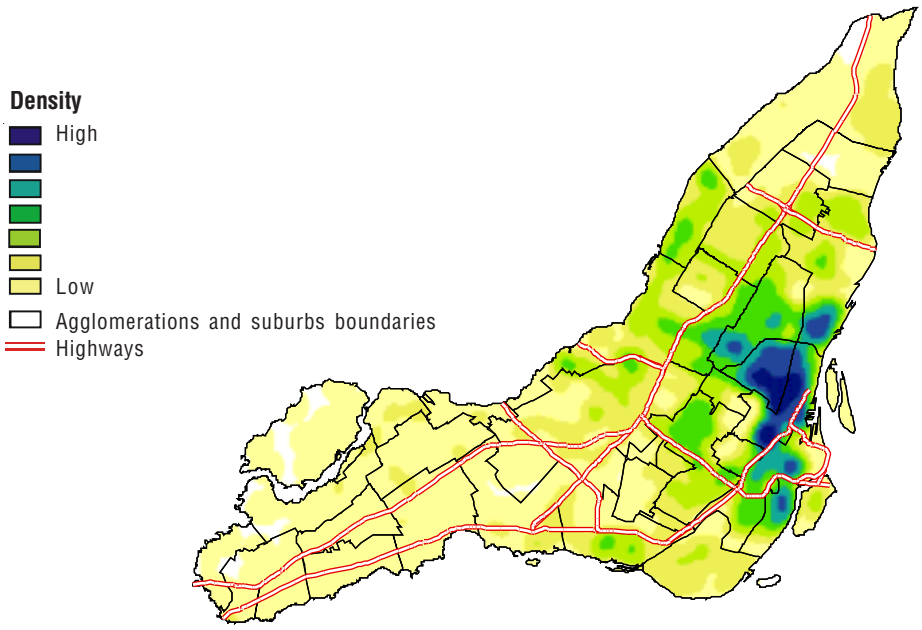
Kernel density distribution of assault offences, Montréal, 2004



Based on 12,229 assault offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 21

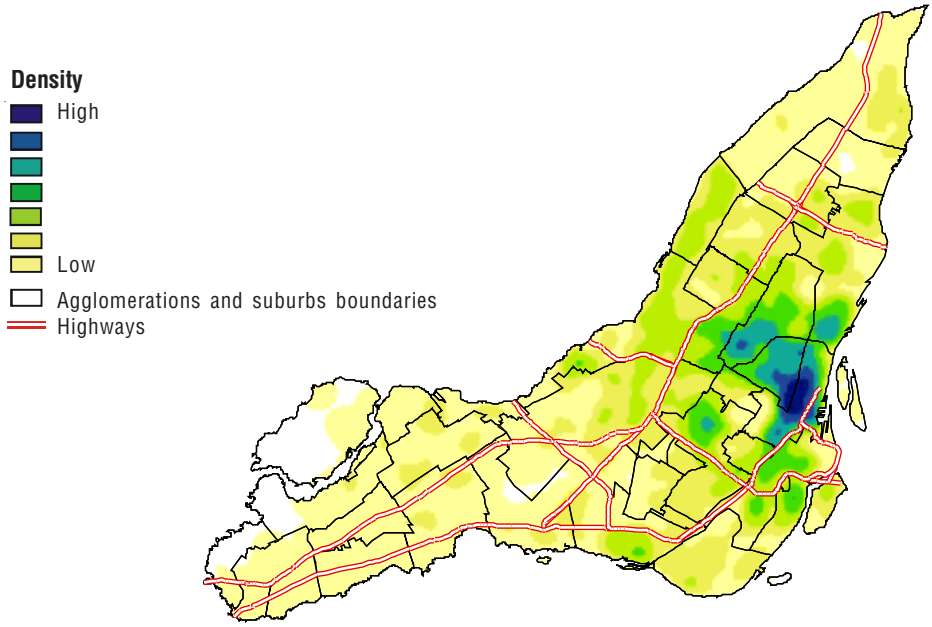
Kernel density distribution of break and enter offences, Montréal, 2001



Based on 22,751 break and enter offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 22

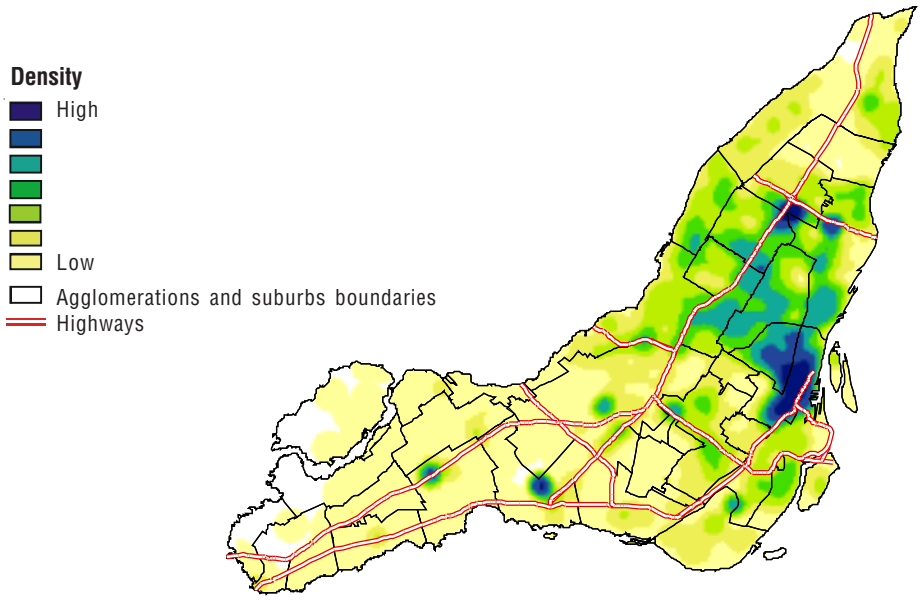
Kernel density distribution of break and enter offences, Montréal, 2004



Based on 19,128 break and enter offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 23

Kernel density distribution of car theft offences, Montréal, 2001

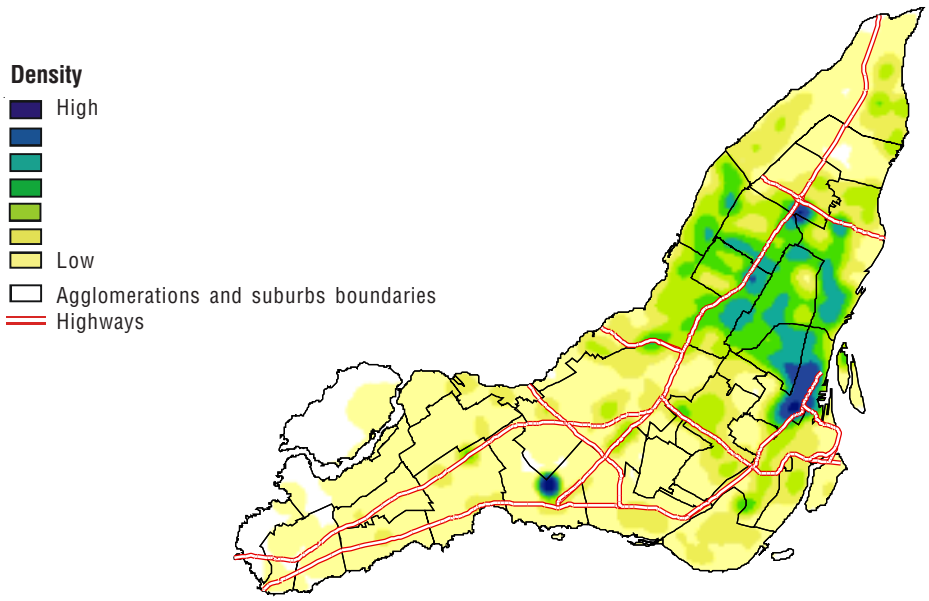


Based on 15,823 car theft offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 24

Kernel density distribution of car theft offences, Montréal, 2004

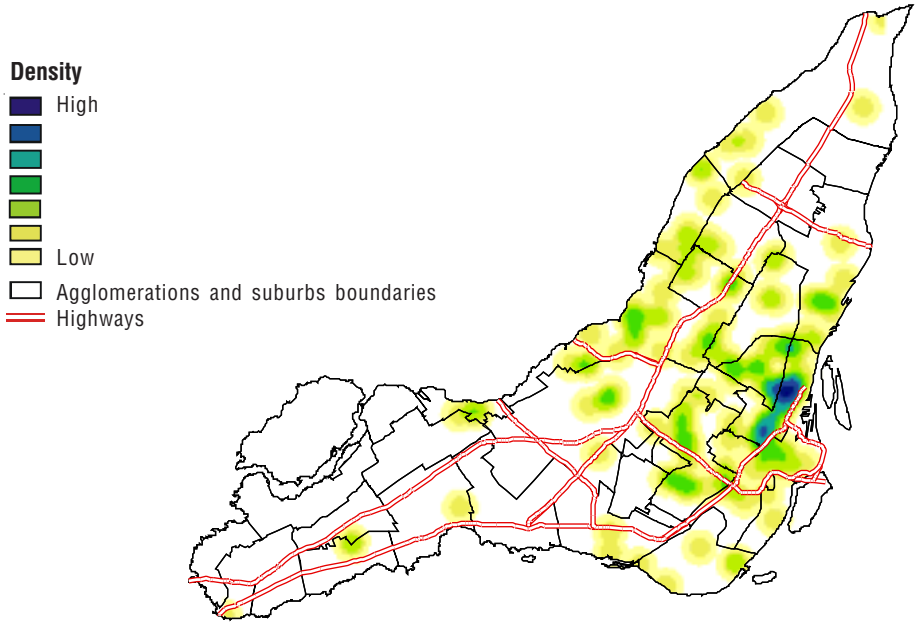


Based on 13,167 car theft offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 25

Kernel density distribution of homicide and attempted murder offences, Montréal, 2001

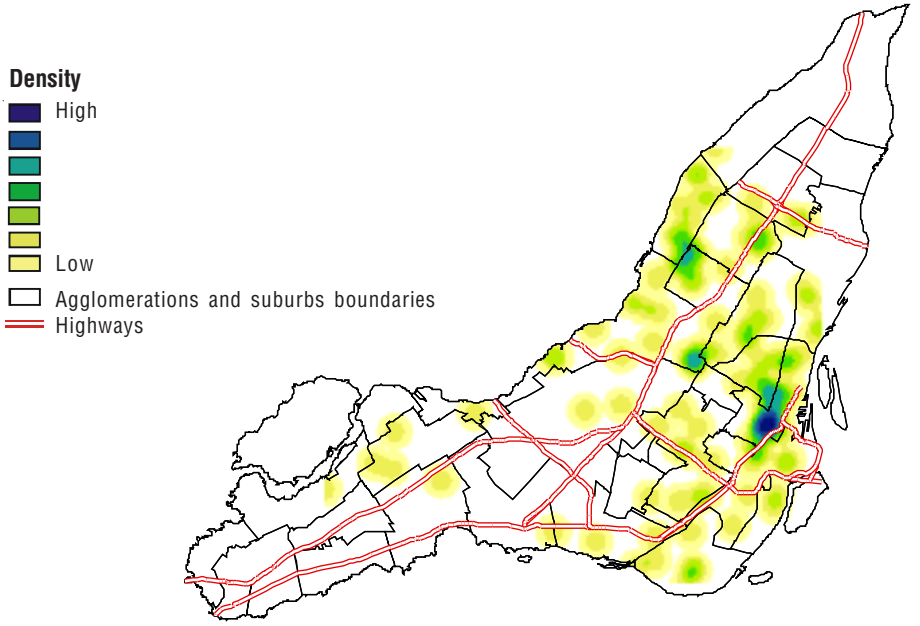


Based on 149 homicide and attempted murder offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 26

Kernel density distribution of homicide and attempted murder offences, Montréal, 2004

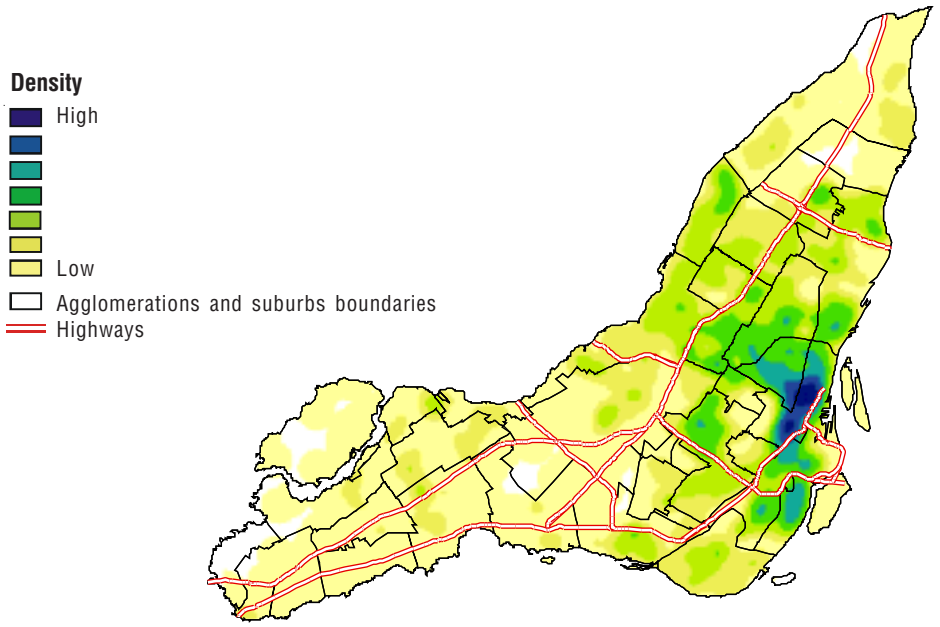


Based on 123 homicide and attempted murder offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 27

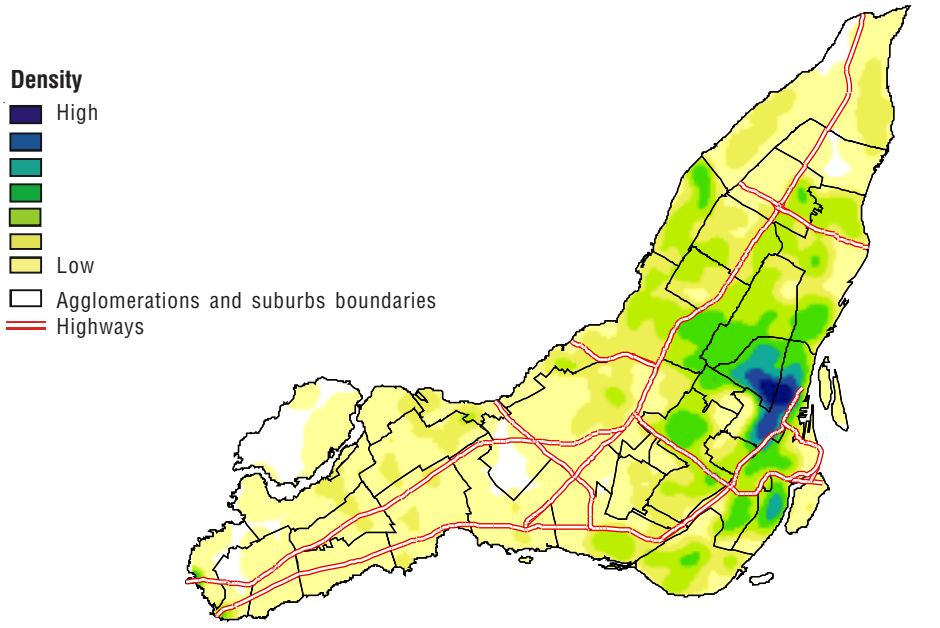
Kernel density distribution of mischief offences, Montréal, 2001



Based on 14,312 mischief offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 28

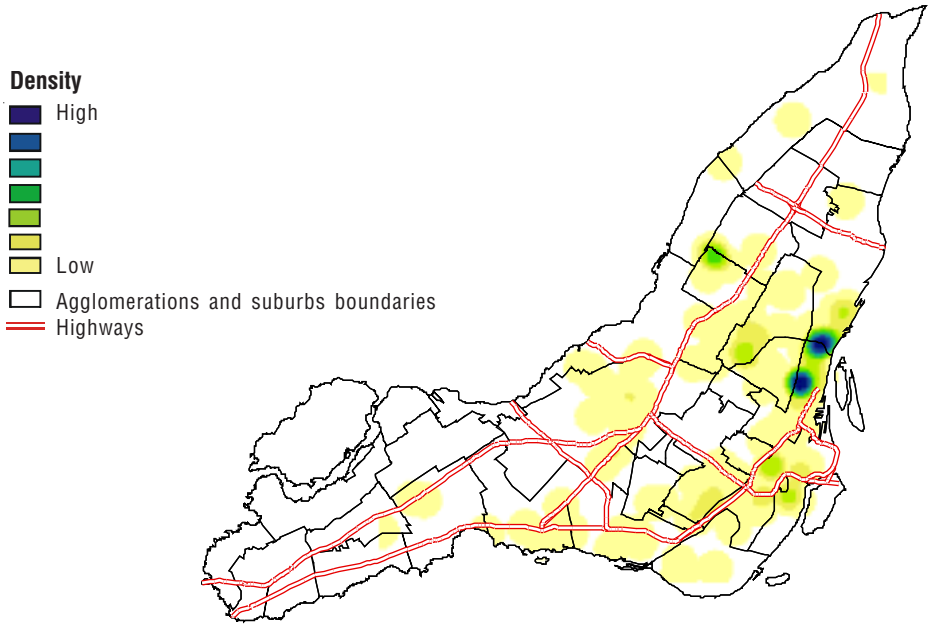
Kernel density distribution of mischief offences, Montréal, 2004



Based on 13,998 mischief offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 29

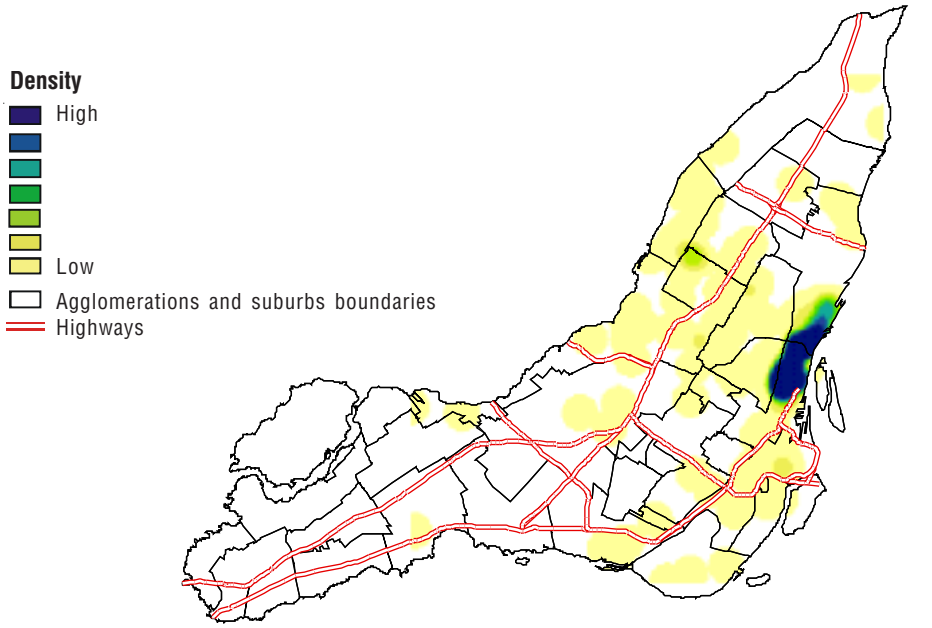
Kernel density distribution of prostitution offences, Montréal, 2001



Based on 511 prostitution offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 30

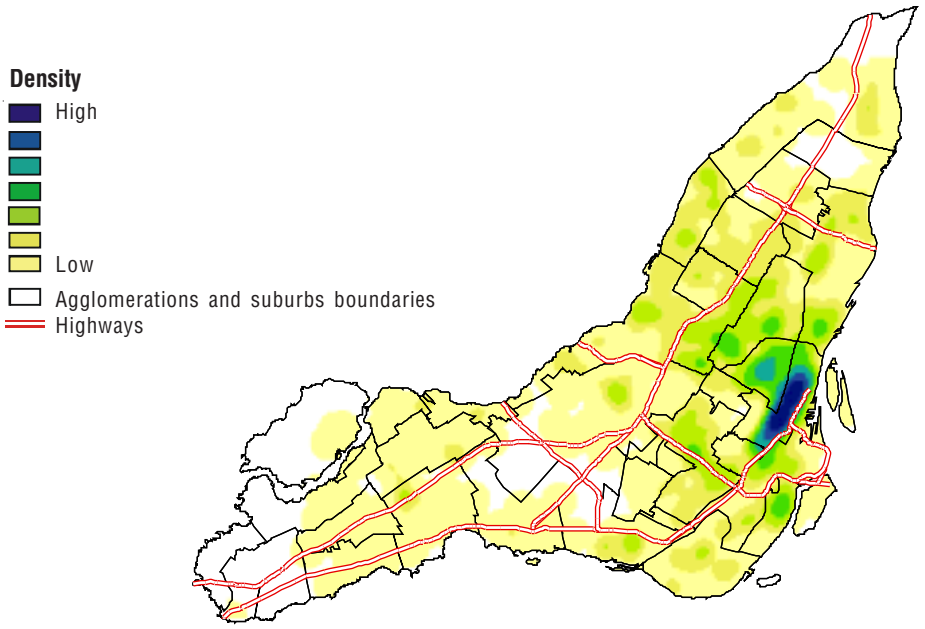
Kernel density distribution of prostitution offences, Montréal, 2004



Based on 1,491 prostitution offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 31

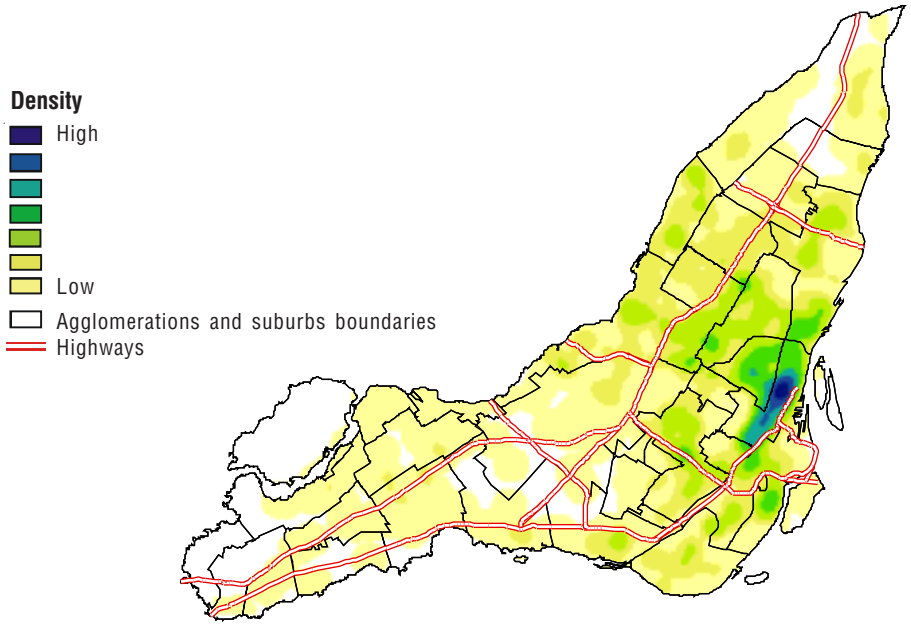
Kernel density distribution of robbery offences, Montréal, 2001



Based on 4,167 robbery offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 32

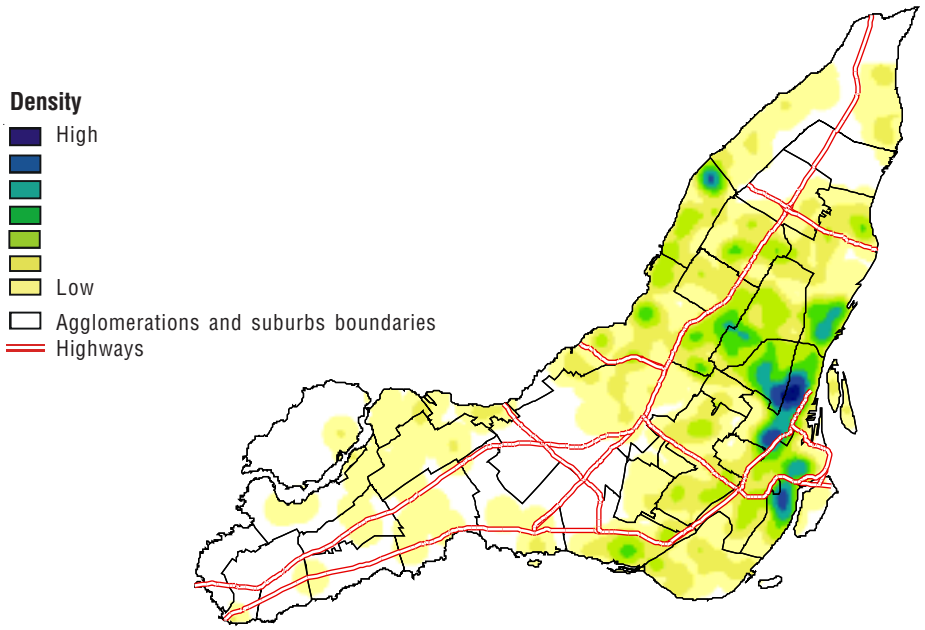
Kernel density distribution of robbery offences, Montréal, 2004



Based on 4,009 robbery offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 33

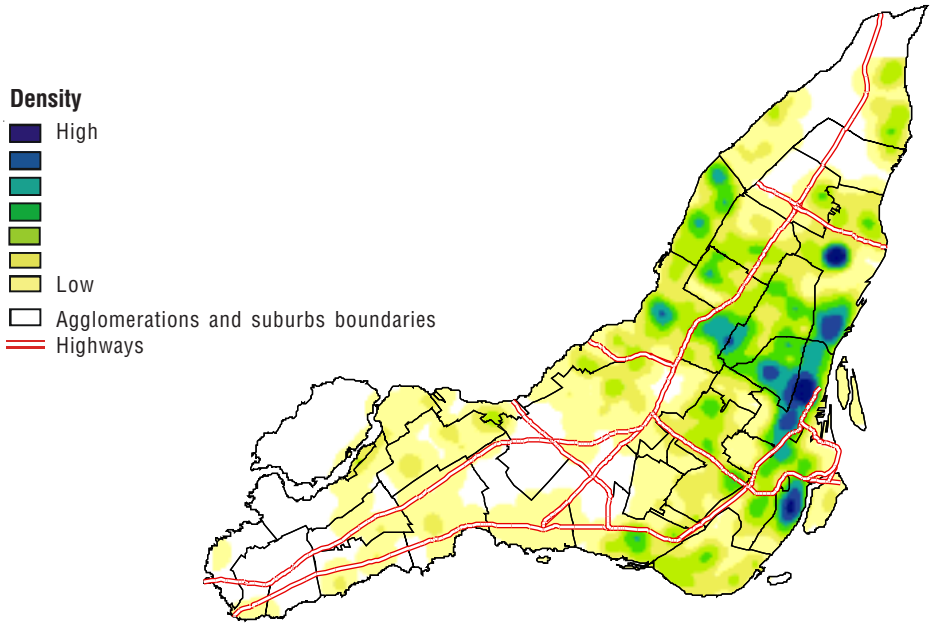
Kernel density distribution of sexual offence offences, Montréal, 2001



Based on 917 sexual offence offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 34

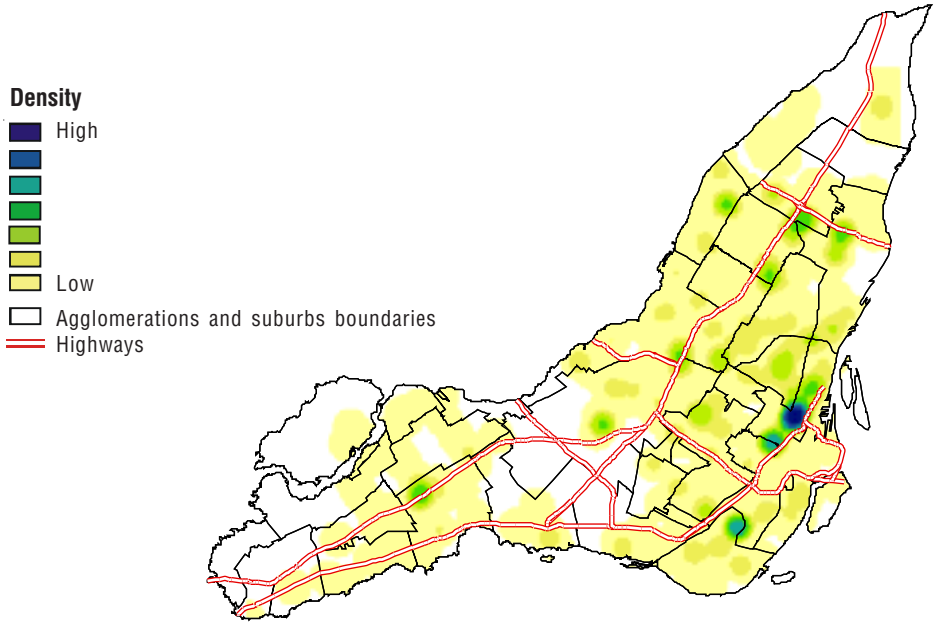
Kernel density distribution of sexual offence offences, Montréal, 2004



Based on 1,301 sexual offence offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 35

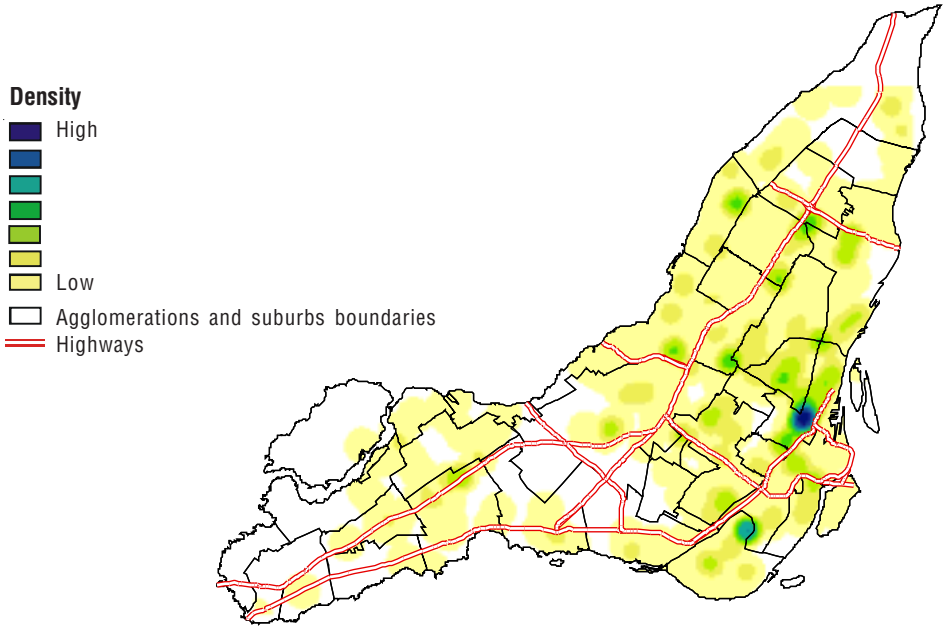
Kernel density distribution of shoplifting offences, Montréal, 2001



Based on 4,708 shoplifting offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 36

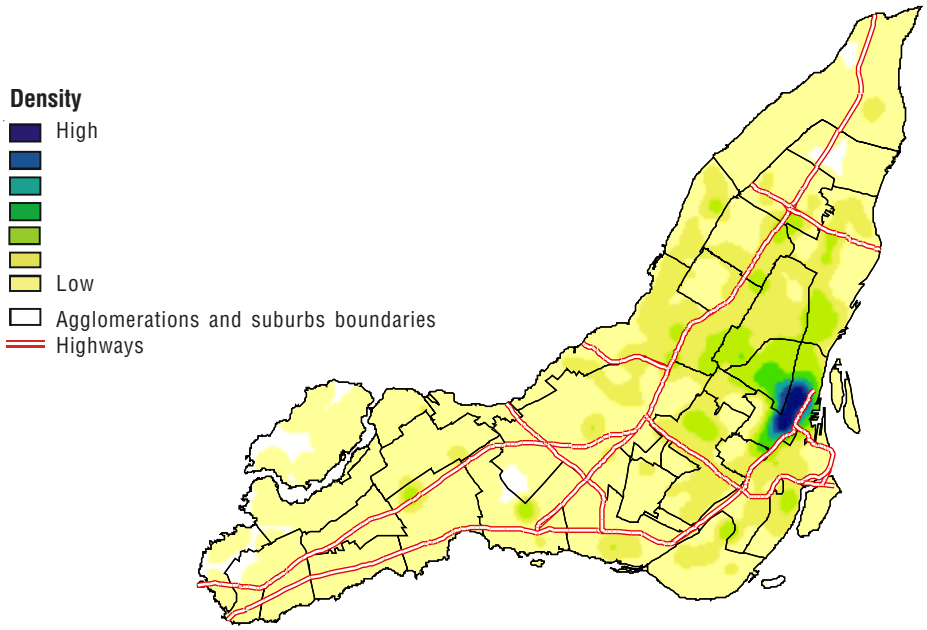
Kernel density distribution of shoplifting offences, Montréal, 2004



Based on 4,736 shoplifting offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 37

Kernel density distribution of theft $5,000 and under offences, Montréal, 2001

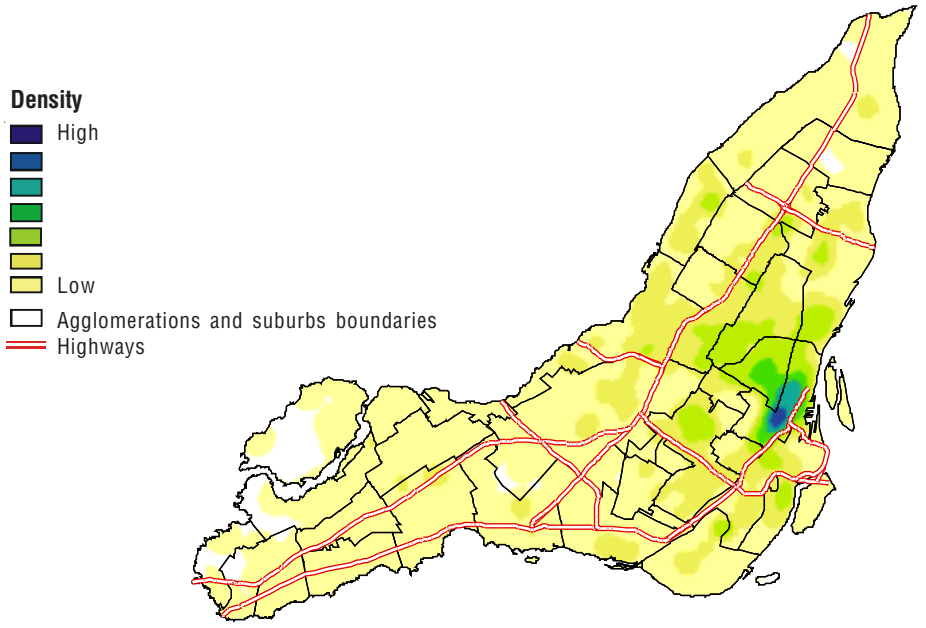


Based on 40,478 theft $5,000 and under offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 38

Kernel density distribution of theft $5,000 and under offences, Montréal, 2004

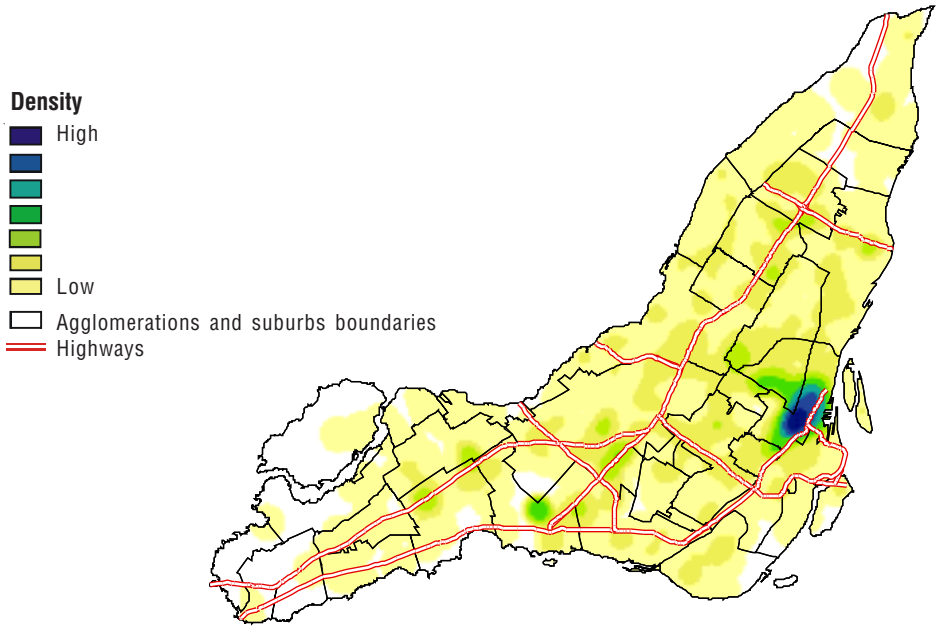


Based on 34,498 theft $5,000 and under offences.

Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Map 39

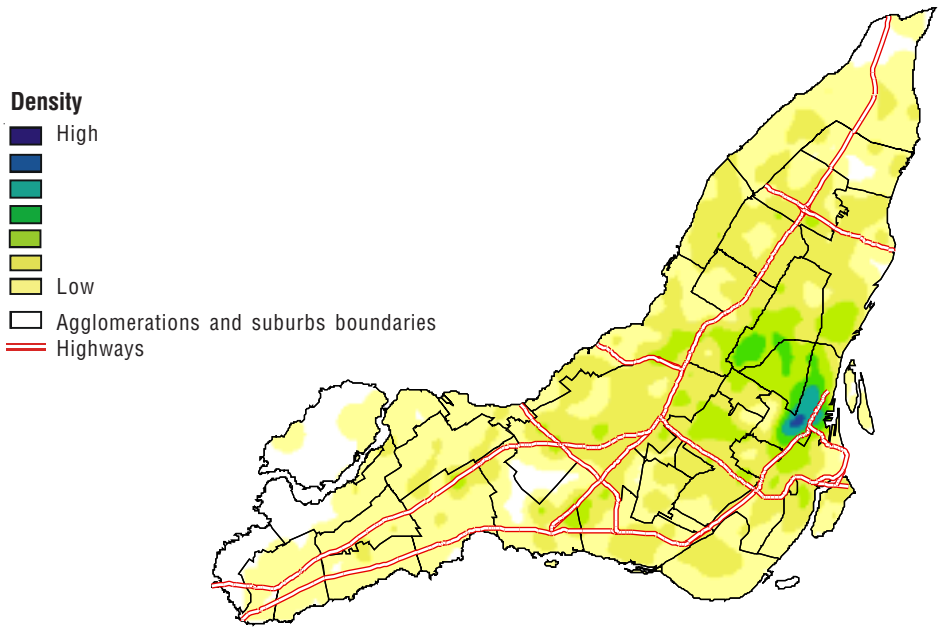
Kernel density distribution of theft over $5,000 offences, Montréal, 2001



Based on 1,832 theft over $5,000 offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2001.

Map 40

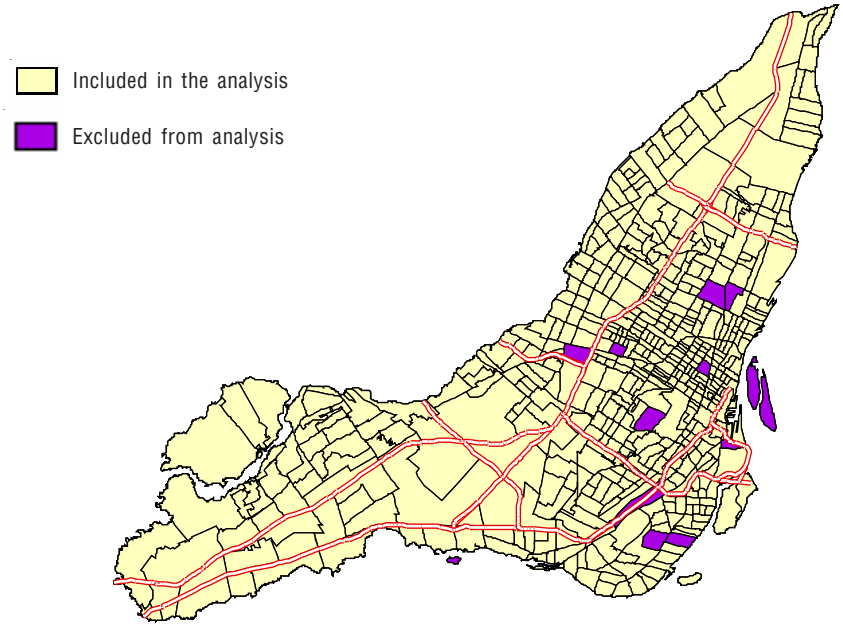
Kernel density distribution of theft over $5,000 offences, Montréal, 2004



Based on 2,497 theft over $5,000 offences.
Source: Statistics Canada, Canadian Centre for Justice Statistics, Incident-based Uniform Crime Reporting Survey, geocoded database, 2004.

Appendix C

Census tracts included in the analysis



Source: Statistics Canada, Census, 2001.

Canadian Centre for Justice Statistics

Crime and Justice research paper series

Cumulative Index

The **Canadian Centre for Justice Statistics** (CCJS) was created in 1981 as a division of Statistics Canada. The CCJS is the focal point of a federal-provincial-territorial partnership for the collection of information on the nature and extent of crime and the administration of civil and criminal justice in Canada. This partnership, known as the "National Justice Statistics Initiative", has become the international model of success on how to develop, implement and manage an effective national justice statistics program. Its analytical output appears in the flagship publication *Juristat* (http://www.statcan.ca/english/IPS/Data/85-002-XIE.htm), in various annual and biennieal publications, and in the *Crime and Justice research paper series* (http://www.statcan.ca/english/IPS/Data/85-561-MIE.htm).

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