Which Way Should We Arrêt/Stop?

A Quantitative Analysis of the Effects of Stop Signs on Traffic Flow in Montreal

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Cite as: Shoenfeld, Julien. 2008. Which Way Should We Arrët/Stop?: A Quantitative Analysis of the Effects of Stop Signs on Traffic Flow in Montreal. *Stop: Toutes Directions*, report 12. http://stoptoutesdirections.org/report12.pdf.

The direction that stop signs face and their relative density within different municipalities play a role in traffic flow in Montreal. This study goes examines stop signs by direction, street alignment (North-South and East-West), and those two categories within municipalities. Correlations are then sought between the studied municipalities for all of those statistics. Areas with a greater proportion of stop signs are considered more residential and thus lower in traffic density, whereas more urban regions are assumed to have more stop lights and less stop signs. Finally, stop sign density per street is examined.

Introduction

As one of Canada's most populous cities with 3.64 million residents, Montreal is a metropolis with considerable daily population displacement by means of an extensive network of roads and a well-developed public transportation system. The implementation of such systems results in many complications. Over 1.5 million people used roads for public transit and driving personal and commercial vehicles in 2006 (Montreal: Census Metropolitan Area/Census Agglomeration 2006). In 2001, about 731,000 people used roads in Montreal to get to work (Montréal en chiffres). From this data, one may infer that there is a high volume of traffic passing through this city on a daily basis. This study examines boroughs of the city of Montreal including: Ville-Marie, the Plateau, Côte-des-Neiges and Notre-Dame-Grace and its western neighbouring municipalities of Hampstead, Côte-Saint-Luc, and Westmount (see figure 1 and also refer to map located at http://www.stoptoutesdirections.org for survey area coverage).

The point of interest of this study is to answer question of where can high density be found in comparison to lower density traffic flows and in which direction. The data used to determine traffic flow and density were stop signs in 30 different zones, covering the area mentioned above.

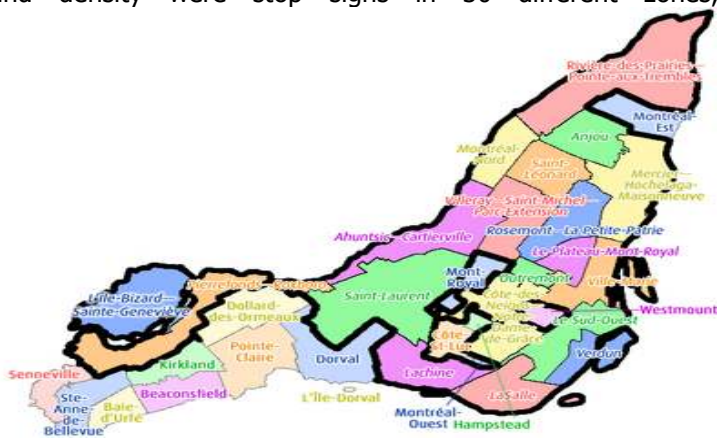

Figure 1: Montreal municipalities and boroughs

Methods

The first step in the process of determining directionality and gaining any insight into the importance of stop sign placement and its effect on traffic flow was to go out into the field (in this case the city of Montreal) and collect data on various important aspects of stop signs. The data of paramount importance to directionality studies is sign placement at an intersection relative to geographic North. The method used to assess this was referencing northwest as North for the purposes of consistency in data entry. A system was then assigned to determine placement of stop signs within an intersection. The stop sign at the West-southwest corner of the intersection was assigned the initial value of 1 with numbers continuing through 8 in a clockwise fashion around the intersection. In this system, there are 2 stop signs counted per intersection (two per side of the street). In the eventuality that an intersection was not found on the side of the road, but at a median or in another location, the stop sign would have been drawn into a diagram at the top of the data sheet and a half value would be used (i.e. 1.5 denotes a sign on a median or wire on the west side of the street). Further, stop signs marked 1 and 2 face towards eastbound travelers, 3 and 4 towards southbound travelers, 5 and 6 westbound, finally 7 and 8 northbound.

After the data had been collected in the field, the next step before conducting any analysis was data entry. The data had to be standardized and entered into a master sheet for which a large number of researchers could view and manipulate the same information. Once this had been completed, the master data sheet was refined for the purposes of this study to include 2706 of the 2817 total stop signs. In this optimized list are columns for zone number, municipality, North-South street, East-West street, sign number and finally direction (see Appendix A). The data was then organized by direction to find how many stop signs were stopped correlated with which cardinal direction for each municipality. These independent figures were then totalled up over all of the municipalities to get a sense of the overall direction of the flow of traffic (see Appendix B).

The next step in the experiment was to do Chi-squared analysis to compare North-South and East-West streets from municipalities that border each other (see Appendix C). Once this was completed for each relationship, a correlation could be supported between the outcomes on the basis of the P-value that was calculated along with the Chi-squared.

The two final steps in the process were to go through the refined master list (Appendix A) again and sort it into two lists of North-South and East-West (Refer to Appendix D). These tables were used to discern the number of stop signs per street, in order to examine the comparative density of stop signs per street. This relationship was graphed into a histogram comparing the stop sign per street density of North-South versus that of East-West streets. The data for the histogram can be found in Appendix E and the histogram will be discussed later in the results section (figure 3).

Results

After the initial fieldwork, the data that had been organized into Appendix A was broken down into municipality components in Appendix B. First, the stop signs had been assigned a direction based on the sign number they were previously attributed to. Secondly, the number of stops signs were added up and listed in the upper left-hand corner of Appendix B. This data shows that Notre-Dame-de-Grace (NDG) and Westmount are the area of Montreal with the highest number of stop signs and the Plateau and Ville-Marie are the areas with the lowest amount. This data should indicate that Westmount and NDG are lower traffic density areas than Ville-Marie and the Plateau. In turn, it may also explain that these areas, being closer to downtown, probably have a higher number of traffic lights. The other three regions, Côte-des-Neiges (CDN), Côte-Saint-Luc (CSL), and Hampstead fall in the middle of the other four municipalities.

After this analysis done, the numbers of each direction per municipality was calculated to provide the next set of results explaining traffic flow. Within the data attained (Appendix B: Municipality & dir. vs. stop tables), the directions with high sign counts were marked green and low counts were marked red. For example, CDN shows a low value of 84 signs for South and a corresponding high value of 131 signs for streets going north. According to this method of analysis, traffic flow in CDN is assessed as moving

predominantly Southbound. If the data were analyzed for the East-West sign distribution, it would indicate that the overall traffic pattern flows towards the big arteries of the city center to the Southeast. Using the same methods of analysis one could conclude that CSL traffic moves southbound but approximately equally eastbound and westbound. Hampstead's numbers all have very even numbers suggesting that the traffic direction can't be distinguished. NDG is found to have a predominant northbound flow with fairly even east/west traffic. The Plateau has no East-West preference, but significant northbound flow. Ville-Marie or the main downtown area moves southbound, out of the city, but there is no significant east west difference. The last studied area, Westmount shows general eastbound traffic towards downtown with a sight southerly preference as well.

The final calculation of this type done with data from Appendix A was the summing of general directions to get an idea of the overall traffic flow for the area of Montreal that was surveyed. This data shows that there is an overall southeast traffic flow according to stop sign data.

The next series of tests done were Chi-Square tests for cross-municipality relationships. If figure C.1 in Appendix C is reviewed, several important pieces of information can be discerned from the test. First, the observed values of North-South streets in the Plateau and East-West streets in Ville-Marie were observed in higher frequencies than the values expected by the Chi-Square test. The North-South in Ville-Marie and East-West in the Plateau were likewise found to be lower than their expected values. The cross-correlation just explained is verified to be significant by the low P-Value of 3.85×10^{-10} calculated within this test. Similar P-values and correlations exist between: Ville-Marie and Westmount, Westmount and NDG, NDG and CDN, NDG and Hampstead, Hampstead and CSL, and finally, NDG and CSL (see Appendix C: figures C.2, C.4-C.8). The only Chi-Square test found to have no correlation is Westmount and CDN (figure B.3). The P-value needs to be smaller than the Level of Significance value in order for a correlation to be established between the two municipalities tested. This outcome means that the difference between the observed and expected frequencies is more likely due to chance than correlation.

The final part of this study deals with stop sign density per street to predict the amount of traffic or traffic density on that street. For this data, Appendix A was reduced to Appendix D and sorted by E/W streets and N/S streets. The number of stop signs for each street was counted and listed in Appendix D. The data from Appendix D was then compiled into a histogram (Appendix E), showing the frequency of stop sign density per street for North-South streets versus East-West streets. The Discussion section contains figure 2 with the histogram and its analysis along with mention of further research possibilities and limitations within the studies conducted in this experiment.

Discussion

The results from the previously discussed tests show general traffic trends within the boroughs of Montreal and its adjacent municipalities. On average, there seems to be a trend of traffic towards the city center from the periphery, as traffic tends to move south and east for most areas west of Ville-Marie. The Plateau shows slight variation with a northbound trend, but there is still a large presence of southbound flow and the significant figure lies in westbound traffic from that municipality as well. Ville-Marie being the downtown area seems to be the primary artery with a relatively low number of stop signs and thus presumably less stagnant traffic. Additionally, the relatively low number of East-West stops signs across the survey area shows a much greater displacement of traffic in those directions. This conclusion seems to be fairly well substantiated as proportionally more of Montreal's suburbs lie to the East and West rather than North and South due to the shape of the island of Montreal.

Figure 2 below, illustrates another general negative exponential trend for streets across the surveyed areas as to be expected. This means that as the value for the number of stop signs per street increases, frequency decreases. This trend is observed by both the North-South and East-West data series. East-West data however shows many outliers at higher densities. These results can be substantiated by the zoning change from more commercial in Ville-Marie to more residential on the periphery. Therefore, the streets that go East and West are likely regulated with traffic lights downtown and more and more stop signs as the streets move into residential neighbourhoods with less traffic.

This brings up the conflict of traffic lights placement and its effect on the ability to predict traffic flow based solely on stop signs. As cited in the introduction, there is a significant amount of traffic in the city and the placement of stop signs; their relative abundance and direction all play a role in restricting traffic flow. Stop signs also restrict traffic, but are more common in areas with higher traffic volumes. Ville-Marie for example is likely covered in stoplights instead of signs, due to the fact that many if not most of the jobs held by commuters are located in this area.

A follow-up study to this could involve an enlargement of the study area including areas of Outremont, St. Laurent, as well as areas further east. With more information and especially more time, one could also undertake a project to geo-reference all stop signs and associated data to maps of the city, so that measurements can be taken to study intra and inter-road stop sign densities. These datasets or projects together would give a more comprehensive analysis of Stop, Arrêt or Arrêt/Stop sign data across Montreal. With more time and resources it would be interesting for another project to correlate stoplight traffic and with that where stop signs are present. Nonetheless, the data presented by the traffic analysis from stop sign data presents interesting information on the various movements of residents, commuters and even visitors of the Montreal region.

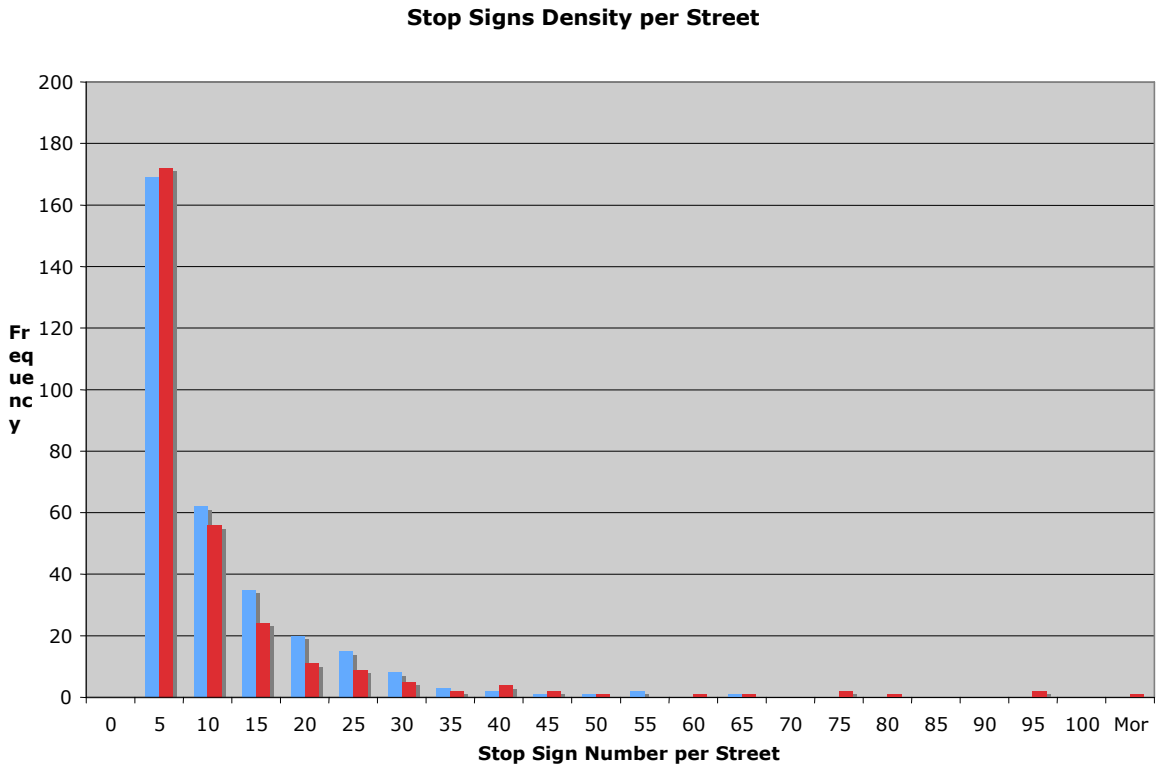

Figure 2: Stop Sign Density per Street Histogram

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