Metrolinx

Activity Centre Report – Intermediate

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Motivation

Metrolinx is the government agency responsible for the coordinated planning and integration of modes across the Greater Toronto and Hamilton Area (GTHA) in Ontario. Of particular interest to Metrolinx is the potential to improve transit quality of service. One major perceived obstacle for transit is the lack of regional service – direct connections (single-seat, no transfer) across municipalities. The motivations for this research are to:

- Identify areas within the GTHA between which high travel demand exists;
- Compare costs by both transit and auto between these areas;
- Quantify the reductions in transit costs that can be achieved by the introduction or improvement of enhanced regional service; and
- Predict the potential gains in mode share that could occur as a result.

This report documents the research done to achieve these goals. The first step in the process is to identify land areas between which high travel demand exists. The approach taken is described in the following sections.

Introduction

Cities are constantly evolving in spatial form; the most significant change in the past century has been the shift from monocentric cities to polycentric cities (Ladd & Wheaton, 1991). The Greater Toronto and Hamilton Area has experienced this change also and is now facing the challenges and opportunities that a polycentric city provides. The economic literature explains this change in terms of utility for both households and firms. As transportation costs declined, employment and population decentralized to maximize their utility (Wheaton, 1979). A household's reduced housing costs and a firm's easier access to export markets on the periphery of a city meant an increase in utility for both parties (White, 1976).

Helsley and Sullivan (1991) expand this analysis outside of the central city to explain agglomerations of employment that they refer to as subcenters. The authors argue that subcenters form because of the tradeoff between production economies of scale and the diseconomies of transportation. Assuming a rational planning environment that focuses on the short-term, their model predicts three stages of

sequential development of a city: growth of the central city, exclusive growth of a subcenter, and simultaneous growth of both central city and subcenter. This sequence aligns well with the historical development of the GTHA. The final stage is accurate in describing the current growth as both the downtowns and the suburban subcenters are growing in population and employment.

The literature uses many words to describe agglomerations of employment or population: subcenter, activity centre, or suburban employment centre. These terms can generally be used interchangeably but this report will primarily use the term 'activity centres'. Activity centres can be defined as having greater concentrations of employment and/or population than adjacent zones and offer firms or households benefits from their economies of agglomeration. Activity centres in urban areas "exert significant influences on land values, housing prices, and travel patterns" (McDonald, 1987, p. 242).

Activity Centres

Public transportation benefits from activity centres' influence on travel patterns as higher densities of employment or residents require higher frequency or higher order transit thus increasing the attractiveness of the system. Clusters of non-residential uses are proven to support increased transit use especially when the total employment is a significant size– above 10 million square feet in this case (Pushkarev & Zupan, 1982). This study also concludes that an increase in residential density can lead to a greater support of public transit, albeit to a lesser degree than employment density. Similarly, Casello identifies employment activity centres in the Philadelphia metropolitan area and determines that public transportation competes best against other modes for trips between these centres (2007).

Identifying Activity Centres

The current literature offers two methodologies for defining an activity centre; both are employment exclusive analyses. The first method defines activity centres as:

- a set of contiguous zones with total employment above a threshold, and
- each zone's employment density greater than another threshold.

The developers of this method, Giuliano and Small (1991), investigated the Los Angeles metropolitan area using 1980 traffic analysis zone data and thresholds of 10,000 total employees and 10 employees per acre. To capture additional employment centres on the periphery of the city, the authors lowered their total employment threshold to 7,000 employees and defined these as 'outer centres'. The second method takes a spatial approach to define activity centres. McMillen (2003) predicts employment densities for each analysis zone based on distance from the CBD and a smoothing function that accounts for the employment density of nearby zones. The density prediction equates to a minimum density threshold; however, the threshold is varied throughout the metropolitan region. Zones with higher than predicted densities are considered candidate zones. In a similar approach to Giuliano and Small, activity centres are then defined as clusters of contiguous candidate zones with total employment greater than 10,000. This approach is more transferable to other regions, requires less prior knowledge of a region, and is better at identifying higher than adjacent densities than the first method.

Although the lack of transferability and variation across a metropolitan region are accurate shortcomings of the first method, it is more widely used due to its simplicity. As an example, Bogart and Ferry (1999) adjust the standard Giuliano and Small method slightly in their analysis of Cleveland. The employment density threshold was set at 5000 employees/mile^2 (~8 employees per acre) and the total employment threshold was maintained at 10,000 employees. Once activity centres were identified in this way, Bogart and Ferry added adjacent zones that were below the minimum employment density in decreasing density as long as the entire cluster maintained a density above the threshold. The purpose of this was to capture zones that possessed similar or additive travel flows adjacent to traditionally identified subcentres but were below the density threshold.

A study by Casello and Smith (2006) has built upon Giuliano and Small and Bogart and Ferry's work in multiple ways. First, this study varies the employment

density and total employment thresholds based on location to account for the difference in characteristics of major urban centres, secondary urban centres, and suburban activity centres. Secondly, it only applies the Bogart and Ferry method for the suburban activity centres to avoid ultra-high density zones in the downtown from creating an activity centre that is too large to be meaningful for traffic analysis. This study also adds a minimum employment density of the adjacent zones to avoid adding open space to a centre. Finally, it accounts for the varying trip attraction rate of each type of employment by weighting each employment type when calculating the employment density and total employment. Through clustering the zones above the density threshold, it then applies the total employment criteria: 20,000 for major urban centres, 15,000 for secondary urban centres, and 10,000 for suburban centres. These contiguous zones can be defined as transportation activity centres because they better reflect true transportation flows.

Each of these studies has agreed that setting the threshold for employment density and total employment is critical to the process. Using methods that are based on the actual data and not on perception helps the study's credibility. As such, Pan and Ma (2006) use a statistical analysis of the range of employment densities in order to determine a proper threshold. They use a simple z-score statistic to select a targeted percentile of zones for further analysis.

Attempts at identifying clusters of population density are much rarer than of employment density; however, modelling of urban population densities has occurred (Griffith, 1981; Griffith & Wong, 2007). These papers' foci are to build upon other models to accurately predict population density at any given location within a city. Previous attempts to model the population density in a city relied heavily on distance from the central business district; Griffith and Griffith and Wong account for the dispersed peaks in population density caused by subcenters and their effect on the surrounding locations. The method used does not provide a framework for determining which clusters or peaks of population density should be considered a subcenter and therefore the methodology used for employment subcenter identification will be replicated.

Although a variety of methods are used to set density thresholds and identify activity centres the following section proposes a methodology based on the Casello and Smith approach with data limitations considered and population analysis added.

Methodology

This research is seeking to identify trips where public transport can be competitive with the automobile. The identification of employment subcenters has been used often in transportation analysis without a proper investigation of residential subcenters or areas of residential agglomeration. This has developed as a result of economic literature studying the travel pattern influence of employment subcenters in cities and other literature proving that transit is more competitive in high-density commercial areas than residential areas (Pushkarev & Zupan, 1982). However, a trip is comprised of an origin and destination and a prudent analysis will also include the areas of high residential density.

The methodology used to identify employment and residential activity centres is very similar; for residential activity centers the number of residents and residential densities are used as thresholds instead of employment data. For the purpose of this study, the analysis was performed at the traffic analysis zone (TAZs) level. Transportation data were gathered from the 2006 Transportation Tomorrow Survey (TTS) for the areas served by the nine municipally run transit systems in the GTHA.

Setting a Density Threshold

As the previously reviewed literature demonstrates, selecting an accurate threshold is critical to appropriately identifying activity centres. The approach taken here was to vary the thresholds across the region to capture the phenomenon of decreasing densities away from urban cores, but to still include zones with higher than adjacent densities on the city's periphery. We also sought to establish thresholds such that a significant but tractable number of zones are identified.

Our approach began by sorting the TAZs within each transit systems jurisdiction based on employment density and subsequently population density. A cumulative distribution plot of this data was created to illustrate the 'natural' thresholds that might exist; Figure 1 and Figure 2 below show the results. Plotting the data this way provides a similar approach to Pan and Ma (2006) and provides an understanding of what percentage of zones are above or below the threshold.

Two of the transit service areas shown in Figure 1, Toronto and Mississauga, have significantly different employment density distributions than the rest of service areas and, therefore, warrant their own density thresholds. The remaining service areas are similar in employment density distribution and can be aggregated before defining a threshold. In Figure 2 the population density plots of Toronto and Mississauga are more similar to the other service areas than in the employment density plots but are still treated separately for continuity purposes.

The next step was to identify the 'natural' thresholds that existed in the plots, points where the gradient of densities is noticeably different on either side. These points are illustrated by plotting trendlines on the curves and are shown in Figure 3 and Figure 4 below. Only the densest 20% of zones were considered in order to limit the number of candidate zones to a tractable total. The first natural break point above 80% in each case was selected (except for the population distribution outside of Toronto and Mississauga as it produced too large of zones for analysis). A summary of density thresholds is shown below in Table 1. To visualize the building typology that achieves a specific population or employment density, refer to Appendix A & B.

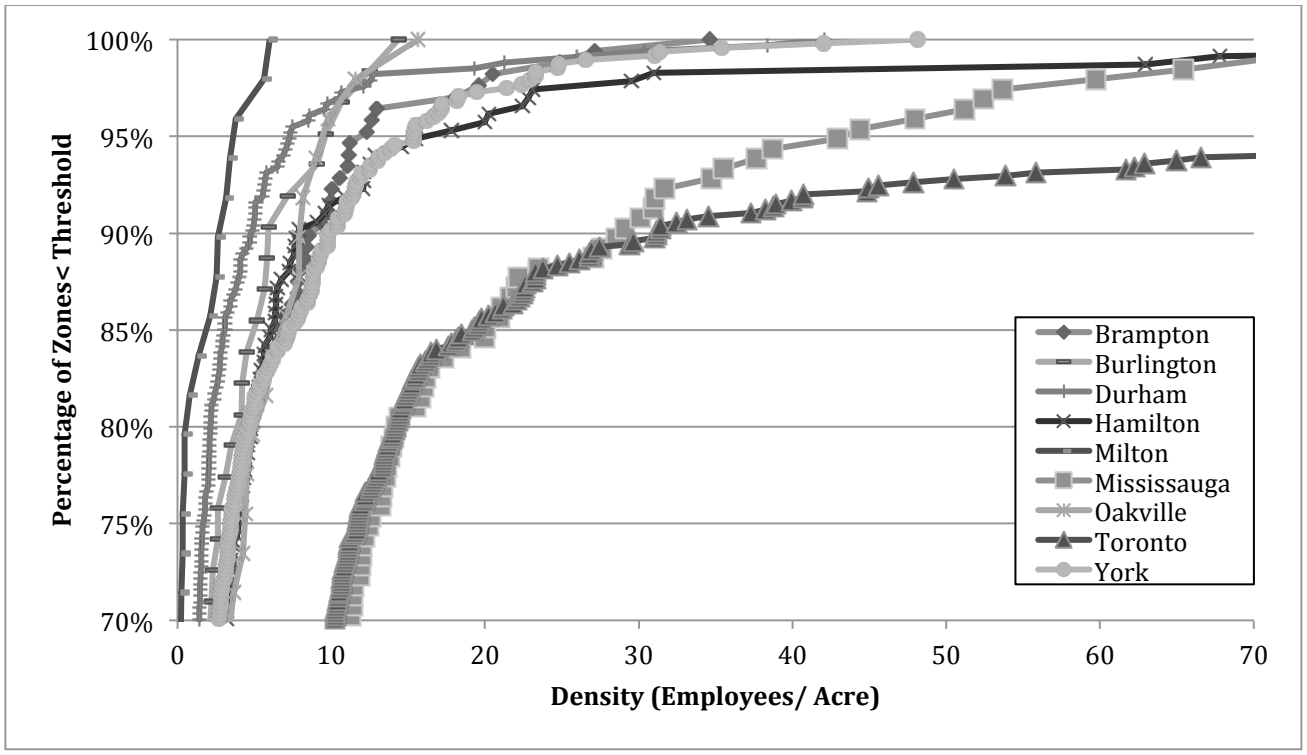

Figure 1 - GTHA Employment Density of TAZs by Transit Service Area

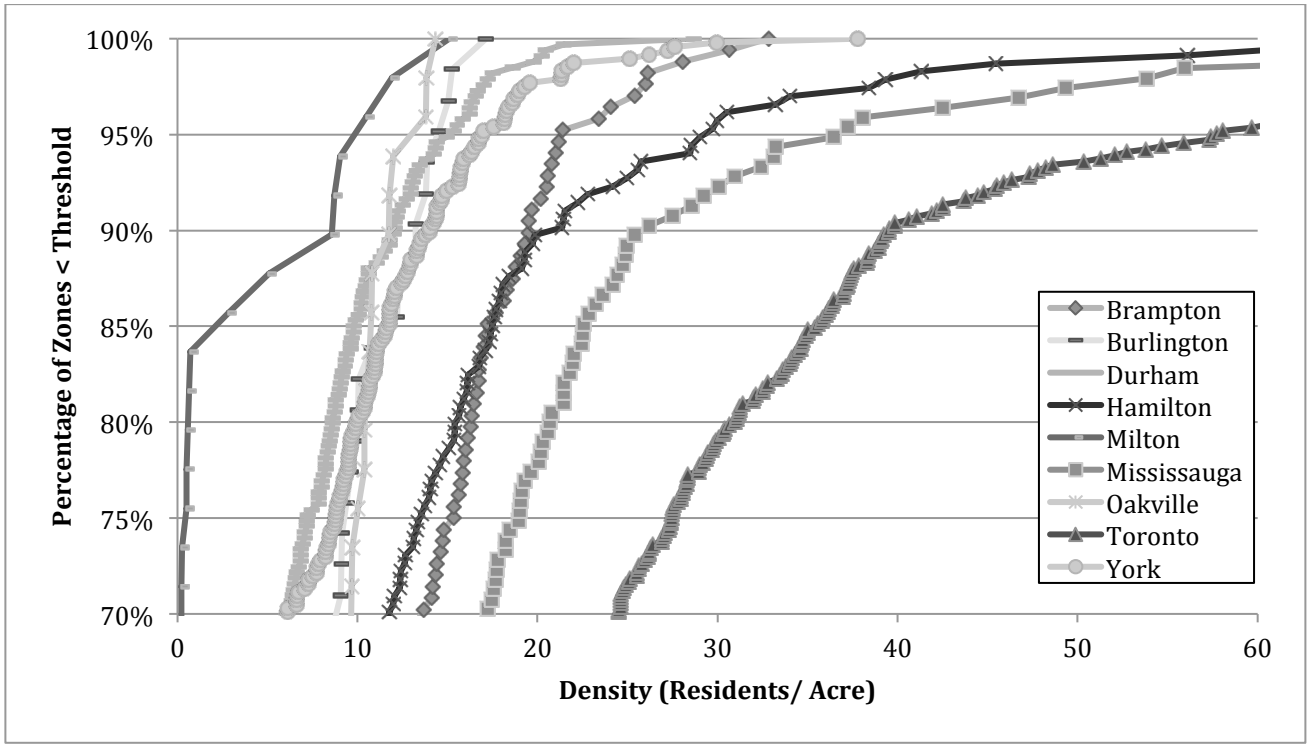

Figure 2 - GTHA Population Density of TAZs by Transit Service Area

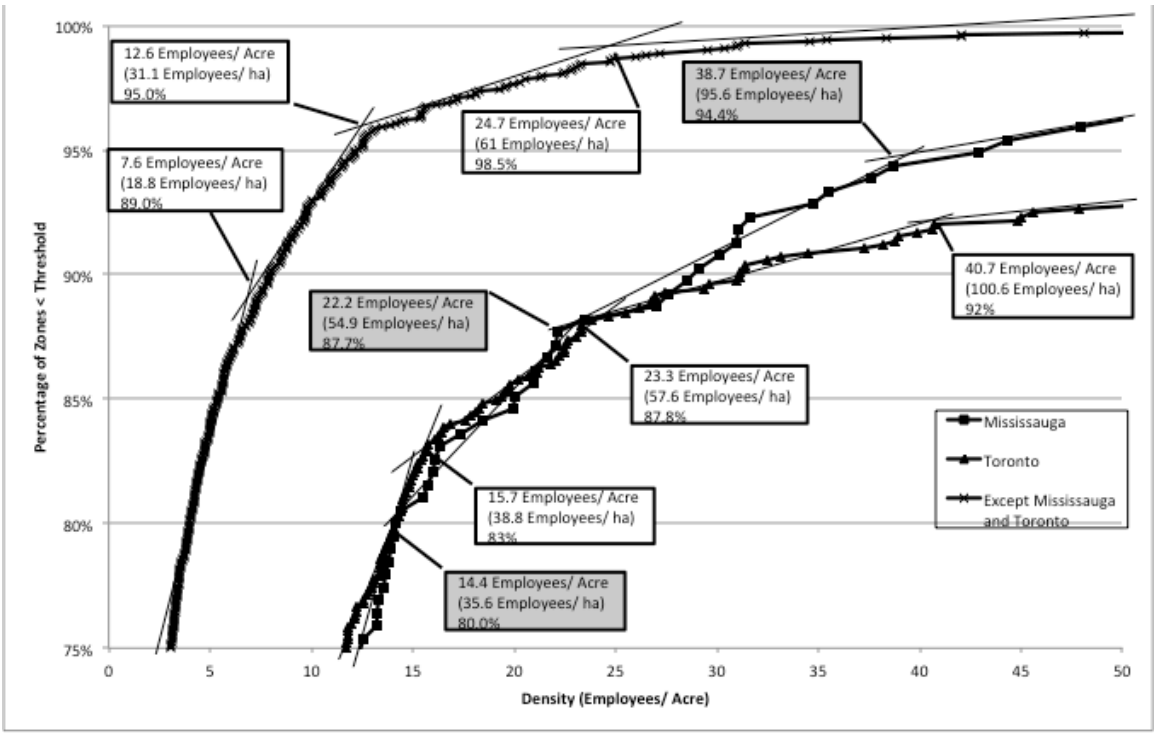

Figure 3 - GTHA Employment Density Thresholds

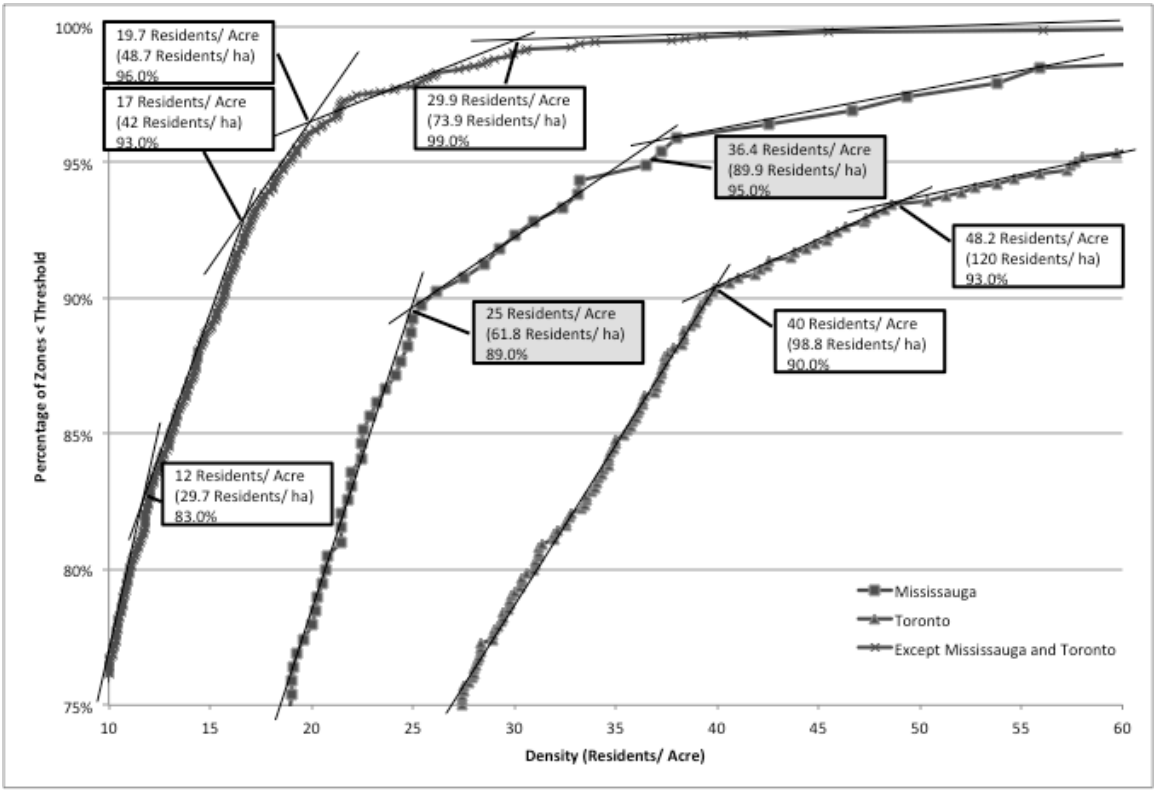

Figure 4 - GTHA Population Density Thresholds

	Employees/ Acre (% of TAZs < Threshold)	Total Employment	Residents/ Acre (% of TAZs < Threshold)	Total Residents
Toronto	15.7 (83%)	10,000	40 (90%)	20,000
Mississauga	14.4 (80%)		25 (89%)	
Elsewhere	7.6 (89%)		17 (93%)	

Table 1 - Activity Centre Thresholds

Selecting Activity Centres

All zones possessing densities below the first thresholds were temporarily set aside. Every cluster of zones or standalone zone with density above the threshold was documented and adjacent zones analyzed to determine if they contributed to the travel demand significantly. Adjacent zones below the threshold were appended to clusters with less than eight zones using the Bogart and Ferry method; zones were added in order of decreasing density while maintaining a cluster density above the initial threshold. If the cluster had eight or more zones it already represented a significant origin or destination and did not require additional zones to be added. Also, very large clusters of zones were split into multiple parts along natural or logical borders – rivers or freeways for example – inorder to best reflect the agglomeration activities or the likely travel patterns.

Clusters along the municipal borders were closely investigated to determine if zones in a different municipality had a continuity of use with the cluster in question. If so, the zones were added to the cluster while maintaining a density greater than the threshold of the initial cluster.

Total employment or residents of each cluster was the next criteria used to determine an activity centre. For employment, if the cluster had greater than 10,000 employees it became an activity centre. For population, if any cluster had greater than 20,000 residents it became an activity centre. These criteria yielded 40 employment and 29 population activity centres; see Table 2 & Table 3 and Figure 5 & Figure 6 below.

	Activity Centres	Total Employment	Total Acres	Employment Density	# of TAZ's
Except Toronto & Mississauga	Pickering Town Centre / OPG	25197	3182.47	7.92	9
	Oshawa City Centre	16185	931.51	17.37	8
	Oshawa Waterfront	16153	1320.69	12.23	2
	403 & QEW	21729	2716.12	8.00	6
	403 & 4th Line - Oakville	14561	1826.08	7.97	4
	Ford Motor	18208	2195.78	8.29	6
	Burlington Mall	36590	4356.27	8.40	8
	Mohawk-HendersonHosp-LimeRidge	12146	1455.55	8.34	8
	Gray & Barton	15460	2005.69	7.71	7
	McMaster	13029	1511.30	8.62	4
	Downtown Hamilton	33475	1424.80	23.49	17
	Brampton City Centre	15750	1446.39	10.89	8
	Bramalea City Centre	25674	2182.04	11.77	8
	Daimler-Chrysler	28749	3149.06	9.13	8
	400 & 407 - West of 400	14449	1653.73	8.74	8
	400 & Steeles - West of 400	24731	1886.16	13.11	6
	400 & 407 - East of 400	28084	2586.94	10.86	9
	Keele & 407	23028	2703.66	8.52	8
	404 & 407 - Richmond Hill	28422	1923.83	14.77	8
	404 & 407 - Markham	22619	1857.23	12.18	9
	Woodbine & Steeles	55455	3293.63	16.84	14
	Newmarket	28391	3311.58	8.57	10
Mississauga	Dixie & 401	48391	3203.75	15.10	7
	Mississauga Rd & 401	22501	1519.62	14.81	7
	Hurontario & 401	23944	1298.28	18.44	6
	Square One	20048	336.35	59.60	11
Toronto	Yonge & St. Clair	14653	424.41	34.53	3
	404 & Sheppard	15734	535.83	29.36	2
	Warden & Eglinton	16126	1000.84	16.11	6
	Leslie & 401 - North York General	18485	864.52	21.38	3
	Kipling & Bloor	25768	1607.42	16.03	7
	Don Mills & Eglinton	27142	1698.83	15.98	5
	Yorkdale	27521	1532.27	17.96	7
	Yonge & Eglinton	32058	1151.78	27.83	6
	North York	33694	463.87	72.64	7
	York University	37548	2415.08	15.55	7
	Scarborough Town Centre	45757	2902.80	15.76	14
	DT Toronto North	101144	1488.57	67.95	20
	DT Toronto - Centre	106507	771.77	138.00	11
	DT Toronto - South	220215	1491.26	147.67	29
	AC TOTALS	1355321	73627.80	18.41	333
	TOTALS	2824452	1903576.21	1.48	2194
	AC %	48.0%	3.9%		15.2%

Table 2 - Employment Activity Centres

	Activity Centres	Total Population	Total Acres	Population Density	# of TAZs
Except Toronto & Mississauga	Westney Rd & Hwy 2 - Ajax	32764	1810.89	18.09	6
	Hwy 400 & Major Mackenzie	33556	1888.42	17.77	4
	Bathurst & Steeles	56559	2525.55	22.39	8
	Yonge & Carrville	63522	3480.67	18.25	12
	Warden & Steeles	30888	1443.38	21.40	4
	McCowan & Steeles	75692	3089.12	24.50	6
	Kennedy & Williams	39550	2005.16	19.72	7
	McLaughlin & Steeles	53023	2835.05	18.70	8
	Bramalea	69219	3293.76	21.02	8
	McLaughlin Rd Brampton	63673	3103.71	20.52	8
	Upper Sherman	29211	1708.85	17.09	7
	Centennial & Queenston	27088	1593.72	17.00	7
	DT Hamilton	31032	998.59	31.08	13
	East Hamilton	27846	1282.27	21.72	9
	DT Hamilton - East Side	28506	1075.14	26.51	8
Mississauga	Goreway & Derry	20570	798.29	25.77	4
	Hurontario & Eglinton	27847	948.38	29.36	4
	Hurontario & Burnhamthorpe	27133	543.49	49.92	7
	Hurontario & Dundas	20677	809.98	25.53	7
Toronto	Yonge St South	45272	769.58	58.83	12
	Yonge St - North of College	52127	436.56	119.4	9
	West Toronto - South of Dundas	66960	1242.03	53.91	9
	West Toronto - Dundas to Bloor	47138	1160.31	40.63	9
	Bloor St West	47277	958.23	49.34	7
	Oakwood	45816	1069.03	42.86	6
	Yonge - St. Clair to Eglinton	38659	661.69	58.42	5
	Thorncliffe Park	34083	851.95	40.01	2
	Keele/ Jane & Finch	45065	1333.36	33.8	5
	North York Centre	36118	404.91	89.2	6
	AC TOTALS	1216871	44122.09	27.58	207
	TOTALS	5764963	1903576.21	3.03	2194
	AC %	21.1%	2.3%		9.4%

Table 3 - Population Activity Centres

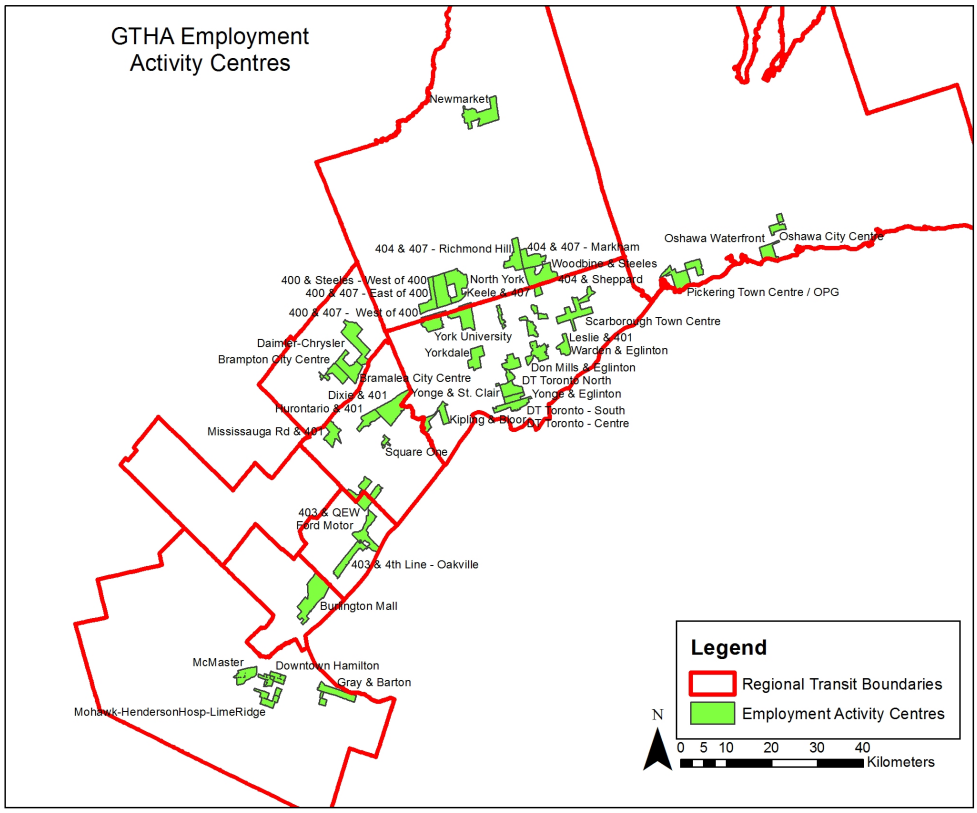

Figure 5 - GTHA Employment ACs

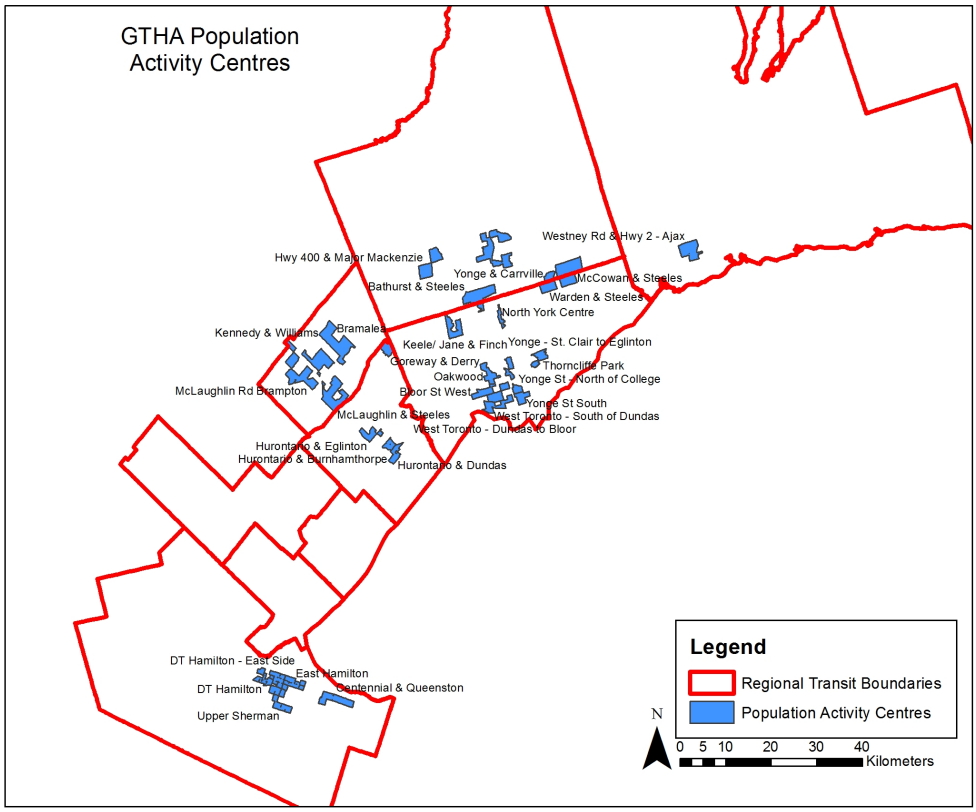

Figure 6 - GTHA Population ACs

Comparison to Mobility Hubs

Metrolinx, as part of their Big Move Regional Transportation Plan, has identified 51 mobility hubs that are significant origins, destinations, or transfer points in the regional transportation system. The vision for these hubs and their surrounding area is to be well connected places to live, work, and play. There are major differences in how mobility hubs and activity centres are defined and identified. Mobility hubs focus on what could be and leverage the current or future rapid transit network while activity centres are a snapshot of where people presently live and work. It is evident in Figure 7 that the two concepts match well; the discrepancies exist where current activity centres have not located near current or future rapid transit.

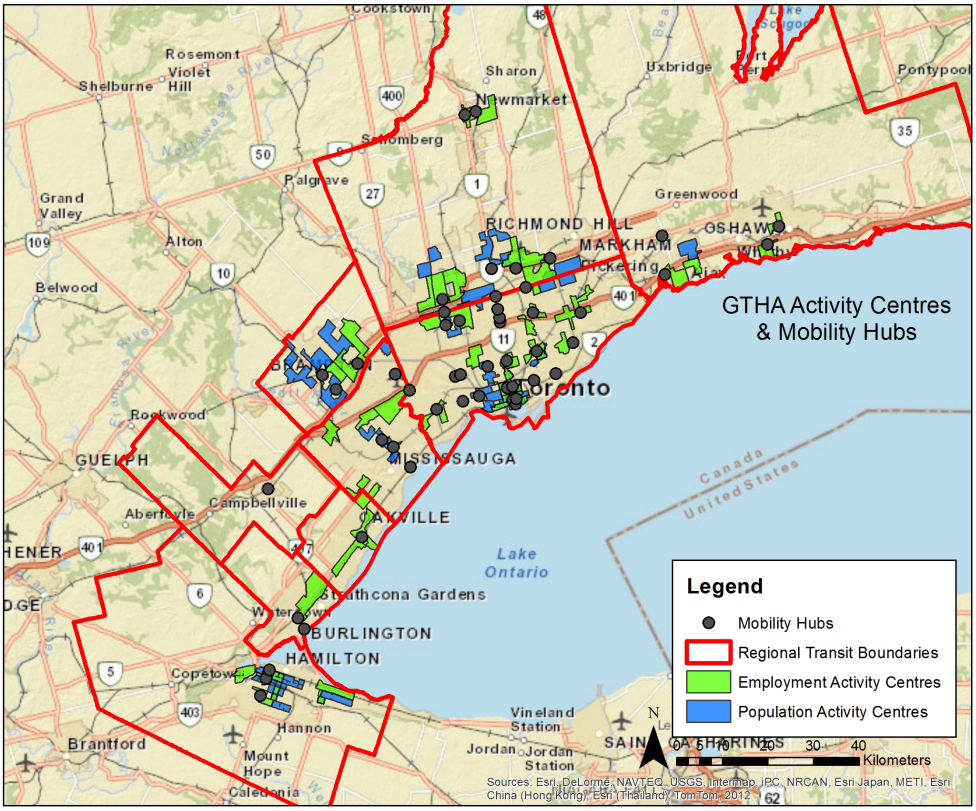

Figure 7 - GTHA Activity Centres & Mobility Hubs

Determining Trip Volumes

A matrix of all origins and destinations was created and populated with TTS data for the peak period between 6 and 9 am. This matrix was expanded to include the travel between employment activity centres because public transit has been

known to compete well against other modes for these trips (Casello, 2007). To visualize the trips taken between activity centres the trip volumes were proportionally plotted as illustrated in Figure 8 below. These flow diagrams will be useful in selecting which trips warrant further investigation. Additional diagrams highlighting trips that have interesting flows are located in Appendix C.

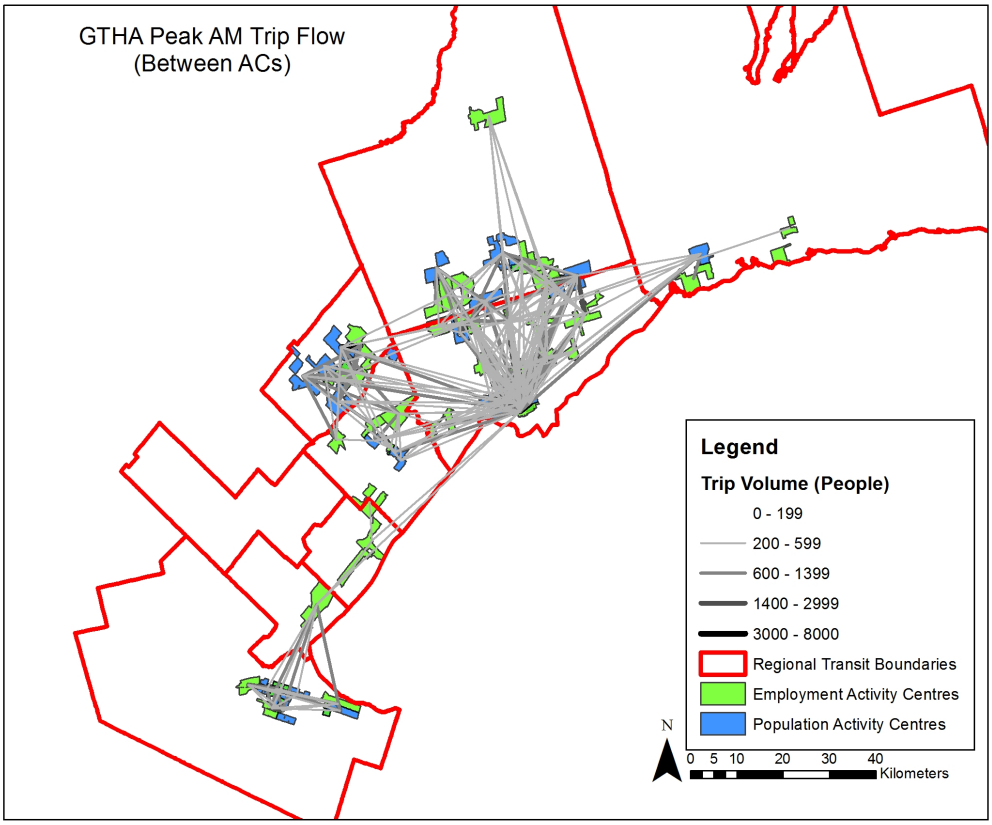

Figure 8 - GTHA Peak AM Trip Flow Between Activity Centres

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