The Impact of Smart Growth Policies on Public Transit Ridership

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1. Introduction

It is generally accepted that since the early 1960s the evolution of urban structure has been mainly affected by the ample use of private automobile (Anderson et al., 1996). Furthermore, there is a fair amount of research that identifies the existence of a significant relationship between urban form and travel behavior (Cervero and Gorham, 1995; Frank and Pivo, 1994; Boarnet and Crane, 2001; Spillar and Rutherford, 1998). Kanaroglou and Scott (2002) define the term of urban form as “the spatial configuration of fixed elements within a metropolitan area”. The concept of travel behavior can be interpreted as the various choices made by travelers (i.e. mode choice) for their various travel actions, under different circumstances. In general, it is argued that the way land uses and transportation networks are organized in urban space affect people’s travel mode choice. According to this approach, a research that investigates the effects of an urban development plan on modal choice could indicate whether this plan is or is not in compliance with the goals of sustainable development, especially when sustainability is the primary goal set by the plan itself.

In 2003, the City of Hamilton adopted the Growth Related Integrated Development Strategy (GRIDS) study design in order to administer the expected growth, which an Ontario projection indicates will occur within Hamilton’s urban area until the year 2031. GRIDS is based on the principles of sustainability and attempts to combine the processes of land use planning, transportation planning and infrastructure investment planning into a unique framework (Dillon Consulting Limited and City of Hamilton, 2006). Hamilton's City Council adopted the growth option that suggests the allocation of 75% of the expected growth to a precisely defined structure of activity nodes and corridors within the existing urban boundary in order to mitigate the urban sprawl process.

The objective of this research is to capture the effects of this urban development plan on the modal split shares in Hamilton CMA during the morning peak period under two different circumstances: a) without any change to the transit's level of service, b) with enhancements to the transit's level of service.

The remainder of this paper is organized as follows. Section two provides an overview on the Hamilton's urban development and modal split shares during the last two decades. Also, it highlights some of the significant factors used to explain the relationship between urban form, transit system and travel mode choice. Section three discusses the methods used to develop the scenarios that were implemented in IMULATE. Section four discusses the results of the simulated policies on the modal shares in Hamilton CMA. Finally, the fifth section provides a conclusion to our study.

2. BACKGROUND

A key characteristic of development in Hamilton over the past two decades has been the growth of suburbs. The urban area expanded into surrounding rural land, where residential and employment growth occurred. Suburban areas such as Dundas, South Mountain, Ancaster etc saw the largest population increases (30%-38%) while West Hamilton, Central Mountain and East Mountain had 20% to 25% decrease. From the employment perspective, there were severe job losses in Downtown, Central Hamilton, Bayfront and West Mountain (17%-24%) while employment growth occurred in the areas where population growth occurred too (City of Hamilton and IBI Group, 2005a). The occurred development was characterized by low densities and based on the use of automobile as basic mode of transportation (City of Hamilton and IBI Group, 2005b). The increased reliance on private automobile, as a result of this urban sprawl process, can be observed from the modal shares of trips during morning peak period. Between 1986 and 2001, local transit's share of total trips decreased from 12% to 6%, while private automobiles share of total trips increased from 74% to 76% (City of Hamilton and IBI Group, 2005b; p.7).

After reviewing the literature, one might argue that there is significant evidence on the observed relationship between urban form, travel behavior and transportation systems. As Taylor and Fink (2003) summarize, there is abundant research on urban form and travel mode choice investigating the role of spatial factors. The findings of these studies indicate that residential and employment densities, mixture of land uses and other urban design methods are important factors that affect travel behavior. Furthermore, as Boarnet and Crane (2001) note, there are many studies that associate factors, such as higher densities, pedestrian "friendly" environments and mixed uses developments, with the reduction in private car dependent travel. In addition, Cervero's and Gorham's (1995) research indicates that neighborhoods in close proximity to transit stations influence the commuting behavior of their residents. Also, an important notion is that of Boarnet and Crane (2001), who discuss that land uses as well as design methods influence travel behavior by altering the cost of travel in terms of speed and distance. In other words, land uses, as well as design methods influence travel behavior by altering the amount of time that travel actors consume for their trips (time-cost of travel). This notion is supported by the argument of Taylor and Fink (2003) that the transit's service coverage and service frequency are factors that significantly influence the choice of transit travel mode.

On the other hand, it is worth mentioning that there is some evidence from the literature that opposes the aforementioned arguments and does not support the existence of a relationship between the urban form and the travel behavior, in general. Frank and Pivo (1994), mention that there are researchers who are "more skeptical of the strength of this relationship".

Clearly, the literature observes that the urban form and the enhancement of a public transit system influence the ridership of transit travel mode. The next question raised is how the transit system could be enhanced. This issue can be addressed from the supply as well as from the demand side. Specifically, from the transit demand side, literature suggests that higher population densities and mixed land uses increase the demand for transit (Cervero and Gorham, 1995; Taylor and Fink, 2003). From the transit supply side, the literature indicates that quality of service is the key issue. The transit Capacity and Quality of Service Manual (Transportation Research Board, 2003) recognizes that "quality of service is quantified by six levels of service for each service measure". The broader groups of service measures are two: a. Availability, b. Comfort and Convenience. Within these broad categories, there are more specific measures available such as Frequency, Hours of Service and Service Coverage for Availability; Passenger Load, Reliability and Transit-Auto Travel Time for Comfort and Convenience. The Level of Service Policy Paper of the Transportation Master Plan for the City of Hamilton (City of Hamilton and IBI Group, 2005c) indicates some typical level of service measures by mode. For the Transit mode typical indicators include: Walking distance to fixed route services, Passenger loads, Travel times, Service Hour and Frequency, Service reliability.

3. METHODOLOGY

Given the implementation of a residential intensification policy, the basic component of the selected "Nodes and Corridors" growth option, which will induce changes to the urban form of Hamilton, this paper searches for possible effects on the population's travel mode choices. It also searches for possible implications to the population's travel mode choices under some hypothetical cases (scenarios) where the "Nodes and Corridors" growth option is combined with some simultaneous enhancements on the transit's level of service.

The research concerns the geographical area of Hamilton Census Metropolitan Area (CMA), Ontario, Canada (see Appendix, Figure 1). The Hamilton CMA includes the newly amalgamated City of Hamilton and the municipalities of Burlington and Grimsby, which are parts of the Halton Region and of the Regional Municipality of Niagara respectively. The variables that will be studied are the shares of travel modes (auto-driver, auto-passenger, transit) for work and school trips within the Hamilton CMA.

The data used for the implementation of this project were collected at five-year intervals and at the level of census tracts. The collected data are: (1) number of new dwellings constructed in each census tract for the periods 1986-1991, 1991-1996 and 1996-2001[1]; (2) the projected number of new dwellings at the aggregated level of the City of Hamilton[2], Municipality of Burlington[3] and Town of Grimsby[4]; (3) GIS data from Desktop Mapping Technologies Incorporated (DMTI).

The research was based on scenario development and implementation within the IMULATE system, which is an operational integrated model for urban land use, transportation and environmental analysis. Specifically, five scenarios were developed and executed. In all scenarios the concept of expected population growth was operationalized with the "number of new dwellings" variable because it is able to reflect the spatial aspect of population growth. Also, the projected total numbers of new dwellings were commonly used in all scenarios but their allocation between census tracts was differentiated for the representation of the different growth patterns. It should be mentioned that because IMULATE operates at the spatial level of census tract and at the temporal level of five years simulation periods all the collected data were adjusted at that levels.

The characteristics of the five scenarios are briefly discussed here. The base case scenario simulates the evolution of the Hamilton's urban system to the year 2031 under the hypothesis that the City of Hamilton, the Town of Grimsby and the Municipality of Burlington will not take any specific urban planning initiative for the accommodation of the predicted growth of their populations; and that the spatial distribution of this growth will follow the past urban development trends. These trends are captured with the method of

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[1] Source: http://dc2.chass.utoronto.ca/census/index.html, Accessed: 29/11/2006

[2] Source: www.myhamilton.ca/NR/rdonlyres/81E38F84-D751-4364-93B7-C8D3D4D23F1E/0/Final_Growth_Report_May2006R.pdf, Accessed: 29/11/2006

[3] Source: www.halton.ca/ppw/planningroads/Planning/PlanInfo/Projections/dm-0301.rpt2.pdf, Accessed: 29/11/2006

[4] Source: http://www.town.grimsby.on.ca/index.php?module=documents&JAS_DocumentManager_op=downloadFile&JAS_File_id=172, Accessed: 29/11/2006

“Moving Window” ratio. Firstly, the average ratio of the number of new dwellings per census tract is calculated for the first three five-year periods, that is, for 1986-1991, 1991-1996 and 1996-2001. Afterwards, this per tract average ratio is multiplied with the next period’s expected total number of new dwellings, and the results represent the next period’s number of new dwellings per tract. Then, a new per tract average ratio of the last three periods is calculated and so on. Finally, all per tract and per period numbers of new dwellings are imported as input data in IMULATE and the simulation is executed.

The next scenario is the “Nodes and Corridors”. It simulates the evolution of the Hamilton’s urban system to the year 2031 under the hypothesis that the City of Hamilton will implement the development plan that was indicated by the GRIDS study; and that the Town of Grimsby and the Municipality of Burlington will not take any specific urban planning initiative for the accommodation of the predicted growth of their populations. Specifically, the GRIDS study specifies a development plan from 2001 to 2031 that allocates the expected 80,000 new dwellings as follows:

1. Residential units of intensification inside the urban boundary: 43,000.
2. Residential units allocated to vacant designated land: 30,000.
3. Residential units in greenfield growth areas: 7,000.

As it is already mentioned, the City of Hamilton plans to direct most of this growth to a defined set of activity nodes and corridors within the existing boundary of the urban area. The GRIDS Growth Report (Dillon Consulting Limited and City of Hamilton, 2006) includes a few maps that provide information about these nodes and corridors. Using these maps, we identified the census tracts that correspond to the nodes and corridors. We also identified the census tracts that correspond to the intensification areas, as well as the census tracts that correspond to the greenfield growth areas (expansion areas, see Figure 2). Dividing the number of new dwelling units to be allocated in each allocation area by the number of census tracts that correspond to these areas we derive the number of new dwelling units that will be allocated per tract and per each simulation period (see Table 1).

Using the Hamilton's Vacant Land Inventory (VLI)[5], which estimates the number of new dwelling units that could be constructed in vacant designated land within the existing urban boundary up to the year 2031, we derive the number of new dwelling units that will be allocated to vacant designated land per census tract and per five year period (Table 2).

Table 1. Dwellings per allocation area, census tract and period

Simulation Periods	Greenfield Growth	Intensification areas
	Units per Tract	Units per Tract
2001-2006	175	83
2006-2011	175	83
2011-2016	263	124
2016-2021	263	124
2021-2026	263	124
2026-2031	263	124
2001-2031	**1,400**	**662**

Table 2. New dwelling units to be allocated in vacant designated land per census tract and per five-year period

Part of Hamilton City	Units per Tract and per Period
Ancaster	83
Dundas	17
Flamborough	163
Glanbrook	530
Hamilton	7
Stoney Creek	81

Based on the Hamilton's Vacant Land Inventory

Finally, because in this scenario we assume that both the towns of Burlington and Grimsby will not take any urban planning initiative, we use for them the data we created and used in the first scenario.

The three last scenarios estimate the induced effects on travel mode choices from the implementation of GRIDS development plan

[5] Source: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PlanningEcDev/LongRangePlanning/InformationPlanning/Vacant+Urban+Residential+Land+Inventory.htm, Accessed: 29/11/2006

in combination with enhancements on the transit's level of service for the simulation periods between 2006 and 2031. In all these scenarios, the forecasted growth is allocated to tracts in a same way with that in the second scenario. The differences are in the way the transit's level of service is handled.

Specifically, in the third scenario it is applied an enhancement on the transit's level of service by a reduction of twenty per cent on the "in vehicle" travel time. That is, the time that one might spend in the bus for a trip is reduced by twenty per cent. This reduction is applied only for trips between specific census tracts, which reflect the nodes and corridors, where the development plan intends to allocate the future growth. The identification of these tracts is based on the maps that the GRIDS Growth Report provides for the "Nodes and Corridors" growth option (see Figure 3). This decrease on the "in vehicle" travel times between these tracts simulates the possible establishment of bus lanes on the road network and/or the future existence of express bus routes. The forth scenario is developed in the same way with the previous one. It incorporates the "Nodes and Corridors" scenario's features (allocation of the number of new dwellings), as well as the twenty per cent reduction on the transit's "in vehicle" travel time between the tracts that represent the nodes and corridors. What differentiates this scenario is that we apply a twenty per cent decrease on the transit's "out of vehicle" travel time between all the census tracts. This reduction attempts to simulate a possible enhancement of transit service frequency for all the existent bus routes. Finally, the fifth scenario incorporates the "Nodes and Corridors" scenario's features in combination with a twenty per cent reduction on both the "in vehicle" and the "out of vehicle" travel times applied between all the census tracts. This scenario attempts to simulate a broader and more intensive enhancement on the transit's level of service.

4. RESULTS AND DISCUSSION

Under the base case scenario, the dominant mode for both work and school trips during the morning peak period is the private automobile. It holds an 87% share of total motorized work trips and a 45-50% share of total motorized school trips for all simulation periods (see Table 3). The transit shares for work trips are estimated as a 3.3% to 3.0% of total work trips and show a decreasing trend over time. On the other hand, transit shares of school trips show an increasing trend over time (8.6% increment between 2001 and 2031) while the auto shares of school trips decrease steadily over time.

Table 3. The Modal Split of the base case scenario

Simulation Periods	**Work trips per mode (%)**			**School trips per mode (%)**		
	Auto	Auto-Passenger	Transit	Auto	Auto-Passenger	Transit
2001-2006	86.9	9.8	3.3	51.7	13.7	34.6
2006-2011	86.9	9.8	3.3	50.8	13.5	35.7
2011-2016	86.9	9.9	3.2	49.5	13.3	37.2
2016-2021	87.0	9.9	3.1	45.3	12.6	42.1
2021-2026	87.1	9.9	3.0	46.9	12.8	40.3
2026-2031	87.1	9.9	3.0	44.5	12.3	43.2

Under the second scenario, we observe the following travel mode share pattern (see Table 4): private automobile dominance for work trips over time with simultaneous low transit shares (between 3.4% and 3.1%). In addition, the transit shares of work trips show a steadily decreasing trend over simulation periods. On the other hand, transit shares of school trips show an increasing trend over time (7.7% increment between 2001 and 2031) while the auto shares of school trips show a decrease of 6.5% over the same period. In essence, what we observe from the results of this scenario is an almost identical modal split with that of the base scenario. This similarity implies that the overall effect of the "Nodes and Corridors" development plan, as it was simulated in IMULATE, on the travel mode choice of CMA's population is weak. The residential intensification policy by itself seems to induce almost no effect on the travel mode choice. This result seems to be in contradiction with what the literature would suggest. As we have mentioned in section 2, changes of the urban form have been observed to affect people's travel behavior. One or a combination of the following arguments might provide an explanation on the above "irregular" result: (1) the way we developed the scenario that simulates the "Nodes and Corridors" development plan does not represent adequately the plan's potential to affect the urban form. This might happened because the available data, which describe how the plan will be implemented in the reality, are not accurate; or because the methodology that we followed in order to develop the scenario using this available data is not able to capture the nature of the development plan. (2) The Grimsby's and especially the Burlington's future growth characteristics interfere with and mitigate the effects of Hamilton's development plan. (3) The "Nodes and Corridors" plan only by itself is not adequate to achieve its demanding goals.

Table 4. The Modal Split of the "Nodes and Corridors" scenario

Simulation Periods	**Work trips per mode (%)**			**School trips per mode (%)**		
	Auto	Auto-Passenger	Transit	Auto	Auto-Passenger	Transit
2001-2006	86.8	9.8	3.4	51.5	13.7	34.8
2006-2011	86.8	9.9	3.3	50.3	13.4	36.2
2011-2016	86.8	9.9	3.3	49.2	13.2	37.6
2016-2021	86.9	9.9	3.2	47.9	13.0	39.0
2021-2026	86.9	9.9	3.2	46.4	12.7	40.9
2026-2031	86.9	10.0	3.1	45.0	12.5	42.5

Examining the results of the third scenario, we derive the Table 5. The modal shares are identical with that of the previous scenario. Although we have reduced by 20% the time that one would spend in a bus for a trip between a tract of a secondary (peripheral) node and a tract of the primary node (or vice versa), we observe almost no effects on the transit ridership.

Table 5. The Modal Split of the third scenario

Simulation Periods	**Work trips per mode (%)**			**School trips per mode (%)**		
	Auto	Auto-Passenger	Transit	Auto	Auto-Passenger	Transit
2001-2006	86.8	9.8	3.4	51.5	13.7	34.8
2006-2011	86.8	9.9	3.3	50.4	13.5	36.2
2011-2016	86.8	9.9	3.3	49.2	13.3	37.5
2016-2021	86.9	9.9	3.2	47.9	13.0	39.1
2021-2026	86.9	9.9	3.2	46.5	12.8	40.7
2026-2031	86.9	10.0	3.1	45.0	12.5	42.5

This might imply either that the 20% is not adequate to increase the attractiveness of the transit system; or that the low ridership of Hamilton's transit system is not resulting only from the travel times that it offers. The low ridership might result from a different reason, i.e. from low service frequency. It should be noted that an in-depth sensitivity analysis testing the ridership of transit system under different levels of service might be able to bring better-established evidence on the aforementioned issue.

From the results of the fourth scenario (see Table 6), we observe that the use of private automobile for work trips is dominant in all simulation periods. In 2001-2006 period auto share is 86.8% and in the next period (2006-2011) reaches the level of 86.4%, reduced by 0.4%. Finally, during the rest periods is stabilized at the level of 86.5%. Simultaneously, the transit share of work trips remains under 4% in all periods. It is interesting that transit shares of school trips show an increasing trend over time (10.8% increment between 2001 and 2031) while the auto shares of school trips decrease steadily over time (8.8% total decrease). Another interesting result is that the transit share of school trips is 2.9% more than the auto share of school trips in the last simulation period.

Table 6. The Modal Split of the fourth scenario

Simulation Periods	**Work trips per mode (%)**			**School trips per mode (%)**		
	Auto	Auto-Passenger	Transit	Auto	Auto-Passenger	Transit
2001-2006	86.8	9.8	3.4	51.5	13.7	34.8
2006-2011	86.4	9.8	3.8	47.8	12.7	39.5
2011-2016	86.4	9.8	3.7	46.7	12.5	40.8
2016-2021	86.5	9.9	3.7	45.5	12.3	42.2
2021-2026	86.5	9.9	3.6	44.1	12.0	43.8
2026-2031	86.5	9.9	3.6	42.7	11.7	45.6

The results of the fifth scenario (see Table 7) show that the use of private automobile for work trips is dominant. In 2001-2006 period auto share is 86.8% and during the next four periods is stabilized at the level of 86.3%, reduced by 0.5%. Simultaneously, the transit share of work trips reaches the level of 4% during 2006-2011, after an increment of 0.7%. This is the highest level the transit share of work trips reached in all scenarios executed in this research. After 2011, transit share has a decreasing trend but it does not fell under 3.7%. On the other hand, transit shares of school trips show an increasing trend over time (13.6% increment between 2001 and 2031) while the auto shares of school trips decrease steadily over time (11.0% total decrease). Interestingly, the transit share of school trips is 2.0% greater than that of auto during the 2021-2026 period and 5.1% than that of auto during the 2026-2031 periods. From the results of the fourth and fifth scenario, one could conclude that the modal split for school trips is more sensitive in the enhancements of transit's level of service than the modal split for work trips.

Table 7. The Modal Split of the fifth scenario

Simulation Periods	**Work trips per mode (%)**			**School trips per mode**		
	Auto	Auto-Passenger	Transit	Auto	Auto-Passenger	Transit
2001-2006	86.8	9.8	3.3	52.8	13.8	33.3
2006-2011	86.3	9.8	4.0	46.8	12.2	41.0
2011-2016	86.3	9.8	3.9	45.7	12.0	42.3
2016-2021	86.3	9.8	3.9	44.5	11.8	43.7
2021-2026	86.3	9.8	3.8	43.2	11.5	45.2
2026-2031	86.4	9.9	3.7	41.8	11.3	46.9

Finally, figure 4 gives an aggregate representation of the scenarios estimations on transit shares of school trips from 2001 to 2031. Specifically, the first scenario (development according to the past trends) appears almost the same or greater shares when compared with the second ("Nodes and Corridors" growth option) or the third scenario.

5. CONCLUSION

The main findings of this research can be summarized as follows: if Hamilton City will not take any action to administer its future growth the travel mode shares of work trips in 2031 will be 87.10% for auto and 3.0% for transit. The travel mode shares of school trips in 2031 will be 44.50% for auto and 43.2% for transit. According to the results of this research, the Development Plan that Hamilton City intends to implement will not have any significant effect on the travel mode shares of work and school trips in the study area. Furthermore, the results of the last two scenarios indicate that the travel mode shares of work and school trips in CMA respond to changes applied on the transit's level of service. Specifically, the 20% reduction on the "in vehicle ", as well as on the "out of vehicle" travel times caused the reduction of auto trip shares up to 0.5% for work trips and up to 11% for school trips. Finally, from these two scenarios we have also observed that the modal split for school trips is more sensitive in the enhancements of transit's level of service than the modal split for work trips.

References

Anderson, W. P., Kanaroglou, P. S., Miller, E. J., (1996). Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy. *Urban Studies.* 33, 1: 7-35.

Boarnet, M. and Crane, R., (2001). The Influence of Land Use on Travel Behavior: Specification and Estimation Strategies. *Transportation Research.* Part A, 35: 823-845.

City of Hamilton and IBI Group, (2005a). Development of Policy Papers for Phase Two of the Transportation Master Plan for the City of Hamilton: BACKGROUND ON LAND USE AND TRAVEL PATTERNS POLICY PAPER. Final Report. Hamilton.

City of Hamilton and IBI Group, (2005b). Development of Policy Papers for Phase Two of the Transportation Master Plan for the City of Hamilton: TRANSPORTATION MODAL SHARE TARGETS AND TRANSIT STRATEGIES POLICY PAPER. Final Report. Hamilton.

City of Hamilton and IBI Group, (2005c). Development of Policy Papers for Phase Two of the Transportation Master Plan for the City of Hamilton: LEVEL OF SERVICE POLICY PAPER. Final Draft. Hamilton.

Cervero, R. and Gorham, R., (1995). Commuting in Transit Versus Automobile Neighborhoods. *American Planning Association. Journal of the American Planning Association.* 61, 2: 210-225.

Dillon Consulting Limited and City of Hamilton, (2006). Growth Related Integrated Development Strategy: Growth Report. Hamilton.

Frank, D. L. and Pivo, G., (1994). Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant

Vehicle, Transit, and Walking. *Transportation Research Record 1466.*

Kanaroglou, P.S. and Scott, D.M., (2002). Integrated Urban Transportation and Land-Use Models for Policy Analysis. In M. Dijst, W. Schenkel and I. Thomas eds. *Governing Cities on the Move.* Aldershot: Ashgate Publishing Limited.

Spillar, R. J. and Rutherford, G. S., (1998). "The Effects of Population Density and Income on Per Capita Transit Ridership in Western American Cities." Institute of Transportation Engineers' Compendium of Technical Papers: 60th Annual Meeting, August 5-8, 327-331.

Taylor, B. and Fink, C., (2003). The Factors Influencing Transit Ridership: A Review and Analysis of the Ridership Literature. Berkeley, CA: University of California Transportation Center.

Transportation Research Board of National Academies, (2003). Transit Cooperative Research Program: TCRP Report 100. Transit Capacity and Quality of Service. 2nd Edition. TRB, Washington D.C.

Appendix

Figure 1

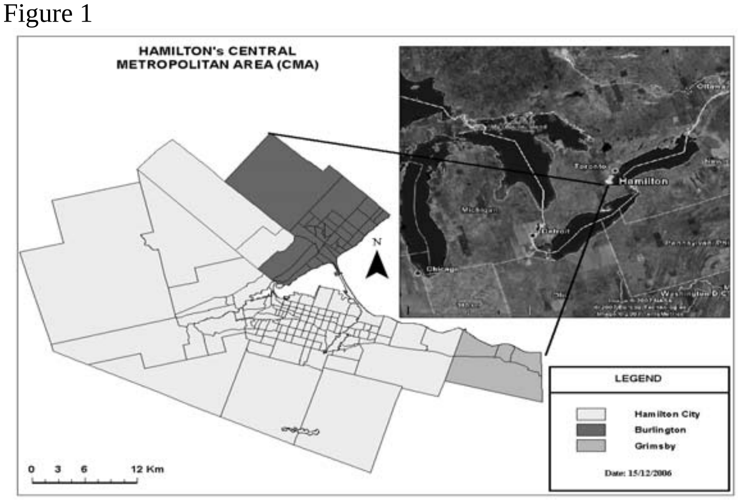

Figure 2

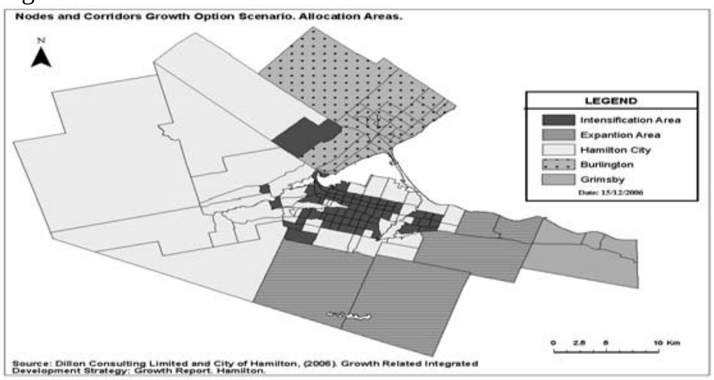

Figure 3

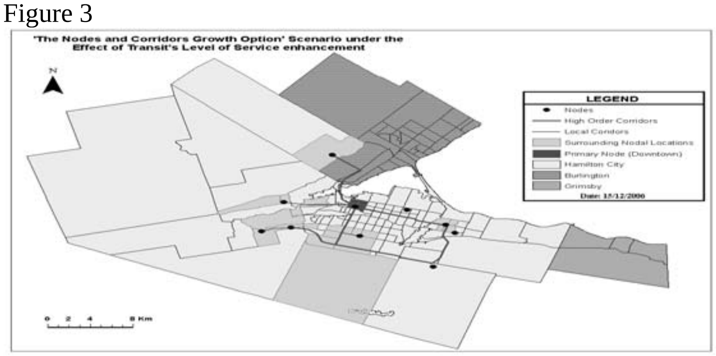

Figure 4