The Urban Metabolism of the Greater Toronto Area

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All work presented in this package is my own, and all research is appropriately referenced.

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Subject: The Urban Metabolism of the Greater Toronto Area

1.0 Introduction

Urban metabolism is defined as a comparison of the energy-matter flows of cities and organisms. An urban metabolism study for the Greater Toronto Area (GTA) was conducted in 2003 and illustrated changes in inputs and waste between 1987 and 1999.

The Greater Toronto Area consists of five regions - Durham Region, Halton Region, Peel Region, York Region and the City of Toronto. These five areas are home to 5.5 million residents in 2011 with an average population density of 1217.78 people/km^2[1]. Located in southern Ontario, it is bordered by Lake Ontario to the south, the Niagara Escarpment to the west, and Lake Simcoe to the north. The region boasts a total area of 7100 km^2[1]. It has a grid road network. Major infrastructure is highly concentrated in the southern end of the area along arterial roadways, such as the subway lines and high-rise buildings. A map of the City of Toronto is attached in Appendix A.

The GTA suffers from urban sprawl - there are hectares of land dedicated to detached housing, supported by road networks accessible only by car. This leads to increased car use, leading to yearly emissions of 16.4 tonnes carbon dioxide and a 27% change from 1987[2]. This in turn increased average temperatures slightly. The basic climate of the GTA are cold winters coupled with humid summers[2]. A range of average temperatures go from -4.5°C in January to 22.1°C in July[3].

The population of the area has grown in the past fifty years. This was caused by immigration, the baby boom generation, and the baby boom echo. To accommodate this, there was an increase in resource consumption, such as fuel, water, food, and raw materials.

These factors all affect the urban metabolism of the GTA. An increase in resource consumption is coupled with an increase in waste production. The GTA has diverted some solid waste as outputs and recycling them, leading to a 11% drop in solid waste[2]. Water is cycled through treatment facilities and reused before final decontamination and drainage into Lake Ontario, but there was still a 4% increase in wastewater disposal[2]. More and more electricity, a 20% change from 1987 to 1999[2], is being used to redirect waste and to provide power to homes in the GTA. Most raw materials are extracted from areas of some distance to the GTA, requiring frequent truck traffic to transport them to destinations, further contributing to greenhouse gas emissions.

Unfortunately, the grid network and major infrastructure design is responsible for the most negative outputs in the GTA. The poor transportation options provided by public transit makes the car the better option to commute from low-density sprawl[2]. Coupled with the transportation network, the climate's occasional production of undesired weather contributes to traffic issues. This requires resources to clean up, increasing fuel needs and creating more emissions.

2.0 Inputs and outputs of the Greater Toronto Area

An overview of the inputs and outputs for the year 1999 is entailed in Appendix B.

3.0 Urban Infrastructure Improvements

One of the biggest waste products in the urban metabolism of the Greater Toronto Area are greenhouse gases. An estimate of 83000 kilotonnes of carbon dioxide was expelled into the atmosphere from the GTA in 1999[2]. There are many examples of poorly designed transportation infrastructure. An example is the lack of transit-oriented road design, forcing transit systems to create better bus service in heavy traffic conditions.

3.1 Bayview-Steeles Intersection Case Study

There are many intersections where transit is second to the car, which contributes to heavy traffic. An example is Bayview Avenue and Steeles Avenue East. Steeles Avenue is situated on a bridge, which prevents expansion from a 4-lane to a 6-lane road[4]. Traffic frequently backs up due to the frequency of the signals and frequent Toronto Transit (TTC) bus pickups and alightings (the westbound and eastbound bus stops at Bayview and Steeles are served by all 53-Steeles East branches). Figure 3.1 shows the locations of the stops[4].

Figure 3.1: The existing locations of the eastbound and westbound stops for route 53-Steeles East, relative to the Bayview-Steeles intersection. The stops also serve York Region Transit route 91-Bayview.

The stops appear to be location to maximize passenger transfers to the TTC route 11-Bayview (which stops in the loop located north of the westbound bus stop and the stop just south of Steeles Avenue), but such that traffic behind the bus must stop, increasing idling time and backing traffic up to the Bayview-Steeles intersection to the east and Conacher Drive to the west. here are solutions to reduce vehicle idling time and allow similar passenger movement.

A solution is to move the stops into their own lanes. This is quicker to build for the westbound stop as its surrounding area is occupied by land of the same grade and is unoccupied. This will prevent the amount of vehicles behind the bus from building up and open the existing outside lane to continuous traffic. The eastbound stop, which is placed on a bridge, cannot simply be placed into another lane due to the costs of reconstructing a bridge. To facilitate better traffic flow at this stop, it can be moved east of the intersection. The boulevard is wide enough to allow an extra lane and is currently occupied by grass. However, it may be dangerous to have buses maneuver in front of a dedicated right turn lane. Better signage will assist in preventing collisions. Pedestrians will have to cross Bayview Avenue in order to transfer to southbound 11-Bayview buses, but this is similar to the existing setup where they must cross Steeles Avenue to access the bus loop.

Figure 3.2: A possible addition of a dedicated right turn lane from Bayview, which allows buses to stop on the east side of the intersection. The grey lines indicate existing infrastructure, and black lines are proposed additions[4].

3.2 Other Traffic Improvements

There are other ways to allow vehicles to pass through intersections quickly[5]. For transit, one method is to move bus stops after the intersection to bypass traffic lights. Another method is to have fare payment off-vehicle, seen on the Viva bus system[6], to allow all-door loading. An example of a fare payment machine is seen in Figure 3.3.

Figure 3.3: An off-vehicle fare collection system[6].

Some streetcar stops have an attendant to check fares. This allows rear door boarding and it is seen to have positive effects on loading times[5]. However, it will require constant patrolling of vehicles to ensure fare payment. Another idea is transit signal priority. Transit signal priority is used by the TTC to either delay green lights until the transit vehicle passes the intersection or to stop green signals on intersecting streets[5]. All buses in the TTC fleet are equipped with signal priority devices, but the required traffic light infrastructure is only in place along five bus routes and most streetcar routes[5]. This should be expanded to the routes with higher ridership and traffic-heavy corridors. Other examples are queue-jump lanes (extended right turn lanes) which allow buses to reach nearside stops without being stopped behind a line of cars on the outside lane[5]. An example of a queue jump lane could be employed at the Don Mills-Steeles intersection, as in Figure 3.4.

Figure 3.4: An example of a queue-jump lane along Steeles Avenue East at Don Mills[7]. The proposed lane is in black.

These transit modifications improve traffic circulation in suburban intersections, where traffic is high in the peak direction. They are fairly low in cost compared to other capital improvements such as the construction of rapid transit lines. By giving transit priority, private vehicles actually benefit as well by lowering idling times (a leading cause for greenhouse gas emissions) and decreased traveling times.

A temporary solution would be to synchronize all parallel traffic signals with each other. This reduces idling time and improves vehicular flow in the peak direction of arterial roads[8]. However, over time, car use is likely going to increase with the recent service cuts to transit[9], which will add traffic to roads. As traffic increases, cars will eventually build up and cause backups, especially in areas with traffic signals in close proximity.

These solutions are highly applicable to suburban arterial streets in the GTA, where there is ample space along the edges of roads for transit improvements.

4.0 Urban Metabolism Metaphor

Urban metabolism is described as a metaphor between the vitality of urban areas and the vitality of an organism. Urban areas and organisms do have their similarities. An organism can be defined as a self-sustaining life form. In this regard, it is easy to see that both urban areas and organisms both take inputs (organisms in the form of food, cities in the form of resources) and return them as a form of waste.

However, this metaphor is not very strong. An organism has set processes for resources and ignores other factors. Cities are dependent on the functionality of its design and its population, where every person affects its health and vitality. An organism is responsible for itself and is already makes use for every single input that it receives. It may apply better to only one portion of a city, such as the residents themselves. This metaphor is weak in that it is based only on inputs and outputs. Therefore, is it better to have an urban metabolism model built on a parallel between cities and natural systems?

This metaphor is also not very strong. While it does account for its surroundings, known as the 'butterfly effect', natural systems will override the actions of its users. A simple example is a natural disaster, such as a tornado. No matter what something does to defend itself from the tornado, it will still wreak havoc. In a city, the actions of its planners and residents affect its health and vitality. A simple example is a city that produces its own goods and a city that ships goods in from other places. A city that produces its own goods will have a healthier economy because people are working for themselves, while there are increased inputs and outputs in the alternate scenario. Ultimately, the second city would fail and cease to live. Natural systems will keep on going regardless of its residents. In a way, this is similar to political reigns in Toronto; it would appear that the mayor would like to do as he pleases without a care in the world. So what kind of metaphor would be best for urban metabolism?

The comparison of an urban area and an ecosystem is better. Ecosystems are places where living organisms work together to build a livable environment. Both areas are dependent on its residents - for the city, it would be the people, and for ecosystems, it would be the various animals, fauna, microorganisms, etc. that decide its future. Both areas have a comparable inputs and outputs, such as food, water, and solid waste. Both areas also illustrate the different types of nodes that animals and people need. For example, animals may live closer to water for food and drink, while people may live closer to their place of work to maximize efficiency. Both scenarios consider the different needs of its occupants and show the parallel between people and nature; for example, how people use technology to reuse solid waste, while it is revived as new ground material in ecosystems. It gives us a good sense of our sustainability, of which Toronto is becoming a world leader[2]. This comparison provides engineers with ideas of how to dispose of our waste or ways to benefit the local economy while improving the metabolism of our city.

Both metaphors are good in their own ways, but the ecosystem metaphor is more sensible. Ecosystems are much more of a living environment than a natural system.

5.0 References

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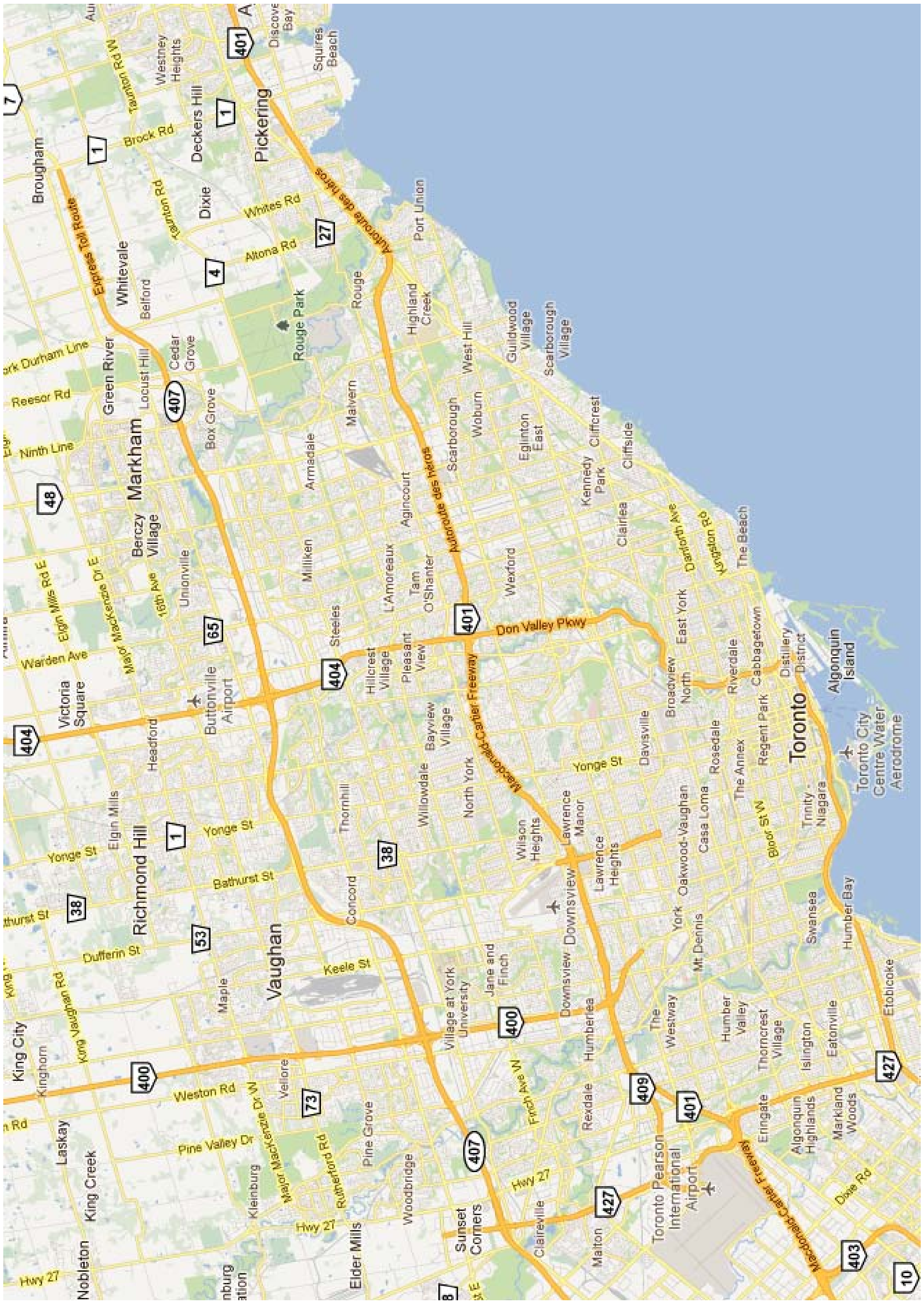
Appendix A: Map of Toronto[10]



The map also shows some of the surrounding area, such as York Region and Durham Region. The grid road network (excluding highways) is visible.