

Mapping Cycling Behaviour in Toronto



The **second** report in a series examining cycling behaviour, social and civic infrastructure and cycling economies in Toronto

www.torontocycling.org

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The Project

The Toronto Cycling Think & Do Tank is a multi-disciplinary, multi-sector research project focused on increasing cycling for transportation. Funded by a Social Sciences and Humanities Research Council of Canada (SSHRC) Partnership Development Grant, this diverse research group is studying, applying and evaluating three elements critical to reinforcing urban cycling as a significant transportation choice: sustainable cycling economies; social and civic infrastructure; and knowledge mobilization. With this initiative, principal investigator Beth Savan, a veteran University of Toronto School of the Environment researcher, has built a coalition of expert practitioners and academics to address an important gap in knowledge about creating more sustainable cities: how experience from the behavioural change field (applied extensively to building occupants) can be successfully adapted and used in the field of active transportation.

Executive Summary

In this study, the second in our research series, we examined evidence of cycling behaviour as it plays out spatially across Toronto's 44 municipal electoral wards. This is a retrospective study using Transportation Tomorrow Survey data from 2006. Our findings suggest higher rates of cycling are complex and reflect more than single parameters. Factors influencing higher rates of cycling in Toronto can be categorized into four areas: 1) who cycles; 2) how they cycle; 3) land use and urban form; and 4) topography. The first three categories are malleable to differing degrees, while topography is a fixed factor.

Within these four areas we identified eight key factors which together, seem to provide significant insight into much of the cycling participation in Toronto. Age and sex (who); trip length and trip frequency (how); population density, destination density and cycling service facility density (land use and urban form); level terrain (topography). Given that hills are essentially permanent features of the landscape and the urban form that favours the short trips preferred by cyclists cannot be created quickly, the factors mentioned in this analysis should be key considerations for determining suitable sites and populations for behavioural interventions and possibly infrastructure installation.

Our findings suggest higher rates of cycling in Toronto are created through a combination of complex conditions. Focusing on these factors will help us direct behaviour change programs to: people most likely to cycle; taking trips under 5 km; that would be viable by bicycle; in areas with medium to high population density; high destination density; and medium to high cycling service facility density; in regions of the city with relatively level terrain.

We found no identifiable relationship between higher cycling rates and the consolidated Bike Score™ for Toronto which combines three equally weighted components: bike lanes (including route density and separation); terrain; and destinations and road connectivity to produce a rating of the physical suitability of an area for cycling. Nor did we find a direct relationship between higher cycling rates and population density.

Through this research, we sought to identify key locations where physical factors being roughly equal (physical barriers, available infrastructure, density of destinations), cycling participation nonetheless varied significantly. The project's first report, **A Tool Kit to Accelerate the Adoption of Cycling for Transportation** (Cohlmeyer, 2012), examined the behaviour change literature as it relates to cycling. Interventions, designed to change individual behaviours over time, use a series of evidence based tools developed by social psychologists, such as prompts, pledges, peer support, reciprocity and positive feedback, as well as identification and removal of barriers. The behaviour change literature emphasizes the necessity of strategically segmenting target populations and identifying barriers to change (Gatersleben, & Appleton, 2007; Davies, 2013).

A key goal of this report is to examine cycling participation in Toronto in order to strategically segment target populations and identify barriers to change. It aims to refine the limited knowledge we have about cycling and cyclists in Toronto in order to determine the most effective locations and target groups for behavioural interventions to increase the use of cycling for transportation. Behaviour change interventions need to take into account the necessary background conditions (land use, urban form, infrastructure and terrain) while bearing in mind the demographic groups most likely to cycle.

Introduction

Evidence from around the world, particularly the Netherlands, Denmark and Germany, indicates three crucial elements interact, in a powerful way, to foster cycling as a healthy, clean, efficient transport mode. These elements are urban design including infrastructure, as it favours or limits cycling trips by diverse users; urban rules and policies, ranging from speed limits, responsibility in the event of accidents, through traffic calming and requirements for short-and long-term cycle parking; and accepted norms of behaviour, including the social infrastructure that supports cycling culture.

For the purpose of this research, the team has initially defined "social infrastructure" as the components of individuals' social relations and personal values, attitudes and behaviours that predispose people to adopt new patterns of behaviour. It could include elements such as activities making cycling conspicuous and appealing, ongoing community and commercial support to overcome barriers to cycling, cycling education programs for youth, etc. To date, most high profile methods to encourage modal shift towards active transportation and cycling have focused on physical infrastructure.

In a complex policy environment, the role of cycling in city transport systems is often lost in rhetorical debates, leaving cities like Toronto lagging behind other urban centres, which have fast-tracked cycling infrastructure (see Appendix G), due to its multiple benefits for all city users (see section 4 Background). Despite a lack of significant investment (Toronto completed less than half of its planned kilometres of cycling infrastructure between 2001 and 2011) cycling for transport is on the rise in Toronto, revealing substantial demand for more options of this nature. Toronto residents give cycling amenities the worst rating out of 20 city services. Moreover, just 32% consider cycling facilities irrelevant to their satisfaction with city life, while 68% consider cycling facilities relevant (City of Toronto Planning Division, 2012). Given cycling's low mode share, these data suggest pent up demand that may be released by infrastructure improvements. We suspect there is a wide variation in the level of preparedness for behaviour change. There is strong evidence that change is a sequential process over time (Gatersleben & Appleton, 2007) and social infrastructure plays an important role.

From 2001 to 2006, the number of Torontonians cycling grew by more than 30% (Toronto Public Health, 2012) and it has continued to grow since (Planning Department, City of Toronto, 2012; Transportation Services City of Toronto 2010; City of Toronto (Ipsos Reid), 2009). Though the physical environment is often cited as the main determinant of cycling behaviour (Mitra & Buliung, 2012; Forsyth & Krizek, 2010; Frank & Engelke, et al, 2003; Frumkin & Frank, 2004; Saelens et al, 2003), the maps in this report demonstrate that there are also other significant factors at work. In wards with very similar physical infrastructure and urban environment, we see substantial differences in levels of cycling. It is important to note, Toronto's physical infrastructure for commuter cycling ranges from weak to non-existent, creating an unusual opportunity to observe the influence of other factors. The data lend support to the assertion that land use and urban form, social infrastructure and cultural factors play an important role in influencing transportation habits.

1 Research Questions

In this part of our research, we focused on the following four questions:

1.1 Who cycles in Toronto?

How do cyclists compare to non-cyclists, in Toronto? What are the main characteristics of cyclists in terms of age, sex, location of residence and work or study?

1.2 What characterizes cycling trips?

What distances do cyclists travel and what is the frequency of daily trips? Where are common destinations located?

1.3 What factors are associated with higher proportions of cycling trips?

Are population density, destination densities, cycling services, terrain and cycling infrastructure related to cycling participation in Toronto?

1.4 Do some municipal wards show behavioural differences? Are they attributable to socio-cultural aspects of the population, physical barriers or facilitating factors?

We then analyzed the data and considered a fifth question:

1.5 What factors should we consider when selecting target sites and populations for behavioural interventions?

2 Cycling in Toronto: Findings

This section of the report examines key findings, based on the data available for Toronto, as they relate to the four research questions posed above.

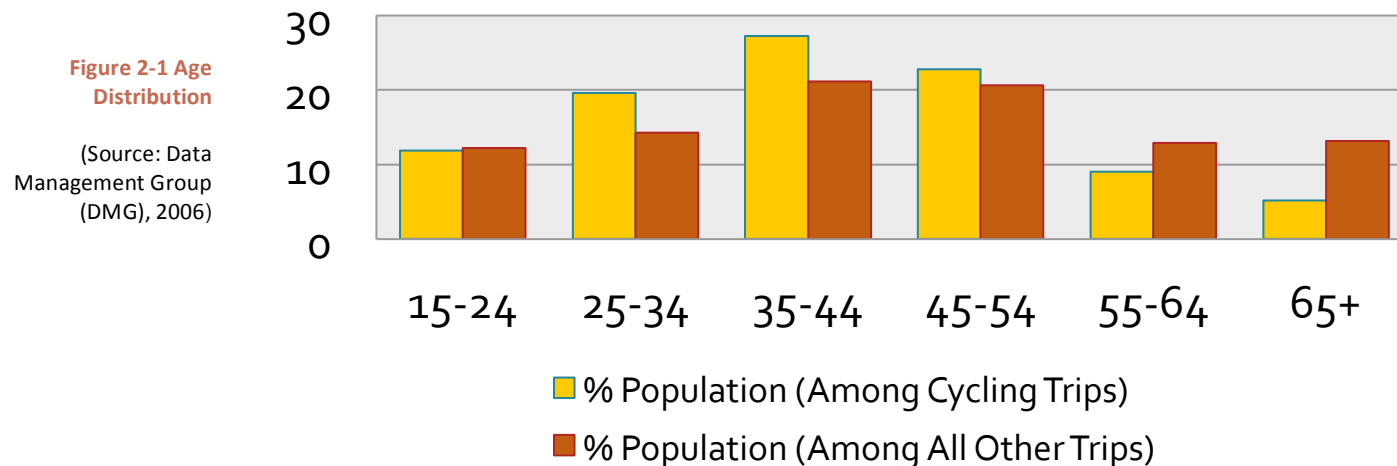
2.1 Question 1: Who cycles in Toronto?

Do Toronto's cyclists, compared to Toronto's non-cyclists, exhibit any particular demographic characteristics? What are the main characteristics of cyclists in terms of age, sex, location?

2.1.1 Age:

Of the population aged 15 and over, those between 25 and 54 years of age account for 59% of the population but 73% of cycle trips. There is a lower frequency of travel by cycle among adults over 55 years of age. The age group responsible for the greatest number of cycling trips is the 35-44 year old bracket. The data for the 15-24 year old age segment shows a roughly similar proportion of cycling to other mode trips (see data limitations Appendix C).

Age Distribution of Trips Taken



2.1.2 Location:

Location plays a significant role in determining cycling participation. We examined the data by municipal electoral ward in order to refine our knowledge of where cycling occurs in Toronto. Cyclists tend to live and work in the central areas of the city. Cycling mode share ranges from extremely low (less than 1%) on the city's outer edges, to relatively high rates for North America (7.5% in Ward 19) in the city centre, with an average across the city of 1.3%. The four western lakeshore wards 14, 18, 19 & 20 create a cluster with high cycling mode share. Low sample sizes in combination with low cycling mode share in the far western and eastern edges of the city create a lack of statistical validity, therefore those regions were excluded from our analysis. (See Appendix A)

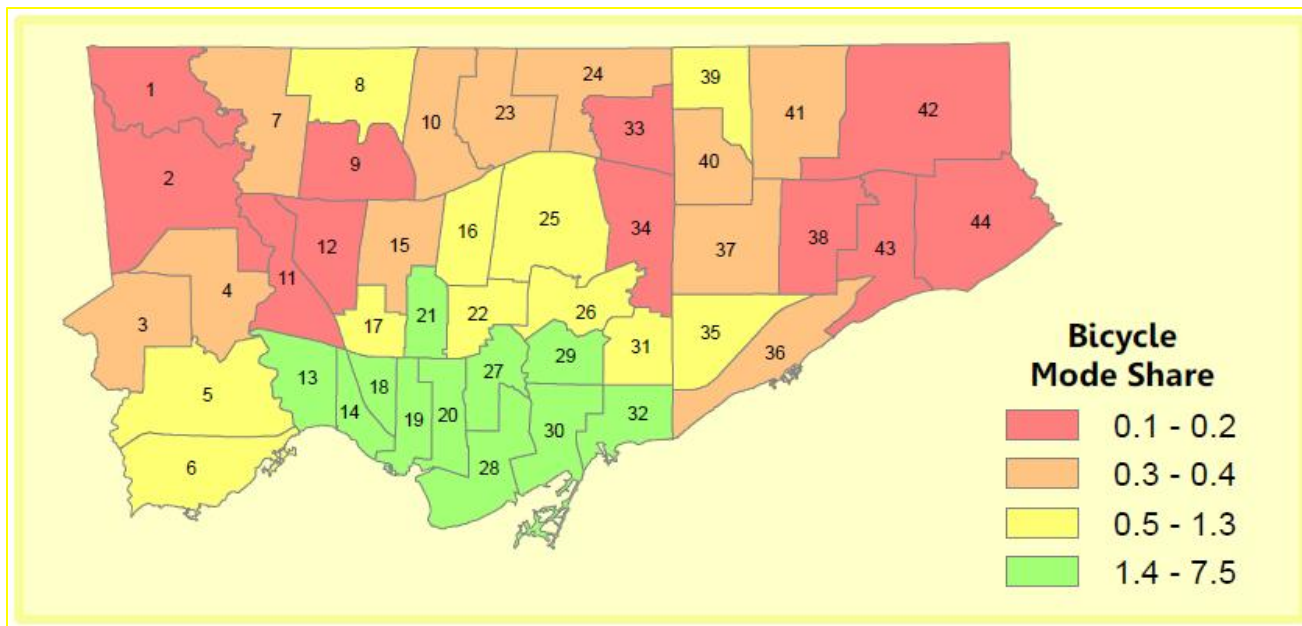


Figure 2-2 Bicycle Mode Share by Ward-Watt (Data sources: City of Toronto Open Data 2012 & DMG, 2006) See page 15 for ward information.

Given the pattern in Figure 2-2, we created a group of 14 “focus wards” seen in Figure 2-3 in order to better identify areas with higher cycling mode share. Within the focus wards, we found significant variation in cycling participation by ward.

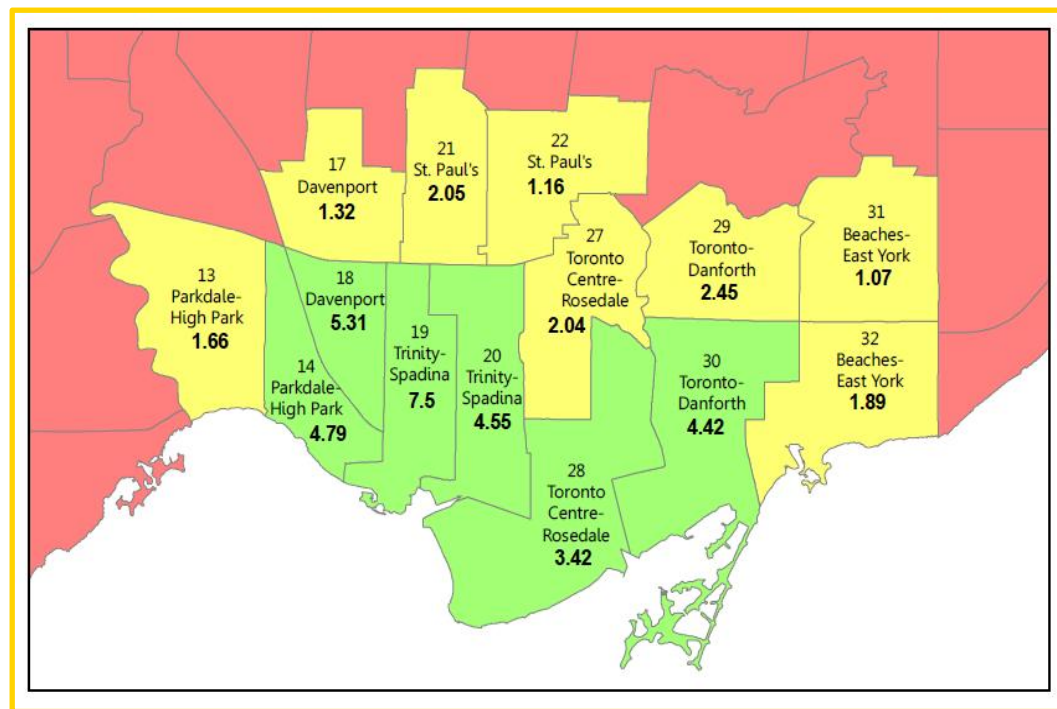


Figure 2-3 Bicycle Mode Share by Focus Ward-Watt
(Data sources: City of Toronto Open Data 2012 & DMG 2006)

Our data sources for the maps are from 2006. There is strong evidence that cycling participation in Toronto has increased since then (Transportation Services City of Toronto 2010; City of Toronto (Ipsos Reid), 2009). A recent survey by Toronto’s planning department “Living in Downtown and the Centres Survey” (City of Toronto, 2012) places the cycling mode share for the entire central city at 7.5%, a significant increase from the 2006 data of 3.1% for our focus wards which have a similar geography. The 2012 data is not refined by ward so we do not know for certain if the participation pattern by ward has continued. Transportation Tomorrow (DMG) completed a new survey in 2012. When those data are released, they will provide insight into where changes have occurred.

Ward Table: Much of this research is based on the 44 municipal electoral wards in the City of Toronto. In Toronto, each of these wards is one of a pair that makes up a federal electoral district of which there are 22. Thus, the names of the wards are duplicated although the numbers are not. I.e. Wards 21 & 22 are both named St. Paul’s and Wards 29 & 30 are both named Toronto Danforth. Consequently, we tend to work with Ward numbers rather than names.

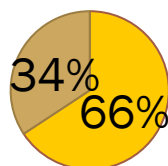
Ward #	Ward Name	Ward #	Ward Name
1	Etobicoke North	23	Willowdale
2	Etobicoke North	24	Willowdale
3	Etobicoke Centre	25	Don Valley West
4	Etobicoke Centre	26	Don Valley West
5	Etobicoke Lakeshore	27	Toronto Centre-Rosedale
6	Etobicoke Lakeshore	28	Toronto Centre-Rosedale
7	York West	29	Toronto-Danforth
8	York West	30	Toronto-Danforth
9	York Centre	31	Beaches-East York
10	York Centre	32	Beaches-East York
11	York South-Weston	33	Don Valley East
12	York South-Weston	34	Don Valley East
13	Parkdale-High Park	35	Scarborough South-west
14	Parkdale-High Park	36	Scarborough South-west
15	Eglinton Lawrence	37	Scarborough Centre
16	Eglinton Lawrence	38	Scarborough Centre
17	Davenport	39	Scarborough Agincourt
18	Davenport	40	Scarborough Agincourt
19	Trinity-Spadina	41	Scarborough Rouge River
20	Trinity-Spadina	42	Scarborough Rouge River
21	St. Paul’s	43	Scarborough East
22	St. Paul’s	44	Scarborough East

Figure 2-4 Toronto Ward #s and names

2.1.3 Sex

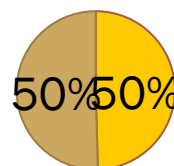
On average across the City of Toronto, two of every three cycling trips are taken by men.

Cycling Trips



■ Male
■ Female

All Other Trips



■ Male
■ Female

Figure 2-5 Sex of Cyclists in Toronto (Source-DMG, 2006)

The average, however, conceals wide differences in female participation among focus wards. Especially striking is the strong correlation between a high proportion of trips by female cyclists, and a high cycling mode share in downtown focus wards. In Ward 17, which has a low 1.3 % cycling mode share only 11.4% of cycling trips were taken by females. However, in Ward 19, which has the highest cycling mode share (7.5%), females took 47.5% of cycling trips.

When we examined all trips (by all methods) in all wards, the difference between the ward with the highest and the ward with the lowest %female trips is only 8.5%. In the lowest %female trips ward, 46.9% of all trips are completed by females, and in the highest %female trips ward, 55.3% of all trips are completed by females.

Focus Ward #	Ward Name	Cycling Mode Share %	Proportion Cycling Trips by females
19	Trinity Spadina	7.5	47.5
18	Davenport	5.3	46.3
14	Parkdale-High Park	4.8	42.0
20	Trinity Spadina	4.6	31.3
30	Toronto Danforth	4.4	37.3
28	Toronto Centre-Rosedale	3.4	29.6
29	Toronto Danforth	2.5	35.5
21	St. Paul's	2.1	35.9
27	Toronto Centre-Rosedale	2.0	30.0
32	Beaches East York	1.9	28.7
13	Parkdale-High Park	1.7	48.9
17	Davenport	1.3	11.4
22	St. Paul's	1.2	33.8
31	Beaches East York	1.1	19.0
	Focus Ward Average	3.1	34.1
	City	1.3	34%

Figure 2-6 Per cent cycling trips by females (Data Sources- City of Toronto Open Data 2012 and DMG, 2006)

2.1.4 Other characteristics of cyclists

Other distinct characteristics of cyclists are difficult to determine from the available data. Students have slightly higher cycling participation than other identified occupations (24% of students are cyclists compared to 20% of others). Cyclists are slightly less likely to have a driver's license than those who do not cycle (74% of cyclists have a driver's license while 77% of non-cyclists have a driver's license). Nonetheless, it is clear that having a driver's license is the norm and the vast majority of cyclists have one (DMG, 2006: Appendix B).

We conducted an extensive examination of the 2006 Census by ward to determine if the wards with higher percentages of cycling participation demonstrated any significant demographic differences from the wards with lower rates of cycling participation. The most significant finding was that demographic details such as education level, property ownership, immigration status (recent immigrant, 1st generation, 2nd generation, 3rd generation), ethnicity, and families with children had no identifiable relationship to cycling participation when examined on a ward basis. There was a very weak correlation between wards with a high proportion of residents with no English or French language skills and higher cycling participation and again, a very weak correlation between wards with lower average household incomes and higher cycling participation. Nonetheless, in each of these cases, there were examples of wards with similar demographic characteristics and radically different cycling participation rates. Of course, we are unable to tell from these data whether the cyclists are representative of the ward population or not. (All City of Toronto Open Data 2012 based on Statistics Canada, 2006 Census)

2.2 Question 2: What characterizes cycling trips?

2.2.1 Distance

A key characteristic of cycling trips is that the majority are less than 5 kilometres long. In Toronto, 74% of all cycling trips are under 5 km, and the average trip distance is 4.2km. Even wards with low cycling participation rates have a large proportion of trips under 5km in length. The average cyclist travels a total of 9.3km per day.

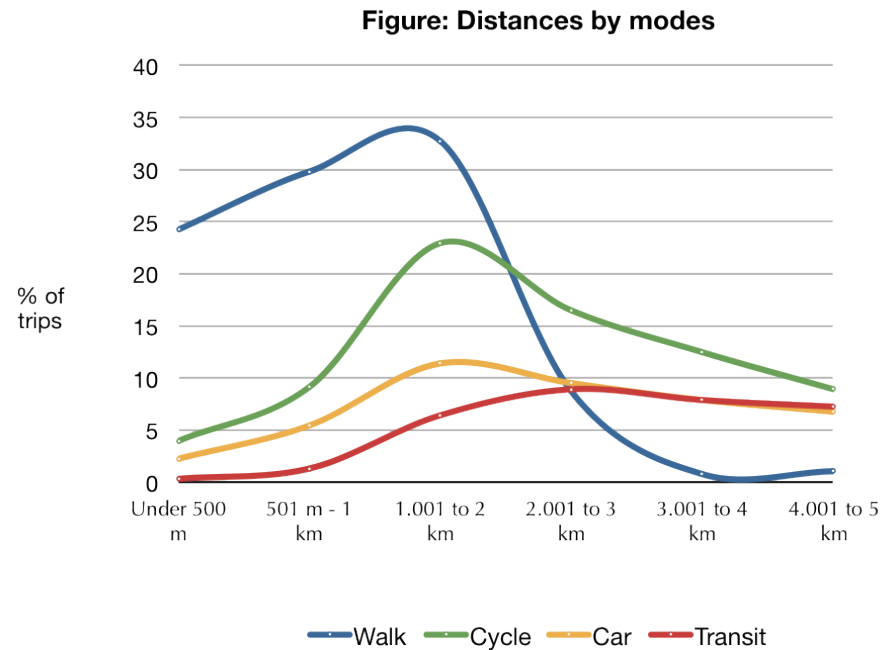


Figure 2-7 Distances by modes in Toronto (Data source: DMG, 2006)

When we break the average trip distance down by ward, we again find a relationship between shorter trip distances and higher cycling participation but not an exact correlation. For example Wards 14 and 18 have cycling mode shares of 5.3 and 4.8 respectively-the second and third highest cycling mode shares by ward, yet their average trip distance is longer (5.0km and 3.5km) than Wards 27 and 28 which have respective mode shares of 2.0 and 3.4 and average trip distances of 2.4km and 2.8km. The most central downtown wards, which are also those within the 5 km. radius of highest destination density (see Fig. 2.11. below), do seem to have the shortest trip distance.

Average Cycling Trip Distance in Toronto by Ward

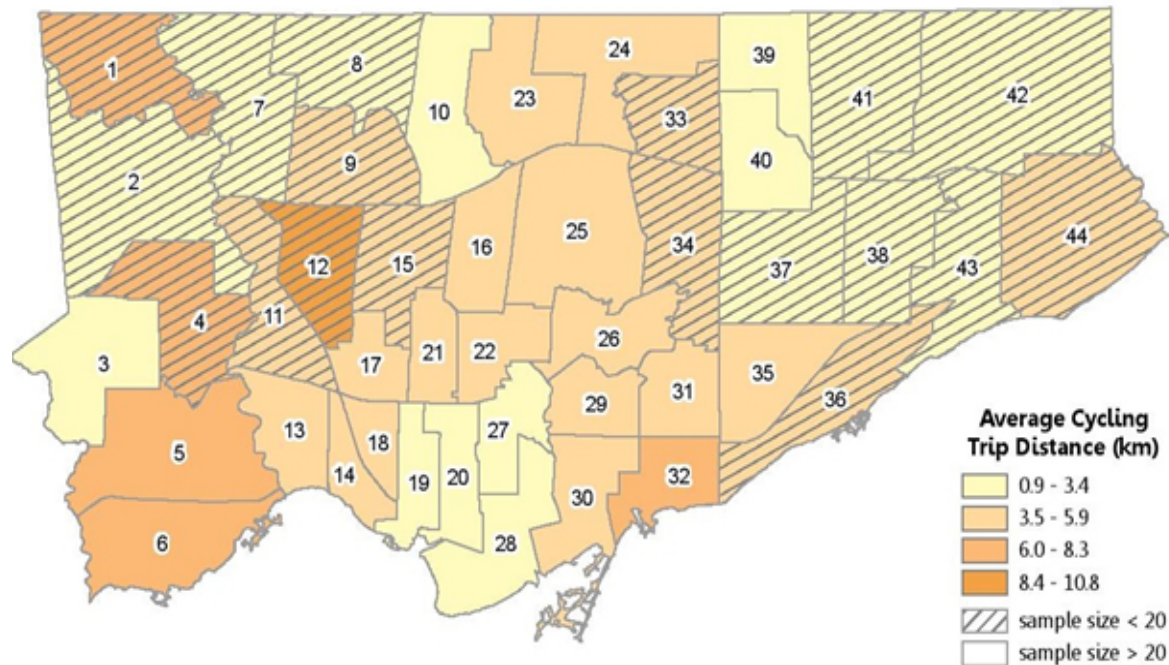


Figure 2-8 Average Cycling Trip Distance- Wittmann (Data sources: City of Toronto Open Data 2012 and DMG, 2006. Sample size in hatched areas too small to be statistically valid)

2.2.2 Multiple Daily Trips

Cyclists in Toronto tend to take multiple cycling trips on a daily basis. However, on a ward basis, the average never exceeds 3 trips per day. Central wards have a higher daily average number of cycling trips.

Average Number of Daily Trips by Cyclists in Toronto by Ward

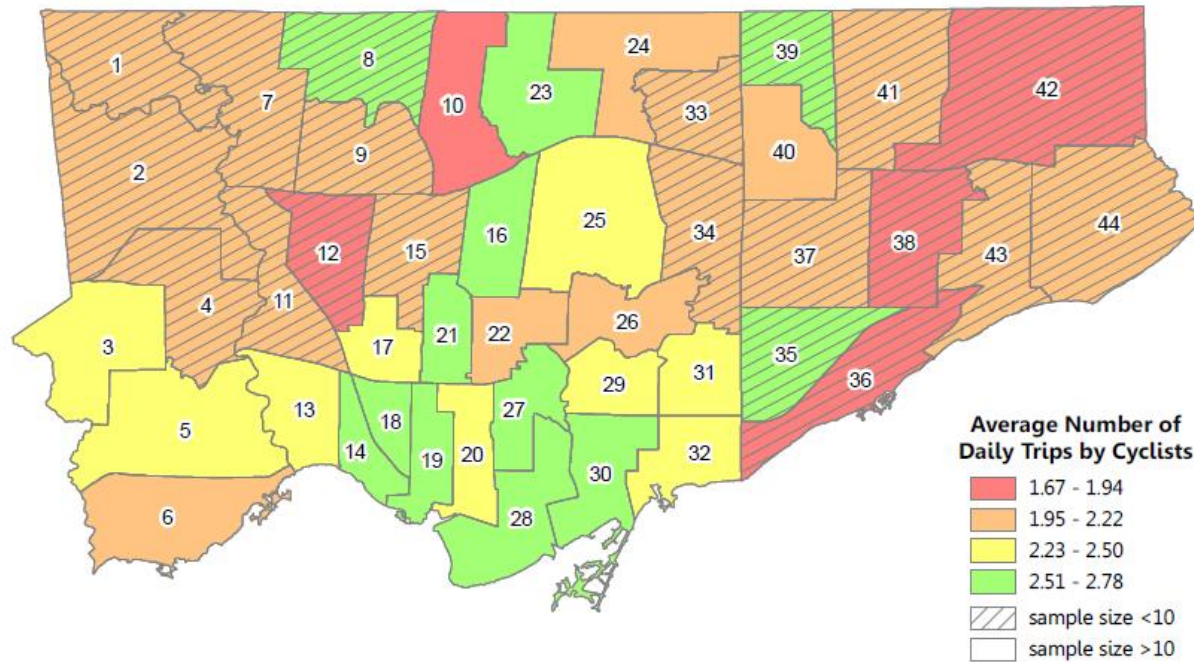


Figure 2-9 Number of Daily Trips –Watt (Data Sources: City of Toronto Open Data 2012 and DMG, 2006. Hatched areas lack enough data points to be statistically valid.)

2.3 Question 3: What factors are associated with higher proportions of cycling trips?

2.3.1 Population Density

Cycling trips are most common in areas of higher population density although they are not directly correlated with the highest levels of density. The wards with the highest population densities 14, 18 and 27 have cycling mode shares of 4.8, 5.3 and 2.0 respectively. Ward 19 with a slightly less dense population has the highest cycling mode share of 7.5.

Population Density in Toronto by Ward

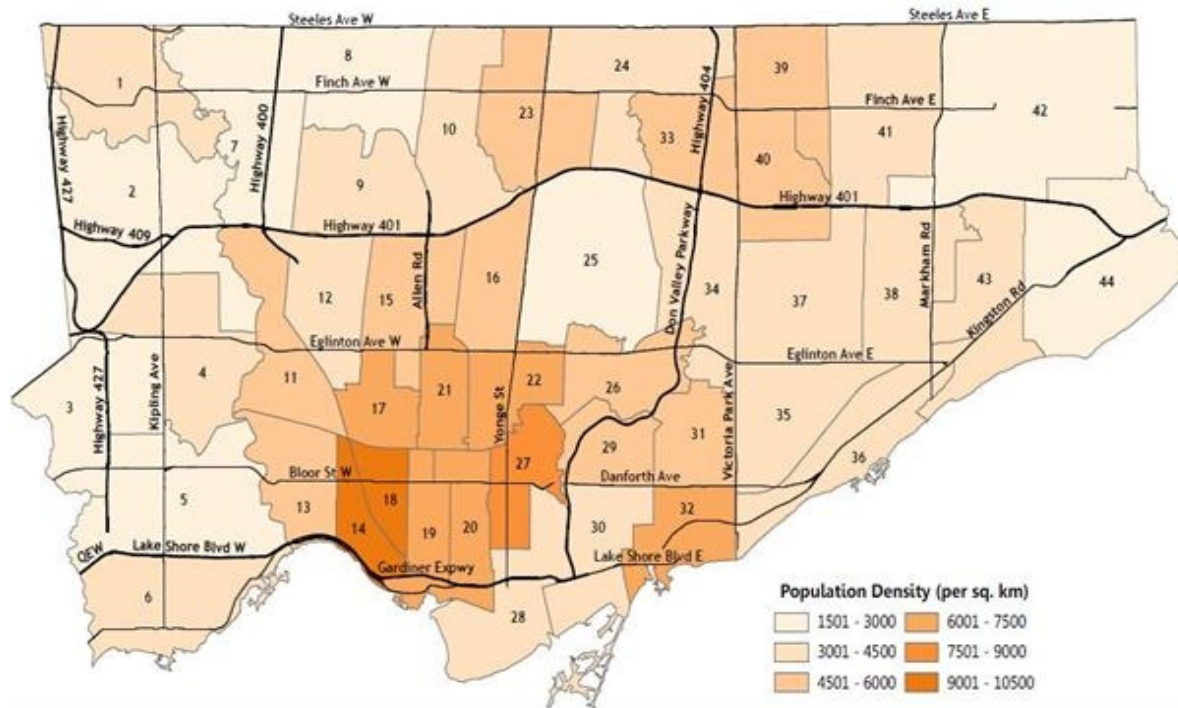
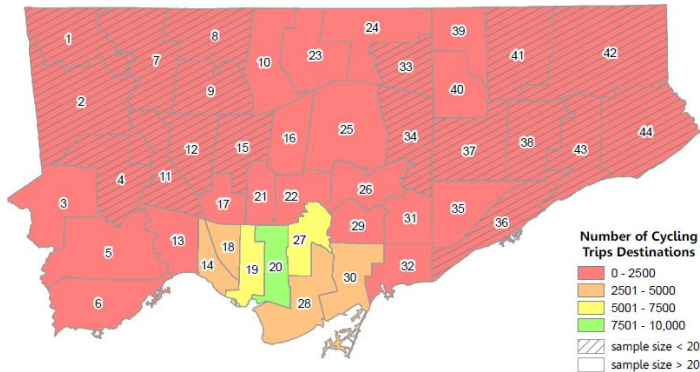


Figure 2-10 Population Density by Ward –Watt (Data sources-City of Toronto Open Data and Census, 2006)

2.3.2 Destinations, Connectivity and Origins

More cycling trips occur in areas with higher destination and connectivity density. Note that these data are derived from the Bike Score™ indicators, described in more detail below. See Appendix D for details on how these are calculated.

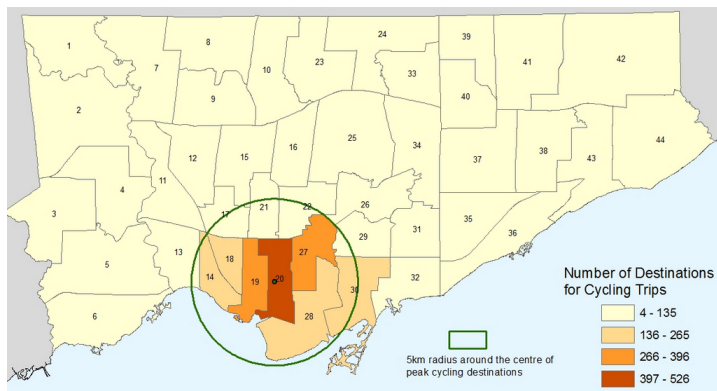
Density of Cycling Trip Destinations and Connectivity in Toronto by Ward from Bike Score™



Ward 19 with the highest cycling mode share at 7.5% has a lower destination and connectivity density than Ward 20 which has a cycling mode share of 4.6%. However, the destinations in Ward 20 are readily accessible by Ward 19 residents.

Figure 2-11 Destination Densities –Watt (Data Sources: Bike Score™ City of Toronto Open Data 2012 and DMG, 2006)

Destinations of Cycling Trips from TTS



TTS data show destinations play a key role. The highest numbers of trip destinations were in Ward 20. The green circle is a 5km radius around the centre of peak cycling destinations in Ward 20.

Figure 2-12 Destinations of Cycling Trips TTS- Wittmann (Data Sources: DMG, 2006 and City of Toronto Open Data 2012)

Origins and Destinations Combined

Ward 19 has the highest intensity of cycling trips both originating and ending in a ward. The combination of trips originating or ending in a ward provides greater insight into patterns of cycling in Toronto. The 5km radius is centred on the peak cycling origins and destinations in Ward 19.

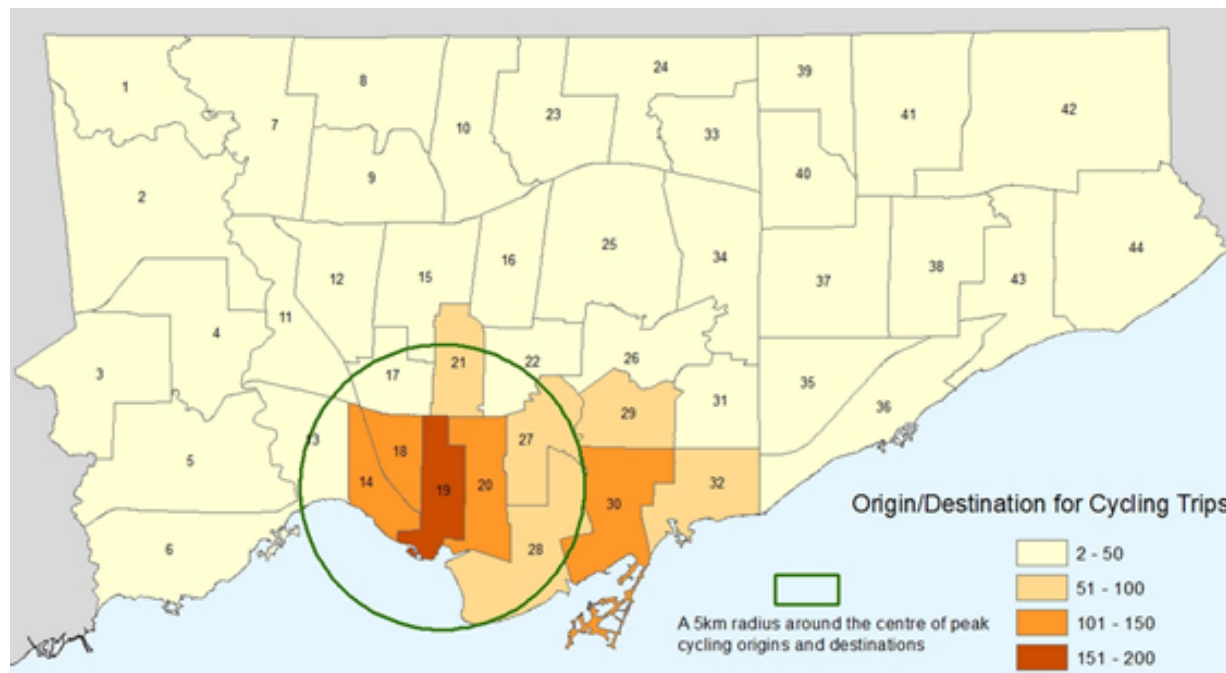


Figure 2-13 Origins and Destinations of Cycling Trips-Wittmann (DMG, 2006 and City of Toronto Open Data, 2012)

2.3.3 Topography

Hills Score is a measure created by Bike Score™ (Appendix D) to evaluate the suitability of the terrain for cycling. Level terrain is a feature of the Toronto wards with the highest cycling participation rates. However, level terrain is also associated with the wards at the further reaches of the city that have low cycling participation rates. There is some correlation between more hills and lower cycling participation. In Toronto, the land rises away from the shore of Lake Ontario to the high ridge of the Oak Ridge Moraine north of the city.

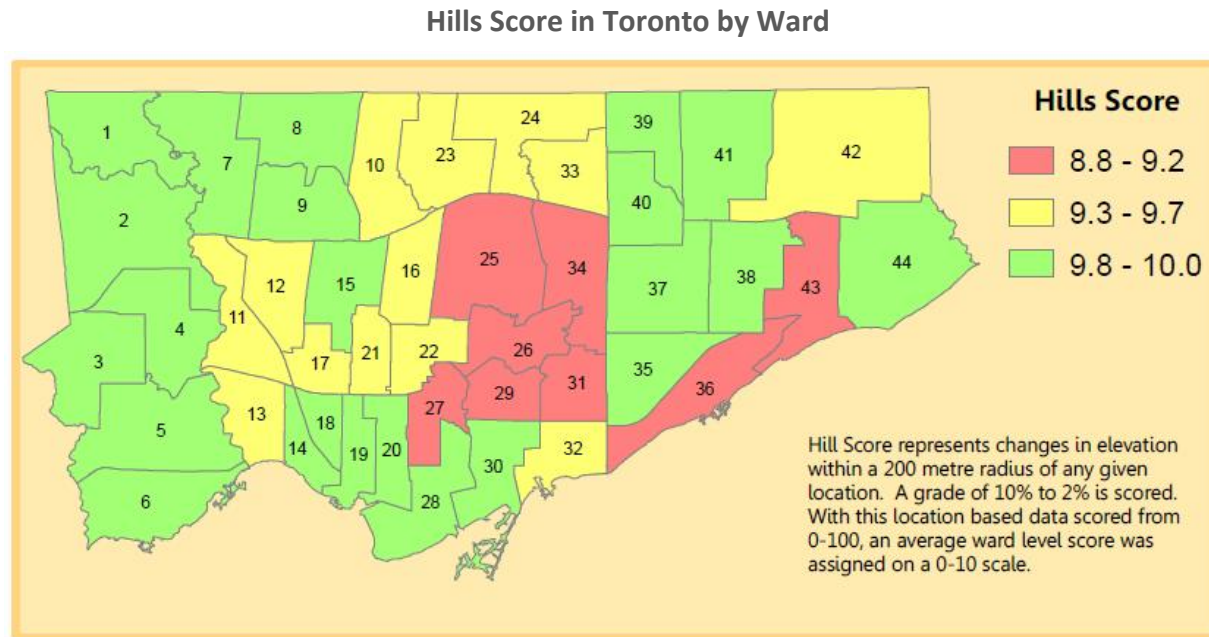


Figure 2-14 Hills Score by ward- Watt (Data sources- City of Toronto Open Data 2012 and Bike Score™, 2012)

2.3.4 Cycling Infrastructure (bike lanes)

A higher Bike Lane Score (Appendix D) is associated with two wards with high cycling participation rates: Wards 20 (4.56% mode share) and 29 (2.45% mode share). However, most wards with higher cycling participation, including Ward 19 which has the highest cycling mode share in the city (7.5%), have lower Bike Lane Scores. Five of the six wards with the highest cycling mode share (Ward 14-4.79%; Ward 18-5.31%; Ward 28-3.42%; Ward 30-4.42% and Ward 19-7.5%) do not score as well for cycling lane infrastructure, as calculated by BikeScore™, as many other Toronto wards.

Bike Lane Score in Toronto by Ward

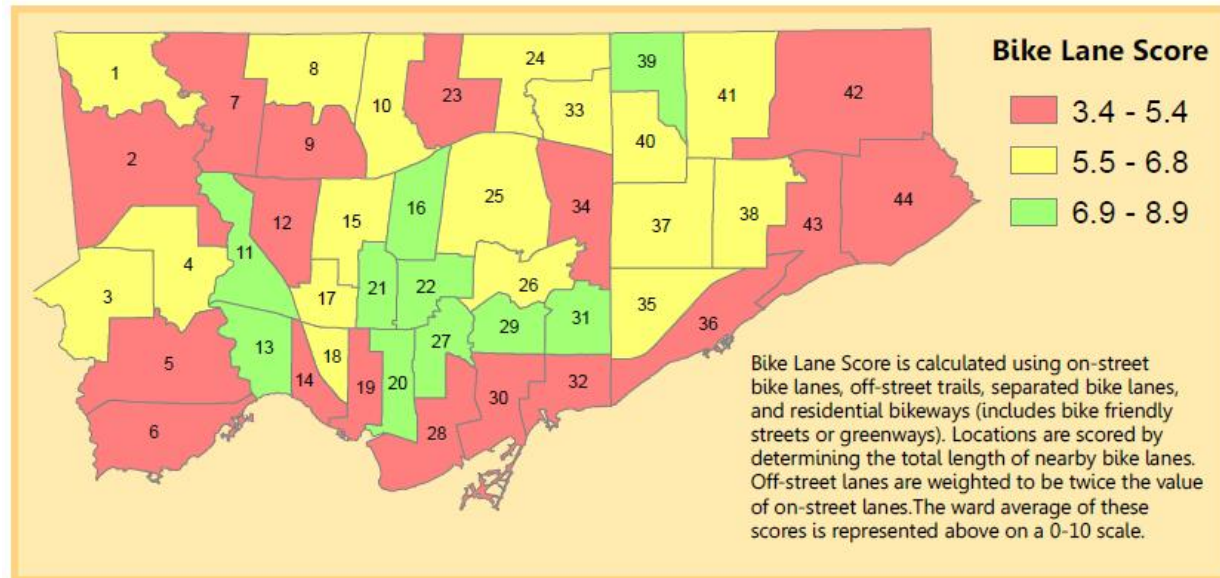


Figure 2-15 Bike Lane Score by Ward, Toronto –Watt (Data sources- City of Toronto Open Data 2012 and Bike Score™, 2012)

2.3.5 Consolidated Bike Score TM in Toronto by Ward

Bike Score™ combines three equally weighted components: bike lanes (weighted by density and separation); hills; and destinations and road connectivity, to produce a rating of the physical suitability of an area for cycling (Winters, 2012 & Appendix D). Bike Score™ does not consider important un-fixed characteristics such as traffic speed and traffic volume. The wards with the highest bike scores in Toronto do not correlate to the wards with the highest proportions of cycling trips.

Consolidated Bike Score™ in Toronto by Ward

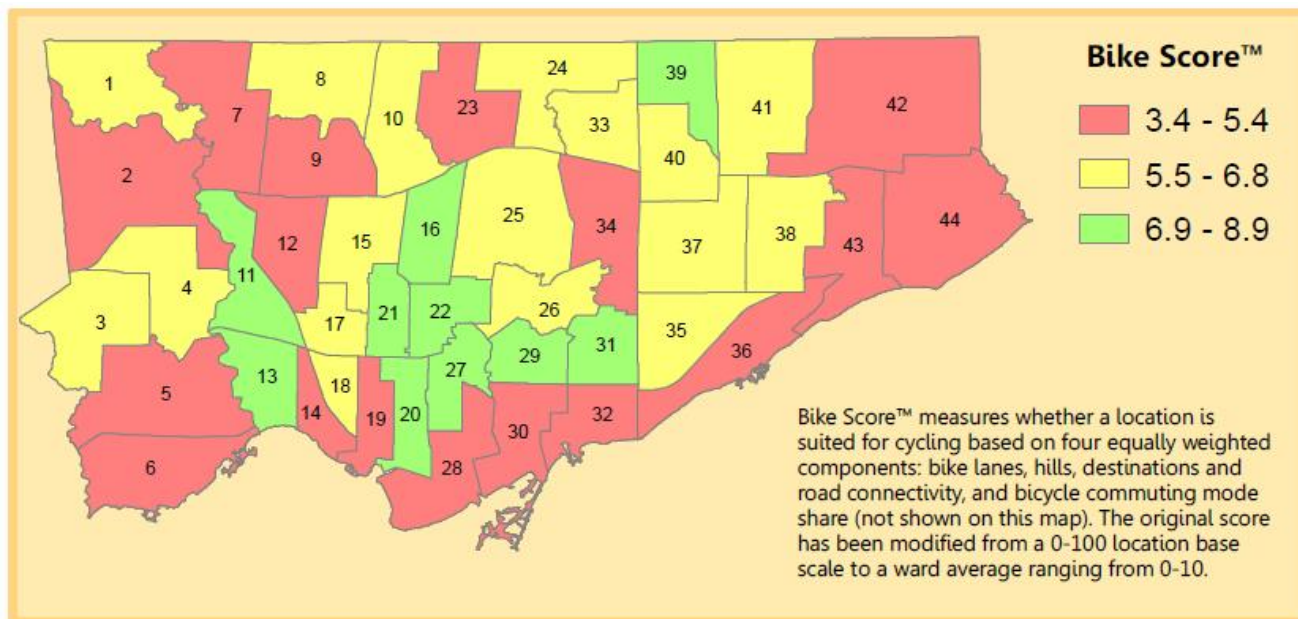


Figure 2-16 Consolidated Bike Score™ by Ward Toronto- Watt (Data sources- City of Toronto Open Data 2012 and Bike Score™, 2012)

Bikeability with Ward Overlay

Considering the unexpected findings of Figure 2-17, i.e. that the areas with the most “bikeable” score on Bike Score™ do not correlate with cycling participation in Toronto by ward, we produced a map using a model that does not fill each of the wards with one value. Rather we used a raster model which is well suited for representing data that change continuously across a landscape. We then laid the ward boundaries over top of the raster model to allow a clearer view of differences within ward boundaries. Nevertheless, the results are similar. While Ward 19 has two distinct areas falling in the “most bikeable” category much of the ward is less “bikeable”. Additionally, Wards 22 and 27, which are categorized as highly “bikeable”, have much lower cycling mode shares at 1.2 and 2.0 respectively. A discussion of the limitations of using BikeScore™ to assess cycling participation is found in Section 3.2 of this report.

Bikeability in Toronto (Raster model) with Ward Overlay

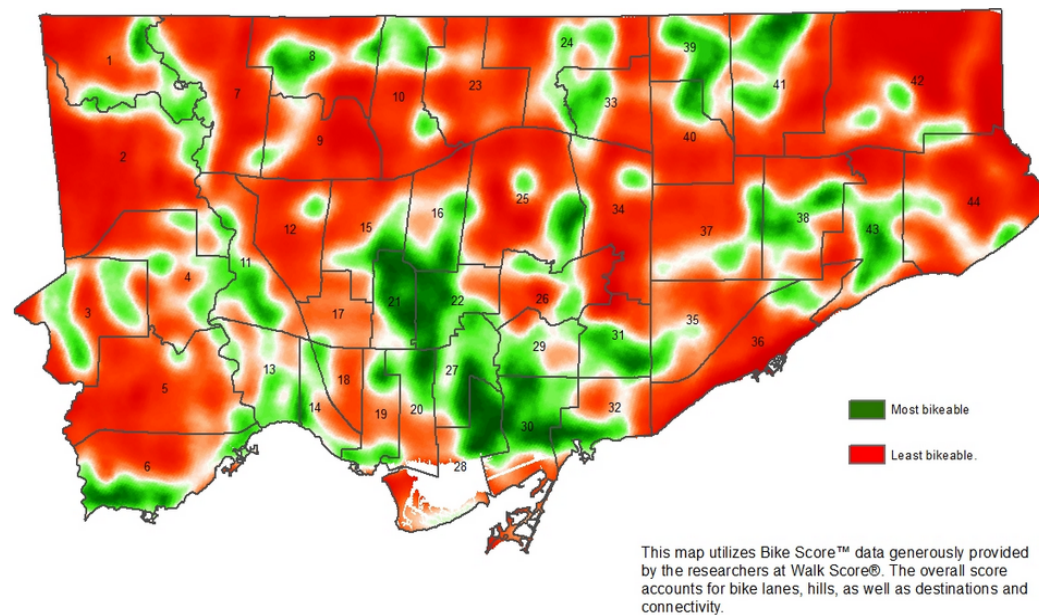


Figure 2-17 Bikeability in Toronto (Raster model) -Wittmann (Data sources-Toronto Open Data, 2012 and Bike Score™)

2.3.6 Cycling Services

Areas with higher cycling participation tend to have the greatest number of cycling service facilities. This was one of the strongest findings of the research. There is an obvious symbiosis between the two which we discuss in our analysis. These data were collected in 2012.

Toronto Cycling Shops and Service Facilities

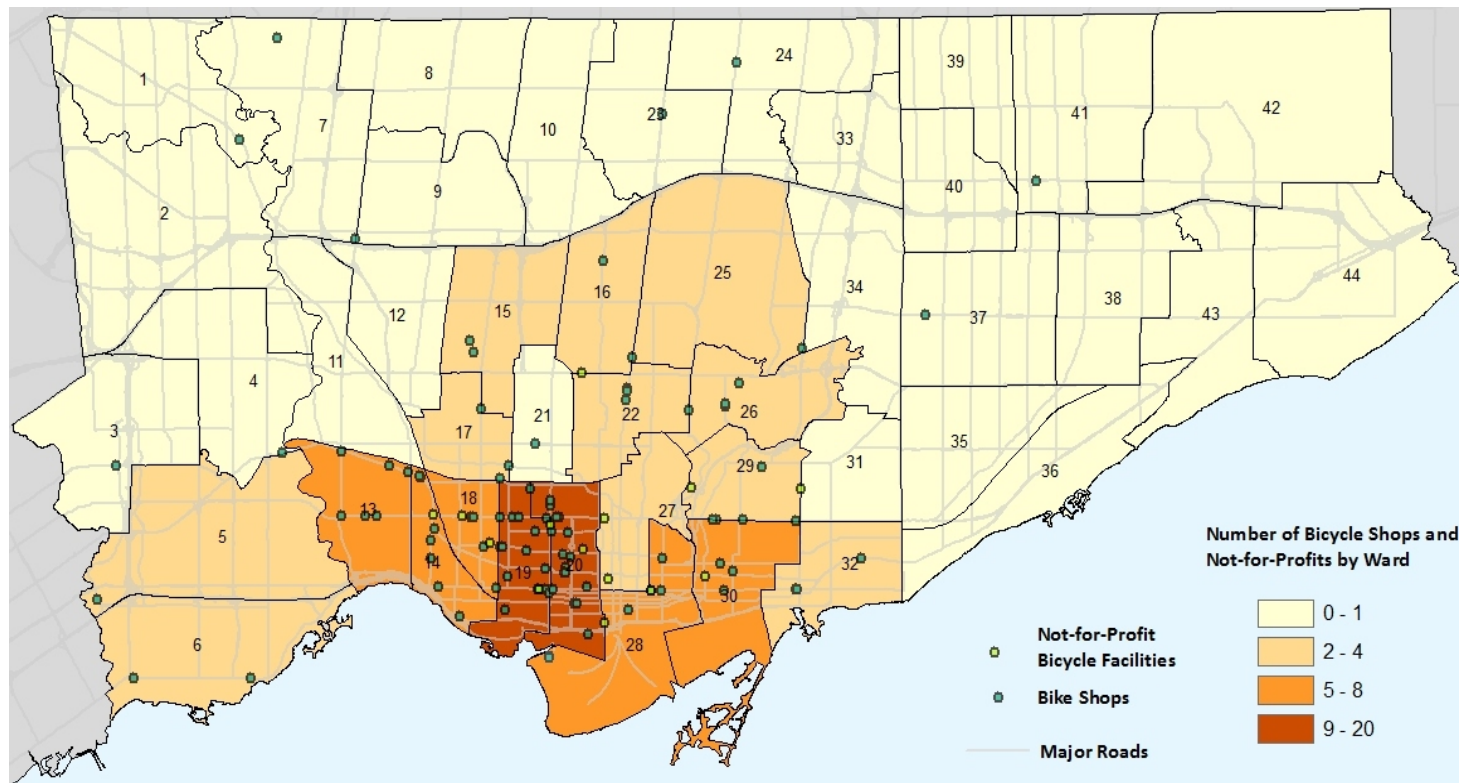


Figure 2-18 Toronto cycling shops and service facilities -Wittmann (Data sources: Toronto Open Data, 2012)

2.4 Question 4: Do some municipal wards show behavioural differences? Are they attributable to socio-cultural aspects of the population, physical barriers or facilitating factors?

2.4.1 Cycling participation by ward is distinctly different.

The 14 central focus wards account for 81% of total cycling trips identified through the Transportation Tomorrow Survey data (2006). Although, as a group, they have a higher average cycling mode share (3.1% average) than the rest of the city (1.3%), within the group of wards there is a very wide range of cycling mode share—from a low of 1.07% in Ward 31 Beaches-East York, to a high of 7.5% in Ward 19 Trinity-Spadina. Discrepancies exist between extremely similar wards. For example: immediately north of and adjacent to Ward 19 Trinity-Spadina (7.5% cycling mode share), in Ward 21 St. Paul's, (above the former lakeshore, up a steep hill) cycling has a much lower mode share of 2.05. The wards along the north-south subway routes show a lower cycling mode share (and higher pedestrian mode share) while the east west subway route appears to have no impact on cycling mode share. No identifiable demographic data was found to be associated with the differences by ward.

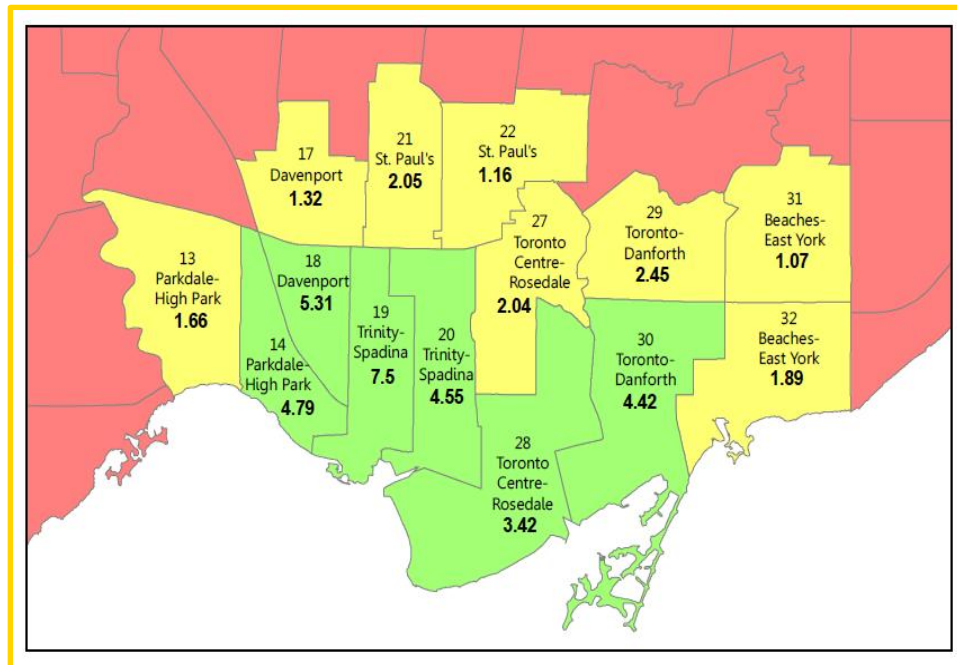


Figure 2-19 Bicycle mode share by ward –Watt (Data sources: City of Toronto Open Data 2012 & DMG, 2006)

3 Discussion and Analysis- including considerations for selecting target sites and populations for behavioural interventions

3.1 Characteristics of Cycling Behaviour in Toronto

Our findings suggest higher rates of cycling in Toronto are created through a combination of complex conditions. Factors influencing higher rates of cycling can be categorized into four areas: 1) who cycles; 2) how they cycle; 3) land use and urban form; and 4) topography. The first three categories are malleable to differing degrees, while topography is fixed. Within these four areas we identified eight key factors which together, seem to provide significant insight into much of the cycling participation in Toronto: age and sex (who); trip length and trip frequency (how); population density, destination density and cycling service facility density (attributes of land use and urban form); and level terrain (topography). Focusing on these factors will help us direct behaviour change programs to appropriate people, in areas with appropriate background conditions.

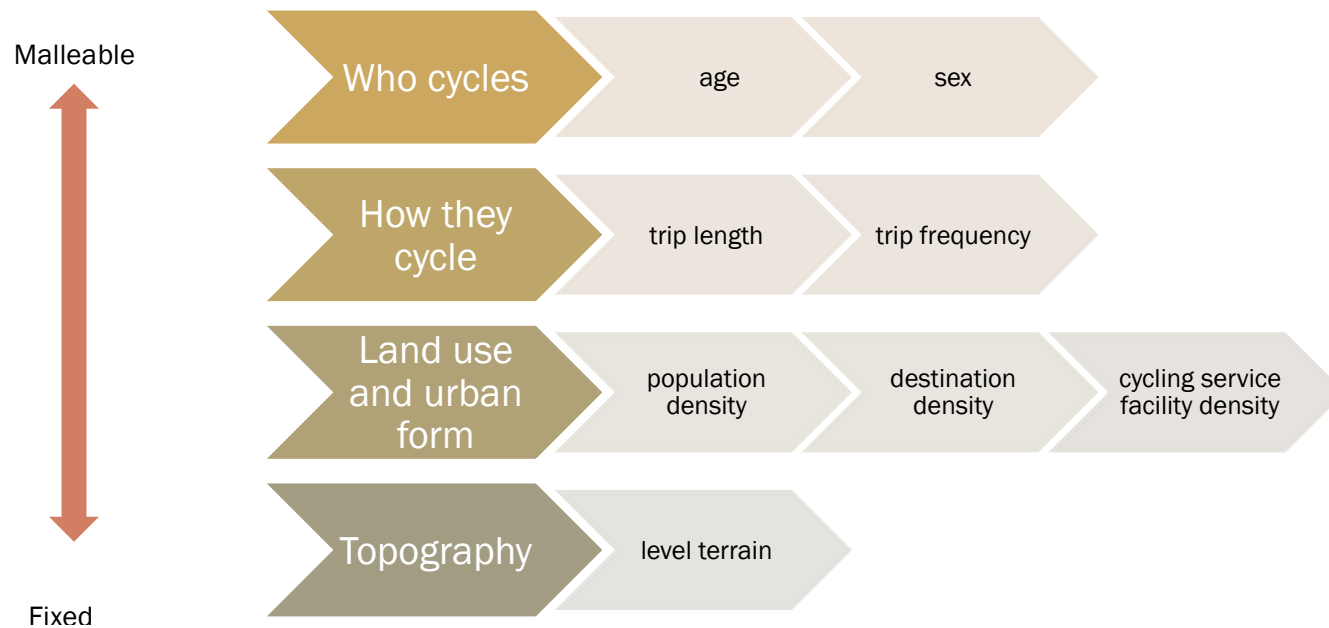


Figure 3-1 Characteristics associated with higher rates of cycling behaviour in Toronto

This conclusion, that a confluence of factors is involved in higher rates of cycling has strong implications for targeting populations likely to take up cycling for transportation and possibly for planning of infrastructure installation. Another key factor affecting cycling participation is, of course, the policy infrastructure associated with rules of the road, speed limits and other governmental regulations that favour or discourage active modes of transportation. In a study of one governmental jurisdiction, like Toronto, the policy infrastructure crosses all ward boundaries and is not suitable for study by segmentation.

3.1.1 Who cycles: The role of age and sex in cycling participation

Adults between the ages of 25 and 54 undertook a disproportionate share of cycling trips. The greatest proportion of cycling trips was taken by adults 35-44 years old. Those over 55 were least likely to cycle for transportation. In 2006, Toronto cyclists tended to be in young adult to mid-life stages. The data suggest the 15-24 year old segment participate in a similar proportion of cycling trips to other modes.¹

When considering targets for behaviour change, youth who would hopefully maintain their behaviour throughout their adult life, should be considered (Tools of Change Landmark Case Study, 2009; Transport for London, 2010; The National Center for Safe Routes to School, 2007). If the current, reported cycling participation rate of 15-24 year olds was to continue as they age, cycling participation would decrease in Toronto. Cycling rates to schools in the Greater Toronto Area for children aged 11-15 declined by over two thirds between 1986 and 2006 (Buliung, Mitra and Faulkner, 2009). Further research, to determine if current Toronto cyclists participated in cycling while younger, would be useful in order to determine if cycling is behaviour acquired as an adult or if the current cyclists between the ages of 25 and 54 cycled when younger and are continuing a behaviour. Research related to cycling behaviour in childhood tends to be focused on cycling as a sport or recreational activity (Perkins et al 2004) rather than a transportation choice.

Similarly, the lower cycling participation rate among the population over 55 years old warrants further examination. The population of the city as a whole is aging (Toronto Public Health, 2010). If the over 55 group previously cycled and is no longer cycling, then the potential for declines in cycling participation in the 45-54 year old age group as they age, exists and needs to be addressed. If however, the over 55 group has had a lower cycling for transport rate throughout their lifespan, then interventions addressing this specific barrier would be more useful.

¹ The data may underreport the participation of 15-24 year olds due to methodology. The 15-24 year old age group may be most likely to not use land line phones. Given that the Transportation Tomorrow data is based on a land line survey it is likely their data under count younger respondents. See Appendix C.

Countries with high cycling mode share tend to have more evenly distributed patterns of participation by age (Pucher and Buehler, 2008). In Toronto, age may interact with sex to explain declines in cycling by age.

Wards with a significant proportion of female cyclists generally have the highest cycling mode shares. On average in Toronto, one of three cyclists is a woman. However, in the wards (19, 18, and 14) with the highest cycling mode share, women account for closer to 50% of those cycling (Figure 2-5). In wards with higher rates of cycling participation, the percentage of women who cycle increases and gender disparity is greatly reduced. This pattern is not completely consistent across all wards. Ward 20, for example, posts relatively high rates (4.6%), well above the citywide average, but just 31.3% of cyclists are women. This is below the 34.3% average for the city.²

Our findings are consistent with gender differences in utility cycling found by other researchers. This is attributed to risks (actual and perceived) associated with cycling in countries with relatively poor cycling infrastructure, policies, regulations and low cycling prevalence (Baker, 2009; Cycle to Work Alliance, 2011; Dickinson et al., 2003; Garrard et al., 2006; Garrard et al., 2008). Nevertheless, data from the United States Household Travel Survey suggest cycling poses no more risk for women than other modes of transportation (Beck et al, 2007).

To increase overall cycling mode share, behavioural interventions should target women. However, evidence of the specific barriers to female cycling participation in Toronto remains limited. Does it relate to child care responsibilities? Multiple trip purposes such as groceries and work? There are strong suggestions that societal gender roles are highly influential over who cycles (Garrard 2003; Garrard, Crawford et al. 2006; Pucher and Buehler 2007; Garrard, Rose et al. 2008; Pucher, Dill et al. 2010). Life cycle transitions may be especially relevant to women, as they are more likely to experience career interruptions related to family issues. “Transitional life events” frequently encourage people to take up cycling (Christensen et al., 2012; Chatterjee et al., 2011; Gatersleben & Appleton, 2007). Infrastructure may be especially important to women (and children and seniors) where the perception of safety created by separated cycling facilities has been identified as an important factor determining cycling participation (Krizek et al, 2005).

² These anomalies deserve closer attention: they may reflect demographic features of specific wards or they may reflect sample size and methodological limitations of the Transportation Tomorrow Survey (see discussion in Appendix C).

In Toronto, sex may interact with age to reduce the overall cycling participation rates of those over 55. Toronto's population over the age of 15 is skewed towards females with 52.7% of the population female (Appendix F-Statistics Canada, 2006). Over the age of 60 this trend becomes stronger; 57.8% of Toronto's 60 plus population is female. The combination of age and sex is a powerful determinant of reduced cycling participation with specific barriers that may be addressed through behavioural interventions in appropriate neighbourhoods.

3.1.2 How do people cycle?

Cyclists take multiple daily trips under 5km in those wards with higher cycling mode share. We found a cycling trip length of 5km or less to be a key characteristic of cycling trips: 74% of cycling trips in Toronto were less than 5km in length. Those wards that showed higher levels of trip frequency (Figure 2.9) generally had a higher cycling mode share suggesting trip chaining and a variety of trip purposes over the course of a day.

The literature suggests trip length is a significant barrier to active transportation participation (City of Toronto, 2010; Nelson et al, 2008; McDonald, 2009; Faulkner et al, 2010; Van Dyck et al, 2010). Metrolinx notes 17% of all trips made by GTHA residents are under 2 km and therefore very walkable and 40% of all trips are 5 km or under, and therefore very bikeable (Metrolinx Strategy 2, 2008; Toronto Public Health, 2012 p.23). Winters (2012) suggests 5km of cycling is a 20 minute commute, roughly 3-4 times the distance covered in a 20 minute walk.

In order to identify trips by other transportation modes that would be targets for behaviour change, we mapped trips under 5km by mode and ward. 45% of all trips in Toronto were less than 5km in length. Of these short trips, the majority (65%) were made by private automobile. Private motorized transport accounts for 68% of all trips in Toronto and 43% of those trips were less than 5km in length (Figure 3-.1).

One of the most important findings of this project is that, even in wards with high cycling and walking mode shares, approximately half of all automobile trips were less than 5km long (See Figure 3.2). Given Toronto Public Health's conclusion in the Road to Health report that cycling may be faster and more convenient than driving for these short trips, (2012, p.17) the data suggest an opportunity exists for many more trips by bicycle.

Trips in Toronto less than 5km by mode

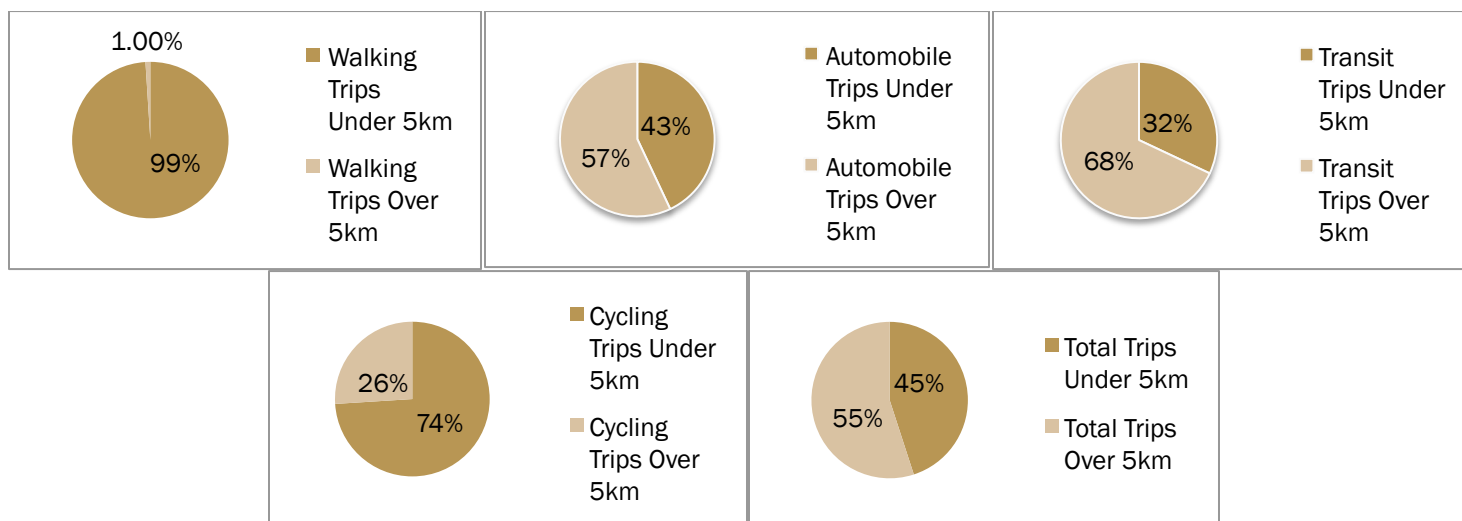


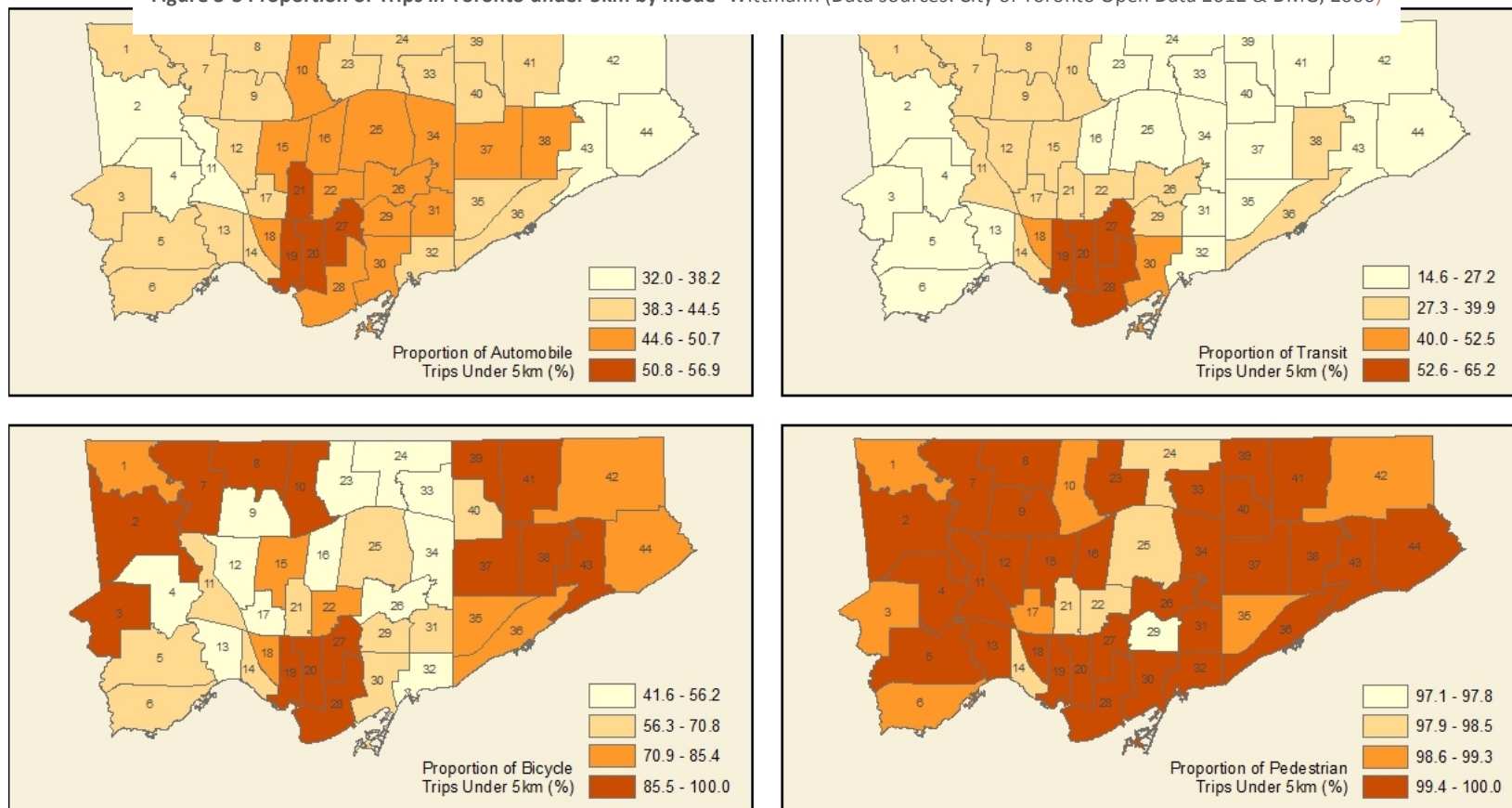
Figure 3-2 Percent of trips by mode < 5km in Toronto (Data source- DMG, 2006)

The maps in Figure 3-3 show that, in the central city, many of the automobile trips taken were for distances less than 5km. The proportion of trips less than 5km declines in the outer areas of the city, although they remain a substantial portion of total trips.

Pedestrian trips offer the most distinct pattern. Virtually all are less than 5km in length. For cycling the pattern is not as clear. In Wards 39, 43, and 10, nearly 100% of cycling trips are shorter than 5km, but the number of cycling trips measured in these wards may be statistically unreliable. Central wards in the downtown area also have high percentages of short trips. Obviously, active transportation trip distance is limited by physical capacity. Krizec suggests a cycling trip length of 2.5km may be the “sweet spot” for planners (Krizec, 2012). Figure 2-7 suggests cycling trip distance in Toronto aligns with his analysis.

Proportion of Trips in Toronto < 5km by mode

Figure 3-3 Proportion of Trips in Toronto under 5km by mode- Wittmann (Data sources: City of Toronto Open Data 2012 & DMG, 2006)



Projection: NAD 1983 UTM Zone 17N

3.1.3 The Role of Land Use and Urban Form in Cycling Behaviour

Three key attributes related to land use and urban form are background facilitators of higher cycling participation in Toronto: population density; destination density and density of cycling service facilities. Without these factors in place, even the most sophisticated behaviour change programmes may have less opportunity for success.

Population Density

Higher population densities are related to higher rates of cycling participation, but they are not directly correlated. Increased density does not automatically increase cycling participation. The 14 focus wards have significantly higher population density per square kilometre than other wards (6692 average per square km versus the 4606 average per square km for the whole city-see Appendix E). However, this does not correspond directly to cycling mode share.

For example, Wards 14, 18 and 27 have the highest population densities in the city, but radically different cycling mode shares: 4.8%; 5.3%; and 2.0% respectively. Ward 19, with the highest cycling mode share of 7.5%, has a lower population density per square kilometre than 5 other focus wards. Wards 17 and 27 with respective cycling mode shares of 1.3% and 2.0% s have a similar population density to Ward 19 (Figure 2-9).

Wards along the north-south Yonge/ University subway lines (20, 21, 22, 27 & 28) have strong walking and transit mode shares. Two other density issues-destination density and cycling facility density seem to interact with population density to create higher levels of cycling.

Destination Density

Higher densities of destinations are related to higher rates of cycling participation. Ward 19, with the highest cycling mode share at 7.5%, has a lower destination density than Ward 20, which has a cycling mode of 4.56%. However, the destination densities in Ward 20 are easily accessible by the population of Ward 19 within a 5km trip length.

Ward 19 shows the highest number of trips both beginning and ending in a ward (Figure 2-12). The combination of destination density, population density and the related trip length under 5km accounts for 4 of the 5 wards with the highest cycling rates: Wards 19, 14, 18 and 20.

Ward 30 has the lowest population density of the focus wards at 3,941 people per square kilometre and yet has the fifth highest cycling participation rate and a similar intensity of cycling trips as wards 14, 18 and 20. It has a higher level of destinations and connectivity (as measured by BikeScore™ Appendix D) than wards with higher population density.

Pucher & Buehler (2006 and 2010) identify urban form and land use patterns as crucial factors of higher cycling participation. The combination of high destination density and trip origins reflects mixed land use patterns with short distances between origins and destinations.

Density of Cycling Facilities

Higher densities of cycling service facilities are found in areas with higher rates of cycling participation. There are distinct differences across wards in terms of the number of bicycle shops and not-for-profit bicycle facilities located within their boundaries. Wards 20 and 19 have very high counts, at 20 and 16 bike shops/not-for-profits respectively. Wards 13, 14, 28, 18, and 30 also have fairly high counts, ranging from six to eight shops and not-for-profits. Many of the remaining wards have only one or two facilities, while others have none. The points are most numerous in the downtown core.

The density of these bicycle service facilities relates quite closely to the bicycle mode share map, where Ward 19 holds the highest values, followed by 14, 18, 20 and 30. There appears to be a strong relationship between density of cycling facilities and number of cyclists. It is possible that this data on cycling facilities, which was collected in 2012, overstates the relationship to the 2006 TTS data. However, there is nothing to suggest that the proportions of cycling facilities by neighbourhood have changed over this time period.

High rates of cycling and dense cycling service facilities logically support one another, but it may also be worth examining this relationship more closely to see what role bicycle facilities play in fostering and sustaining new groups of cyclists. How strong might the effect be, and can we harness this support in other forms as well? Is this a causal relationship, and if so, in which direction? Or is it in fact bi-directional? Do cycling services encourage greater cycling participation at the same time as they

seek to locate in areas of higher cycling participation for market reasons? Can this relationship be utilized to create increased cycling participation?

Further analysis of the bicycle shops and their customers is necessary before significant conclusions can be drawn. Future reports from this project will examine cycling economies in more detail, suggesting that cycling stores may be able to increase their success by encouraging new cyclists and collaborating with programs to increase cycling uptake.

3.1.4 Topography and the influence of hills on cycling behaviour

Areas of Toronto with higher population density, destination density and cycling facility density and level terrain are associated with higher levels of cycling participation. Level terrain is not associated with higher rates of cycling in areas that lack supporting land use and urban form. There is little data on the directional aspects of cycling in Toronto. To date, the concentration of higher mode shares in the city centre suggests that much of the travel is along an east-west-east axis, which avoids the main hills (Figure 2-14), in the downtown area.

Toronto is located on the north shore of Lake Ontario in the Lake Ontario basin. The land rises from the lake, which is 74 metres above sea level on a steady basis towards the Oak Ridges Moraine (approximately 45km north of the city), which is 350 metres above sea level. The majority of north-south routes gradually (or in some cases rapidly) rise from the lakeshore northwards. The old lake bed of glacial Lake Iroquois ended roughly along Davenport Rd which is the southern boundary of the wards with lower cycling mode shares ringing the high-mode share central wards, particularly Davenport (17), St. Paul's (21 and 22), Toronto Centre-Rosedale (27) and Toronto-Danforth (29). Elevation may be a significant factor in these wards.

The factors mentioned in this analysis should be key considerations for determining suitable sites and populations for behavioural interventions and possibly infrastructure installations. Interventions lacking the background support of appropriate topography, land use and urban form attributes may require very specialized target communities linked to very specific destinations in order to be effective.

3.2 Bike Score™, infrastructure and cycling participation in Toronto

Cycling participation in Toronto was not found to correlate with higher Bike Score™ ratings. Nevertheless, the physical environment is frequently cited as the main determinant of cycling behaviour and sites with appropriate infrastructure would seemingly provide an easier transition for those new to commuter cycling. (Mitra & Buliung, 2012; Forsyth & Krizek, 2010; Frank & Engelke, et al, 2003; Frumkin & Frank, 2004; Saelens et al, 2003). High quality bicycle infrastructure is deemed important to improving safety and attracting new people to bicycling (Dill 2009, Titze et al. 2008). Evidence suggests this is especially true for women and older and younger populations (Krizek et al, 2005, Dill, 2012). This may be related to perceptions of safety (Krizek, 2012) rather than actual safety as research indicates that safety risk for females is no greater for cyclists than for walkers or drivers (Beck et al, 2007). Bicycle facilities that separate cyclists from motor vehicle traffic are strongly associated with increased levels of cycling (Pucher et al. 2010).

In Toronto, the lack of suitable signage and infrastructure, particularly physically segregated facilities on major routes may undermine or confound this relationship. Toronto has primarily pursued cycling infrastructure consisting of on street bike lanes (113km) and off road paths (191km). Most of the off road paths are heavily oriented to recreation, as they frequently do not follow commuter paths, are generally not maintained in winter and often require steep entrances and exits from valley locations. Thus, commuter infrastructure in Toronto may be overstated. Toronto has just recently initiated 14km of physically separated cycling lanes (Toronto Public Health, 2012 pp. 52-53).

BikeScore™ does not measure a number of important factors that make cycling safer and more comfortable. Traffic volume and traffic speed are key factors left out of the BikeScore™ measure of bikeability. Additionally, although they include a key measure in their BikeScores of American cities- cycling mode share- they do not include this in Toronto's BikeScore™ (Winters, 2012). The inclusion of this critically important social infrastructure would have changed their map of Toronto significantly; however, it would not have provided as much insight into environmental conditions for cycling (Winters, 2013).

The Netherlands organization, CROW (the national knowledge platform for infrastructure, traffic, transport and public space), publishes a *Design Manual for Bicycle Traffic* (2007). This publication identifies five key characteristics of successful cycling facilities. Both the network and individual routes should be direct, safe, attractive, comfortable and coherent. Toronto, with facilities consisting of recreational paths and visually separated lanes, with virtually no intersection treatments or counter flow lanes, is not meeting these requirements. CROW rates the need for physical segregation as low on low-traffic, low-volume, low-speed streets and proportionately higher as speed and vehicle volume rise.

A recent survey by the City of Toronto's Planning Department showed that residents of downtown and four other densely populated centres rated their satisfaction with cycling facilities the lowest of any of the 20 services and amenities examined. At the same time, only 32% of respondents considered bike paths and bike lanes as not applicable in their lives (City of Toronto Planning Division, 2012). Given that 68% of respondents consider bike paths and bike lanes applicable to their satisfaction with city life, but a far lower percentage of the population cycles for transport, there appears to be significant latent interest in cycling for transportation, interest that may be released through appropriate infrastructure and behavioural interventions.

At 7.5%, Ward 19 has the highest cycling mode share in Toronto. This rises to 10.45% mode share for trips under 5km. It has the largest number of origins and destinations of cycling trips, and the most daily trips by bicyclists on average. Reflecting the close proximity of the many origin and destination locations, 90% of bicycle trips in the ward are less than 5km long. It has one of the highest counts for bicycle shops and not-for-profits. In terms of perceived bikeability by Bike Score™, however, Ward 19 scores quite low. The ward may score fairly well for having minimal hills, but it receives very poor marks for bike lanes and connectivity. Given the lack of a supportive physical environment for cycling, Ward 19 is an excellent example of the role of social and civic infrastructure in supporting cycling behaviour.

Future reports in this series will examine target wards in depth and discuss target sites and populations, intervention plans and metrics. We will also be analyzing the literature available on the use of mapping to understand cycling behaviour. Additionally, our cycling economies research stream will be releasing reports on the economic impacts of replacing on street parking with bike lanes; the use of social marketing for behaviour change as a business strategy for cycling retailers; and an overview of the cycling business in Canada.

4 Conclusions

Factors influencing higher rates of cycling in Toronto can be categorized into four areas: 1) who cycles; 2) how they cycle; 3) land use and urban form; and 4) topography. The first three categories are malleable to differing degrees, while topography is a fixed factor. Within these four areas we identified eight key factors which together, seem to provide significant insight into much of the cycling participation in Toronto. Age and sex (who); trip length and trip frequency (how); population density, destination density and cycling service facility density (land use and urban form); level terrain (topography). The factors mentioned in this analysis should be key considerations for determining suitable sites and populations for behavioural interventions and possibly infrastructure installation.

Our findings suggest higher rates of cycling in Toronto are created through a combination of complex conditions. Focusing on these factors will help us direct behaviour change programs to: people most likely to cycle; taking trips under 5 km that would be viable by bicycle; in areas with medium to high population density; high destination density; and medium to high cycling service facility density; in regions of the city with relatively level terrain.

This report does not conclude that these are the only factors involved in higher rates of cycling participation, only that in an urban area like Toronto, with very limited cycling infrastructure, these factors influence cycling participation. The roles of both policy and cycling infrastructure are more effectively examined through comparisons to those urban areas which successfully provide these supports to active transportation.

Toronto residents give cycling amenities the worst rating out of 20 city services. Moreover, just 32% consider cycling facilities irrelevant to their satisfaction with city life, while 68% consider cycling facilities relevant (City of Toronto Planning Division, 2012). Given cycling's low mode share, these data suggest pent up demand that may be released by infrastructure improvements, policy improvements and behaviour change programmes. Like Portland, where the largest demographic group (60%), related to cycling, was identified as: "Interested but Concerned" (Geller, 2007), we imagine that these people who consider cycling facilities relevant would like to cycle more, if they felt safe, confident and admired when doing so. We suspect there is a wide variation in the level of preparedness for behaviour change. There is strong evidence that change is a sequential process over time (Gatersleben & Appleton, 2007) and social infrastructure plays an important role.

Our findings suggest higher rates of cycling in Toronto are created through a combination of complex conditions. Focusing on these factors will help us direct behaviour change programs to: people most likely to cycle; taking trips of less than five km that would be viable by bicycle; in areas with medium to high population density; high destination density; and medium to high cycling service facility density; in regions of the city with relatively level terrain.

5 Background

Traffic Congestion is a significant problem for urban centres in all parts of the world. It damages economic viability, urban sustainability, human health and environmental quality. In 2008, traffic congestion in the Greater Toronto & Hamilton Area cost

commuters \$3.3 billion and reduced gross domestic product by \$2.7 billion. It is estimated this cost will rise to \$15 billion by 2031 (Greater Toronto Transportation Authority, 2008; Toronto Region Board of Trade, 2013).

Active transportation has been identified as a significant part of the solution to traffic congestion. It has multiple economic, health and environmental benefits helping to reduce the cost of unnecessary physical infrastructure, as well as the negative impacts and the considerable financial costs arising from environmental damage, poor health and long commute times associated with personal automobile transportation (Bell et al., 2006; Dekoster & Schollaert, 1999; Garrard et al., 2006; Jones et al., 2009; Toronto Board of Trade, 2010; Toronto Public Health, 2012).

Physical infrastructure has been the focus of most active transportation research, but even cities like Copenhagen and Amsterdam with superb infrastructure and cycling-mode shares approaching 40%, seek to increase the use of behaviour change tools to further increase cycling uptake (Brussel, 2011). Behaviour change interventions designed to change individual behaviours over time use evidence based tools, developed by social psychologists, like prompts, pledges, peer support, reciprocity and positive feedback as well as identification and removal of barriers. There is strong evidence that change is a sequential process over time (Gatersleben & Appleton, 2007). An individualized behaviour change marketing campaign (Neighborhood Smart Trips) in Bellingham Washington increased cycling participation in target groups by 35%, while decreasing automobile usage by 13%. A campaign in Portland Oregon that cost 0.002% of the total infrastructure investment increased ridership twice as much as the new infrastructure alone (Horst, 2012).

Portland, Oregon which has increased cycling for transport to approximately 8% divides cyclists into four types: 1) strong and fearless –less than 1%; 2) enthused and confident -7%; 3) interested but concerned-60%; and 4) no way no how -33% (Geller, 2007). The majority of their population lies in the interested but concerned group and this is where new cyclists come from. As mentioned above, safe and comfortable cycling infrastructure is a significant concern for Torontonians as well. We do not know if the Portland typologies apply to Toronto, but certainly the 68% of Torontonians who consider cycling facilities relevant in their lives aligns very closely with the first three Portland typologies.

Studies in London, England found cycle tracks increased the number of cyclists on the roadway by 58% over 3.5 years (Pucher et al. 2010). The evidence is strong that a large number of people do not cycle due to fear of automobiles (Pucher & Bueller, 2008). Certainly, cities with significant cycling mode share such as Copenhagen (37%) and Amsterdam (40%) have physically separated cycle

tracks. However, the infrastructure in these cities cannot be reduced to physical separation alone. The Netherlands organization, CROW (the national knowledge platform for infrastructure, traffic, transport and public space) identifies five key characteristics of successful cycling facilities: direct, safe, attractive, comfortable and coherent.

Different transportation modes have optimum distances and travel times, but these often become distorted in car-centred cities. Each transport mode functions with optimum efficiency in different conditions, making an integrated, multimodal approach to land use and transportation increasingly important, as cities attempt to shift toward more sustainable living systems. In combination, higher densities of population and destinations shorten commuting distances, making walking and cycling the most competitive and efficient transport modes. In an integrated transport system, cycling becomes the missing link, able to cover intermediate distances for daily shopping, school or other tasks, while also providing door-to-door access to public transport, which users increasingly see as an essential component of a higher standard of urban living.

The combination of better transit service, walking and cycling conditions also reduces car use, if not car ownership. Frumkin and Frank's work suggests that many car users would prefer to replace at least some of their commutes with walking or cycling trips, were other conditions met (Frank, Engelke et al. 2003; Frumkin, Frank et al. 2004; Frank and Engelke 2005).

As cities become choked with congestion and air pollution, the social and spatial determinants of health come into focus. Some experts increasingly talk about "peak car use" (Newman and Kenworthy, 2011) and land-use models that enhance proximity and the effectiveness of multimodal approaches to transport planning are moving into the foreground of discussions. Thus, we see practitioners such as the world renowned planner and designer, Jan Gehl, basing proposals for New York and other global cities on studies that examine trip distance as the basis for redistributing modes (Gehl 2008). This generates a powerful response to a significant problem in many cities: people use cars even for short distances, creating unnecessary congestion and numerous other negative side effects that reduce the quality of urban living. Policy, infrastructure and behavioural supports aimed at transferring a portion of these short trips to active transportation offers the opportunity to significantly improve the quality of life in urban areas.

6 Methods and Data Sources

6.1 Research Steps

Our research for this report followed six key steps, enriched by work-shopping that brought senior researchers, community partners and interested students into the discussion. These were followed in an iterative, rather than linear fashion, so that key observations and new questions could be integrated through additional statistical and spatial analysis, as we progressed in our data processing.

- Identified key data sources
- Extracted data
- Determined minimum sample size for cycling data
- Selected map scale and divisions
- Examined relationships between variables
- Mapped key cycling indicators
- Identified wards of interest where further demographic and barriers analysis may take place.

6.2 Key Data Sources

Data Management Group, University of Toronto, Transportation Tomorrow Survey, 2006 (see Appendix for information on limits to TTS data on cycling)

- “Snapshot” of transportation patterns for one day
- Cyclist specific trip and per person data
- Demographic information

Bike Score™, 2012 (see Appendix D for information on how this is elaborated)

- Determined ward average on a scale of 0-10
- Bike Lane Score
- Hills Score (Elevation Change)
- Destinations & Road Connectivity Score
- Overall bike Score

City of Toronto Cycling Study: Tracking Report (1999 and 2009)

- Measures cycling attitudes, frequencies and attributes across 4 city districts

City of Toronto Open Data, 2012

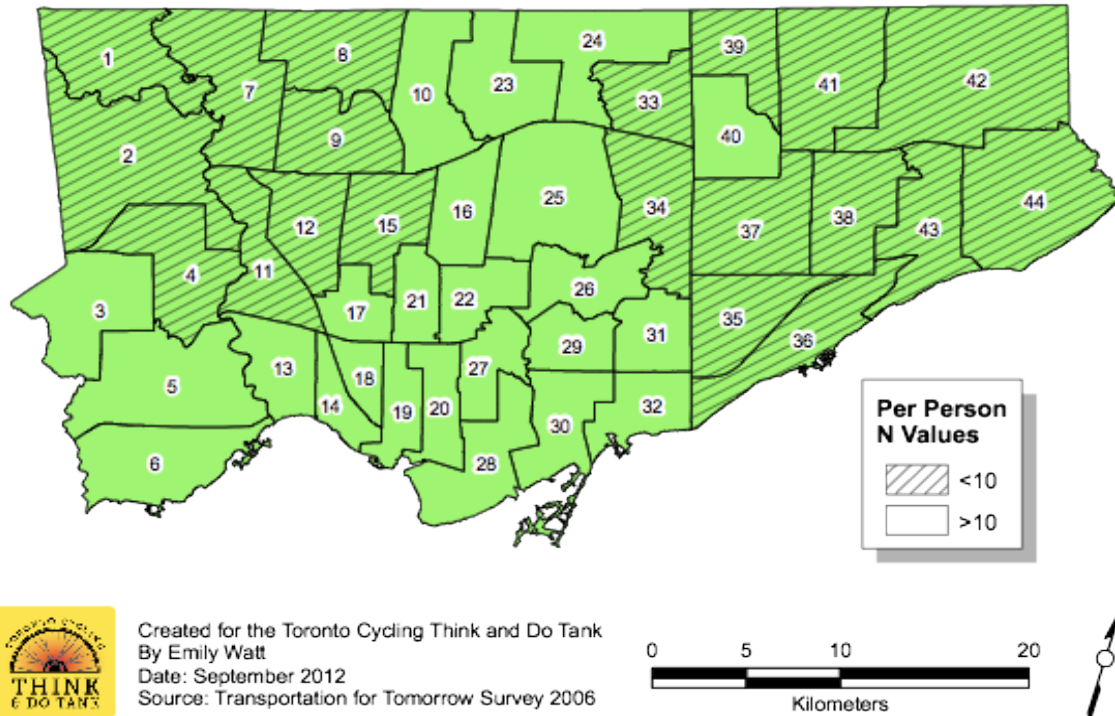
- Shape files used for mapping.

City of Toronto Ward Profiles: Census, 2006



Appendix A- Analytical mapping methods

The analytical maps followed a qualitative process to identify focus wards for further demographic segmentation and barriers



Created for the Toronto Cycling Think and Do Tank
By Emily Watt
Date: September 2012
Source: Transportation for Tomorrow Survey 2006

analysis. We measured cycling by modal share and average number of cycling trips originating in or destined for each ward (Transport for Tomorrow 2006), and examined breakdowns at the ward level. As with much transportation data, the Transport for Tomorrow 2006 survey data tends to under-report cycling levels (see Appendix B). For many wards, this meant that the sample size for cycling was lower than ten individuals. These wards (Figure A.1) tend to be located on the eastern and western edges of the city, are denoted with hatching, and were excluded from our analysis due to the low sample size.

Figure A.1. Analytical mapping process. To establish the wards of interest, we first examined and ruled out wards with data reflecting less than ten cyclists, marked with hatching.

Appendix B- Key characteristics of cyclists

Key characteristics of cyclists, according to Transportation Tomorrow 2006					
Variable	Cyclists	Others	% Cyclists	% Others	Observations
Trips	54,022	4,732,223	1.13	98.87	Equals Total Mode Share
Female	18,509	2,385,765	34.26	50.42	Women are under-represented
Student	13,037	947,004	24.13	20.01	Students are over represented
Driver License	40,038	3,661,331	74.11	77.37	Drivers are slightly under represented
18-64 Unemployed	7,434	678,548	15.93	18.71	Out of Total 18-64 year olds
18-64	46,673	3,627,156	86.40	76.65	Out of Cycling/Other Trips
Age Categories			% of Cyclists	% of Others	
15-24	6,428	577,281	11.90	12.20	
25-34	10,569	674,593	19.56	14.26	
35-44	14,722	1,001,042	27.25	21.15	
45-54	12,295	974,314	22.76	20.59	
55-64	4,885	608,674	9.04	12.86	
65+	2,798	624,008	5.18	13.19	

Data Source: DMG, Transportation Tomorrow Survey data (2006).

Appendix C- Limits to Data

This report uses data from 2006. This is a retrospective study based on existing travel behaviour and not a prospective one based on who might travel differently in the future. The Mapping Cycling Behaviour in Toronto report does not examine explicit reasons most Torontonians do not cycle. Instead we are focused on examining the behaviour and characteristics of those Torontonians who do cycle. Analyzing transportation data based on ward boundaries cannot capture the full variety of circumstances within wards. To more fully understand these limitations please see Hess, Sorenson and Parizeau: Urban Density in the Greater Golden Horseshoe (2007).

Limits to Transportation Tomorrow Survey affecting cycling data

Administered by the Data Management Group at the University of Toronto, the internet Data Retrieval System (iDRS) organizes and releases detailed information about their 2006 Transportation Tomorrow Survey (TTS). The TTS is a comprehensive questionnaire about all travel modes, including walking, cycling, driving, and mass transit use. Along with the questionnaire, limited demographic information is collected about age, gender, and household attributes. The U of T Data Management Group is in charge of administering and managing TTS survey data. Their report on Data Validation for the 2006 survey provides some insight into the biases and sources of error in this data set:

Sample Frame

The survey sample frame is listed residential phone numbers. They do not include cell phones, which are listed to the individual and are unlisted and unavailable for sampling. The selection of the 5% sample is not random. Apartment buildings are underrepresented in the TTS, which may be due to the fact that they don't receive advance letters explaining the survey (DMG, Dec 2008, p. 4). Note that the data likely under-represents the 15-34 age group who are less likely to use land lines. A comparison with 2006 Census data suggest that the 15-34 age group is underrepresented in the data while 35-64 year olds are overrepresented. While it is possible ages 15-34 make fewer daily trips than Torontonians between the ages of 35 and 64, it seems unlikely. On the other hand, the lower number of daily trips of those over 65 could reflect fewer trips due to retirement. In fact, the over 65 representations of daily trips is interesting suggesting the over 65 age group remains very active in terms of daily transportation activity in spite of declines in employment activity.

Toronto	% of Total TTS 2006 Trips by age group	Age group as % of total population aged 15+ (2006 Census)	Difference
15-24	13%	15%	-2%
25-34	15%	18%	-3%
35-44	23%	20%	3%
45-54	22%	17%	5%
55-64	14%	12%	2%
65+	14%	17%	-3%

Under-reporting of trips

Trips are only reported by one person in the household and post-survey analysis shows that while school and work trips are relatively accurate, discretionary auto trips are under reported (DMG, Dec 2008, p. 4-5). The *Transportation Tomorrow Survey* database only allows “Primary mode of travel” as part of their “Trips” option. The parsing of certain demographic and trip data requires sufficient data and sample size to create meaningful categories. Especially where cycling mode share is low, there tends to be few cycling data points as well. For example, a cycling mode-share of 0.5%, even in a ward with 1000 total trips sampled, will yield only 5 cyclist data points. Of these 5 cyclist data points, it then becomes impractical to further categorize their cycling demographics by factors such as age or employment status.

Moreover, the TTS surveyed just 1169 cyclists across 44 wards. This means that there were very few cyclists surveyed in the northwest and eastern sectors of the city. Sample sizes fell below ten cyclists, in the case of per person data, and 20 (two trips per person), for trip data. Thus, we excluded 20 wards from our analysis due to insufficient sample size. It should be noted, however, that research using a finer toothed comb than the general transport survey questions could nonetheless tease out invaluable data on cycling patterns in these wards.

Other factors

Timing of survey

Non-response rate

Incorrect information

The TTS Data Validation report does not have a section explaining specific underreporting of walking or cycling. The Metrolinx “Big Move Plan” offers this explanation for undercounting of walking and cycling in the TTS data:

“The Transportation Tomorrow Survey (TTS) is a travel survey conducted in the Greater Golden Horseshoe once every five years. Approximately five per cent of the households in the region are surveyed by telephone with questions pertaining to mode choice, trip purpose, trip timing, trip origin and destination, and other related issues... One shortcoming of the TTS is that it counts walking and bicycling trips only if they are undertaken for work purposes. Walking and bicycling trips for other purposes, such as going to school, shopping and visiting friends, are not counted. As a result, these modes are systematically undercounted and information about their use for non-commute trips is lacking, which hampers efforts to match the supply of walking and biking facilities with the demand.” (Metrolinx, 2008, pg. 56)

The Toronto Public Health “Road to Health Report” offers this explanation of TTS data:

“The 2006 census provides information on the number of people walking and cycling to work, while the 2006 TTS provides data on the number of people walking and cycling to school. The number of people who walk and cycle to shopping and other destinations is estimated based on the TTS and walking survey ratios of people who walk and cycle to shopping versus to work.” (Toronto Public Health, 2012 pg. 25)

This seems to contradict information in the 2006 TTS Data Guide, however, which states that all bicycle trip are counted, not just work and school trips (DMG, Oct 2008, pg 1).

It would be useful for researchers, if in the next TTS data set (based on 2012 surveys) this specific issue were more clearly addressed.

Other Limits:

The cycling facilities data was gathered over the course of 2012 and may have changed since 2006. Facilities would likely have been fewer in 2006. The Bike Score data was gathered in 2011 (?) but in the areas we are focused on it is unlikely the data would be significantly different than 2006.

Appendix D- Bikeability and Bike Score™ Methods

The bikeability mapping system and Bike Score™ method was developed by Simon Fraser University researcher Meghan Winters, in partnership with the University of British Columbia-based Cycling in Cities research program and community partners, Walk Score, with funding from a Knowledge Translation Grant through Canadian Institutes for Health Research, in cooperation with pilot cities in Canada (10) and the US (16). It required data sharing across cities and universities and reconciling data from diverse sources. In the case of Toronto, the beta version of results is available on the website (www.walkscore.com/bike), and open source data files from the City of Toronto.

Bikeability for Toronto was defined by looking at five key factors: bike route density, bike route separation, connectivity, topography and destination density. A Bike Score was calculated for each city location, using scores ranging from a low of 0 (deep red) through intermediate levels (yellows) to a high of 100 (deep green). These were used to generate individual heat maps for: bike lanes (facilities); hills; and connectivity and destinations. These three sets of factors were equally weighted to determine overall bikeability. Routes focused on utility cycling (cycling for transport, not recreation) and considered cycle tracks and off street paths (with a weighting of 2), residential bikeways (1.5) and bike lanes (visually but not physically segregated, with a weighting of 1), and excluded the sharrows common in Toronto, shared bus/bike lanes, wide curb lanes and pedestrian trails. Connectivity and destination density measures the network distances to a diverse set of amenities and calculates connectivity metrics such as average block length and intersection density (Walkscore/Bikescore™ Methodology).

Bikescore™ for American cities includes commuter cycling mode share. Canadian Cities do not include this factor.

Information in this appendix was sourced from Winters' presentation at the Velo-City conference (Vancouver, 2012).

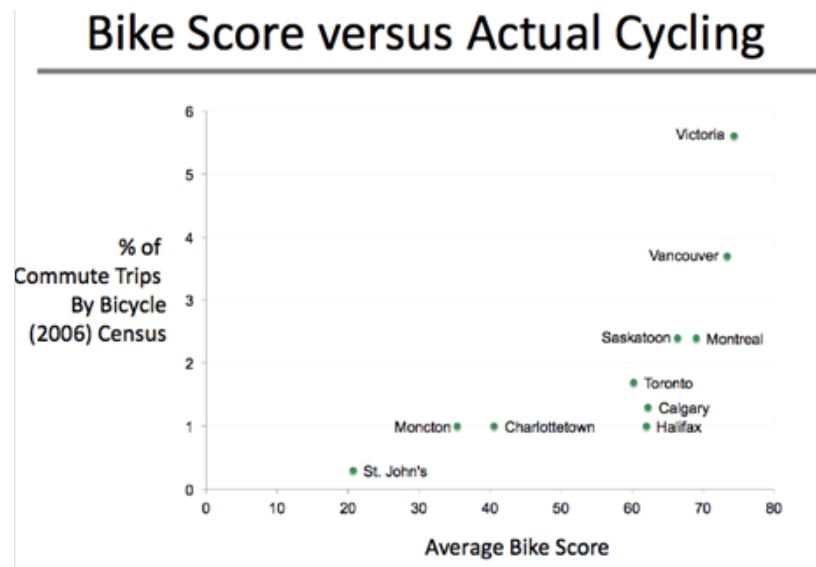


Figure D.1. Bike score compared to cycle mode share in Canadian cities. Source: Winters (2012).

Appendix E- Mode Share and Population Density by Ward

	Ward #	Cycling Mode Share %	Walking Mode Share %	Total Active %	Transit Mode Share %	Automobile Mode Share %	Population Density
	30	4.4	9.5	14.0	31.6	54.5	3941
S	28	3.4	19.8	23.2	38.9	37.9	4209
	13	1.7	6.6	8.2	25.8	66.0	5064
	29	2.5	6.8	9.3	28.1	62.7	5553
	31	1.1	5.1	6.2	31.0	62.9	5826
	32	1.9	1.9	3.8	24.5	66.4	6157
S	22	1.2	8.2	9.3	29.2	61.5	6656
S	21	2.1	6.2	8.2	26.7	65.1	6726
	19	7.5	13.6	21.1	30.0	48.9	7121
	17	1.3	6.6	7.9	29.9	62.2	7261
S	20	4.6	22.9	27.4	31.6	41	7443
S	27	2.0	22.7	24.7	25.9	49.4	8480
	18	5.3	9.7	15.0	35.5	49.5	9124
	14	4.8	9.8	14.6	34.1	51.3	10128
		1.3	7.7	9.0	23.1	68	4606

S= North south subway routes

Appendix F- Population 15 and over by age and sex- 2006 Census

2006 Census	Total	%male	%female
15-19	146,205	51.3	48.7
20-24	172,450	49	51
25-29	190,255	47.5	52.5
30-34	195,670	48	52
35-39	212,600	49	51
40-44	212,600	49.7	50.3
45-49	193,980	48.7	51.3
50-54	168,445	47.6	52.4
55-59	148,120	47.4	52.6
60-64	109,460	46.9	53.1
65+	353,450	42.2	57.8
Total =>15	2,103,235	47.3	52.7
Total =>15		994,830	1,108,404

Appendix G Types of Cycling Infrastructure in Toronto

The table below from Toronto Public Health's 'Road to Health' report (2012) details the current types of cycling infrastructure in Toronto.

Data: City of Toronto Transportation staff (2012), Ville de Montreal (2010), City of Vancouver Bicycle Program Coordinator (2012)

City	Separated bike lanes	On-street bike lanes	Off-road paths	Marked shared lanes (sharrows)	Local street bikeways	Total	Kilometers per 100,000
Montreal	249 km	94 km	84 km	0 ² km	0 km	528 km	28
Toronto	0	113 km	191 km	9 km	147 km	460km	17
Vancouver ²	6 km	30 km	41 km	10 km	134 km	221 km	38

*The values in Table 9 represent approximate kilometers of roadways and pathways with bicycle lanes. A one kilometer path or road with two-way cycling infra-structure is counted as 1 km.

1. Montreal primarily uses sharrow markings in intersections
2. Estimates based on data on one-way lane-kilometers

In 2012, Toronto completed its first cycle track on Sherbourne Street. A Wellesley Street cycle track is due to be built in 2013. Although attractive, many of the off-road paths are only consistently useful as recreational facilities as they do not correspond to commuter traffic patterns nor are they maintained in winter. Many require steep entrances or exits from ravine locations.

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