Spatial Access Measures

Spatial Access Measures 2024 Update Report

Urban
Data
Lab

Release date: July 21, 2025

Statistics   Statistique
Canada   Canada

Canada

How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website, www.statcan.gc.ca.

You can also contact us by

Email at infostats@statcan.gc.ca

Telephone, from Monday to Friday, 8:30 a.m. to 4:30 p.m., at the following numbers:

- Statistical Information Service   1-800-263-1136
- National telecommunications device for the hearing impaired   1-800-363-7629
- Fax line   1-514-283-9350

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, the Agency has developed standards of service which its employees observe in serving its clients. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on www.statcan.gc.ca under "Contact us" > "Standards of service to the public."

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Table of contents

Spatial Access Measures 2024 Update Report

1 Introduction

In 2021, Statistics Canada, in partnership with Housing, Infrastructure and Communities Canada (HICC) began the development of the [Spatial Access Measures](#). These measures were developed to quantify potential access to amenities across Canada by various modes of transportation. The access measure is a numeric value (ranging from 0 to 1) which quantifies the ease of accessing the type of amenity. This led to the release of the Spatial Access Measures data set[1] in 2023 (referred to as the 2022 SAM in this report since that is the vintage of the data) and the methodological report "Active and Public Transportation Spatial Accessibility Measures: Methodology and Key Results"[2] in 2024.

This report discusses the updates of the Spatial Access Measures from 2022 to 2024 in addition to the improvements to how cycling routes are generated, which now incorporates three different personas based on Cabral and Kim's (2021) Level of Cycling Comfort classification system.

In total, eight access measures have been produced: (1) access to employment, (2) access to healthcare facilities, (3) access to public K-12 education facilities, (4) access to public post-secondary facilities, (5) access to grocery stores, (6) access to sports and recreation facilities, (7) access to cultural and art facilities, and (8) access to child care facilities.

This report gives a background of the spatial accessibility measures as they relate to the new additions, data sources and dependencies, methodology (how data was collected, processed, and analyzed), and provide highlights on key results. Specifically, section 2 provides an overview of the updates to the inputs used to calculated the SAM; section 3 details the derivation of the measures and some general results; section 4 show some illustrative examples of the SAM; and section 5 details the limitations of the measures and summarizes the main results of the 2024 update.

2 2024 Updates

This report explains the first set of updates to the SAM. Consistency with the 2022 SAM methodology was an objective; however, there were some changes from the previous approaches with the aim of enhancing the results of model.

2.1 Masses

Destinations and destination masses were derived in similar fashion to the 2021 SAM. In fact, for measures based on open data, the data sets were largely unchanged outside of marginal updates since many of these sources were updated within the last couple of years for the first iteration of SAM. Employment, grocery stores, and health care facilities were updated to 2024 using a similar approach to the 2021 SAM. Child care facilities were added as a new amenity to SAM in this iteration. Masses for this amenity are derived from the count of facilities in a dissemination block[3] based on Business Register[4] data.

2.2 Active Transportation

Travel times based on the active transportation modes were updated using a more recent (September 1st, 2024) OpenStreetMap (OSM) network. Furthermore, there were some changes made to how routes are calculated, particularly with cycling.

---

1. See: [Spatial Access Measures](#).
2. See: [Active and Public Transportation Spatial Accessibility Measures: Methodology and Key Results](#).
3. See: [Dictionary, Census of Population, 2021 – Dissemination block (DB)](#).
4. See: [Business Register (BR)](#).

2.2.1 Cycling Typology & Routing

A significant component of the 2024 update to the Spatial Access Measures includes the grouping of the cycling mode into three cycling personas, to reflect people's willingness and ability to use different types of cycleways and roads. The cycling typology was derived from the Level of Cycling Comfort framework (Cabral & Kim, 2021) and from the Canadian Bikeway Comfort and Safety (Can-BICS) classification system (Winters, Zanotto & Butler, 2019). The three cyclist personas are:

- **All ages and abilities:** the least confident and least able cyclists with a strong preference for dedicated cycle infrastructure and no tolerance for high stress infrastructure. Stress level is quantified by different roadway characteristics, such as speed limit, number of vehicle lanes, adjacency to vehicles, bike lane width and more. Cyclists from this category mainly travel on high to medium comfort cycling infrastructure, such as off-street paved bike paths, protected cycle tracks, multi-use paths and local street bikeways.

- **Cautious:** cyclists with a preference for bike-designated infrastructure but with some tolerance for shared residential roads with low traffic stress.

- **Confident:** as above, but also willing to use lower comfort cycling infrastructure such as painted bike lanes and shared roads with moderate traffic stress.

The cycling typology was integrated into the Spatial Access Measures in two steps: First, by creating a restricted network of bikeways and roadways considered comfortable by each persona, and second, by adjusting parameters in the routing algorithm to adjust characteristics such as cyclist speed.

To create networks for each persona, OSM data for bikeways and roadways was used. Bikeways were categorised using the Can-BICS classification system. Different cycling infrastructures were targeted by filtering with bike specific OSM tags (e.g., bicycle, segregated, traffic calming). Roadways were restricted using OSM tags to filter the network by speed limit and road type (e.g., primary, residential). The bike and road networks were restricted for each persona according to the specifications shown in Table 1. The values for shared roads and painted bike lanes were derived from Cabral and Kim (2021). One exception was that the speed limit tolerated by confident cyclists on shared roads was increased from 40 kph to 50 kph following review of the networks. A speed limit of 40 kph yielded a network too restrictive for routing.

To facilitate connectivity between segments classified in the network corresponding to each persona; each network was supplemented with directly connected, non-conforming segments that have a speed limit of 50 km or less. For example, this allows for travel between two AAA bike paths that are disjoint and require a short traversal on another road to move from one path to the other. While these segments are generally short (less than 100 m), they can be larger depending on how they are defined in OSM. In addition, more than one of these intersecting segments may be traversed along a given route. Cases like these will result in more optimistic estimates of access relative to assuming travel exclusively on segments that correspond to the respective persona and disallowing travel on intersecting segments.

Table 1
Bikeway and roadway characteristics considered comfortable for each cycling persona

Road / Can-BICS bikeway type	Persona		
	Confident	**Cautious**	**All Ages and Abilities**
	kilometres per hour (kph)		
Mixed traffic/ painted bike lane max speed			
Local street bikeway	50	30	30
Residential			
1 lane	50	30	…
2 lanes	50	…	…
3 lanes	…	…	…
Non-residential			
1 lane	50	…	…
2 lanes	…	…	…
3 lanes	…	…	…
Bike path, cycle track, multi-use path	Comfortable for all personas	Comfortable for all personas	Comfortable for all personas

… not applicable
Source: authors' computations.

To calculate the spatial access measures, paths from different origin points to amenities were computed on each network using the Valhalla routing engine. Parameters for the routing were specified for each persona as shown in Table 2, including their average speed, willingness to traverse hills and bad surfaces, and a time cost for each maneuver (turn). The parameter values were derived from experimentation, internal review and validation with existing literature. Since the networks considered have been restricted to OSM features containing tags that correspond to each persona, the specification of parameters, aside from speed, in this iteration of the measures have a reduced bearing on the final scores. Previously, all infrastructure that was tagged as legally cyclable was considered in the cycling measures. This meant that costing played a vital role in both routing along safer and more comfortable infrastructure as well as being used as a heuristic to filter out particularly undesirable cycling routes. With the networks in this update being fundamentally limited in scope prior to routing, this significantly reduced the role that the costing parameters play in the current set of cycling measures.

Table 2
Valhalla costing parameters for each cycling persona

Valhalla parameter	Persona		
	Confident	Cautious	All Ages and Abilities
Willingness to use shared roads (0-1)	1.0	0.5	0
Willingness to use hills (0-1)	0.5	0.2	0
Avoid bad surfaces (0-1)	0.0	0.5	1
	kilometres per hour (kph)		
Cycling speed	18	16	12
	seconds		
Maneuver penalty	4	5	7

Source: authors' computations.

Confident cyclists were assigned the default cycling speed in Valhalla and the other two personas were assigned increasingly slower speeds after internal discussion with active transportation academics and researchers. The all ages and abilities persona had the greatest time penalty for maneuvers as literature suggests intersections and roundabouts are one of the greatest risk factors for cyclists (Møller & Hels, 2008). Lastly, Reynolds et al. (2009) suggested that smooth paved surfaces and low-angled grades improve cyclist safety. These findings were considered when defining the routing parameters in Table 2.

Sub-section 4.2 details the validation strategy for the cycling networks while section 7 includes example output from this validation, including the visualised networks and Street View imagery at sample locations.

2.2.2 Pedestrian Routing

Changes to pedestrian routing were more limited compared to cycling. While costing parameters used for pedestrian routing were largely unchanged, some small adjustments in the routing engine's internal cost of walking on slopes has led to more conservative estimates for walking durations relative to the previous release.

2.3 Transit

Like pedestrian routing, transit routing followed an analogous approach to that of the 2021 SAM measures.

2.3.1 Transit Regions

The generation of transit regions started with the collection of GTFS data for transit services in Canada. The GTFS data was collected from a variety of sources including direct from municipality or transit service websites, via transit data APIs, or through sources found with the help of these transit data APIs.[5]

In preparation for the next step of generating travel time matrices, manual modifications were made to some transit regions and their corresponding data. These manual modifications included:

---

5. See: Mobility Database, Transitland, OpenMobilityData.

- Around Vancouver, British Columbia (BC), the transit region created via the above methodology was manually subdivided into smaller transit regions. This was done because of bounding box overlap combining unconnected transit services (e.g., over water).
- Calendar dates were adjusted in some of the GTFS data to simulate overlap of transit services within individual transit regions.
- Removal of seasonal GTFS data which does not overlap with the selected date range for the transit region.
- Removal of the content in the transfers text file in instances where they lead to routing errors.
- Removal of problematic service IDs and unwanted route types (e.g., the taxi route type).
- Updated time zone to match other GTFS data in a transit region.

2.3.2 Travel Time Matrices

Like the SAM 2021 vintage, Rapid Realistic Routing with R5 R library (r5r) was used to create a routing network for each transit region study area using GTFS and OSM data as inputs. Following the creation of the network, travel time matrix (TTM) parameters were set for how the TTM should be performed by the r5r library. This included defining the modes of travel to include both walking and transit methods, defining the max length of the trip to 90 minutes, and lastly limiting the maximum amount of walking time to 12 minutes. Following the setting of these parameters, specific departure dates and times were selected for each transit region.

Selection of the departure date for each study area was informed by selecting days which were both reflective of a typical transit day but also being a day which was available in all GTFS source data contained within the transit region. When possible, identical days were used for most travel time analysis but in some cases data availability required using an alternative date. With updated GTFS data available at the start of 2025, departure dates fell in the range between March 2024 and January 2025, with most selected days being in January 2025. In addition to considering data availability, dates were also selected based on a typical workday. Consequently, dates were always on a weekday, never on a holiday, and were selected in the middle of the work week. Lastly, selection of departure times also attempted to capture the ebb and flow of typical transit travel. To accomplish this, departure times at the start of the day (7:00 am) and mid-afternoon (2:00 pm) were selected to provide a richer view of transit analysis in each region.

With the departure days selected, the r5r TTM analysis was generated for each transit region, using the representative travel origin/destination points. This resulted in 68 different transit region TTMs for two departure times: 7:00 am (peak) and 2:00 pm (off-peak).

3 Measures

Access to all seven amenity destinations were computed with the same gravity model used in the 2021 SAM indicators. Consistent with the previous release of SAM, the dual of the gravity model was applied to estimate the level of access to grocery stores. An explanation of both models is detailed below.

3.1 Methodology

The formulation of the gravity model remains the same as in previous iterations (Newstead et al. 2024) where the attractiveness of a destination point j from an origin point i is proportional to the amenity mass (m) at j and to the willingness to travel (f) the duration (d) between i and j. Less formally, a place becomes more attractive if it has more or higher quality amenities, and if it's close enough such that people are willing to travel there. Given that, the access level (AL) of origin point i is the summation of the destination attraction of all destinations J within a designated range of i. That is, the attractiveness of each nearby place is summed to find the overall access level for a location. The impedance function, which is expressed as $f\left(d_{i,j}\right)$ is a negative exponential cumulative distribution function with the parameter, λ, is chosen such that the median duration of travel to that amenity corresponds to the midpoint of the interval [0,1]. More simply, a downward sloping curve was used to model the effect on willingness-to-travel based on how long it takes to travel to a destination. The curve was adjusted such that the median travel time to that amenity indicated in the General Social Survey (GSS) Time-Use Survey is halfway between 0 and 1.

The conditions defining the access level for a geographic unit i are illustrated below:

$$AL_i = \sum_{j \in J} f\left(d_{i,j}\right) \cdot m_j$$

where

$$f\left(d_{i,j}\right) = 1 - \left(1 - e^{-\frac{d_{i,j}}{\lambda}}\right)$$

And is rescaled into index form:

$$SAM_i = \frac{AL_i - \min\left(AL\right)}{\max\left(AL\right) - \min\left(AL\right)}$$

Likewise, the formulation of the dual of the model – which is only used for the grocery stores measure – remains the same. Whereas the gravity (or primal) model can be thought of as the number of opportunities that are reachable within a certain time constraint, the dual can be thought of as the length of time it takes to access a certain number of opportunities. This model is expressed as:

$$AL_i = \max\left(Q_{i,j} \cdot d_{i,j}\right)$$

That satisfies:

$$\min_Q \sum_{j \in J} m_j \cdot Q_{i,j} \cdot d_{i,j}$$

Subject to:

$$\sum_{j \in J} m_j \cdot Q_{i,j} \geq n$$

$$Q_{i,j} \in \left\{0,1\right\}$$

Where Q is the binary origin-destination (OD) matrix of the DB-to-DB network pairs, $d_{i,j}$ is the travel duration between origin i and destination j, n is some threshold of the count of amenities, and m_j is the mass of amenities in the destination DB j. The mass used is the count of grocery stores in a DB.

The time travel cut-off for transit is 90 minutes and 30 minutes for both cycling and walking. This cut-off was chosen to reflect the upper end of travel time to a place of work for each mode.

3.2 Validation

There were three main aspects of validation for the Spatial Access Measures and its dependencies: validating inputs for the computation of TTMs; validating the end results of the TTMs; and validating the resulting access scores for each destination type.

The validation process for the TTM inputs involved ensuring the OSM data extract matched what was expected. This involved looking at individual street segments for the three cycling persona networks. These segments were randomly chosen for each network and compared to Google Street View imagery. If the street view image appeared to show a piece of infrastructure that matched the description in the typology, it was deemed accurate.

If it didn't match, the vintage of the imagery was accounted for as a potential limitation. Sample validation imagery from this process can be seen in Figures 4-18 in the appendix.

To validate the TTMs for each cycling persona, walking, and transit (peak and off-peak), random origin dissemination blocks (DB) were chosen from within several census metropolitan areas (CMAs) and census agglomerations (CAs). For each selected origin DB, the corresponding destination DBs were subset from the TTM and visualized in the open-source software QGIS.[6] Spatial patterns were analyzed to see if the distribution of travel times matched expectations based on the travel mode and region. The data was also compared to the previous iteration to ensure that any discrepancies were justified based on methodological changes to the mode or changes to the networks caused by infrastructure developments.

Finally, access scores for each amenity and destination type was visualized among a subset of CMAs and CAs to validate the final model outputs. Apart from cycling transport modes, access levels were compared to the levels from SAM 2021 to ensure consistency between datasets. Additionally, access levels for all amenities and transport modes were visually assessed for coherence with their corresponding destination masses. The following CMAs were included to ensure major urban areas were analysed: Ottawa/Gatineau, Toronto, Montreal, Halifax, Winnipeg, Calgary, and Vancouver. In addition, ten additional random CMA and CAs were also included to give a better national scope.

3.3 Results

The tables below show the percentage of the population in the bottom, middle, and top accessibility tercile for the respective transportation modes and amenities. The "No access" column refers to populations that do not have access to the amenity. Population percentages in the tables below are based on DB populations.

3.3.1 Access to Child Care

Nationally, 73.8% of Canadian's have access to a child care facility within a 30-minute walk. There is considerable variation across provinces and territories with British Columbia having the highest proportion of population with access (78.5%) and Nunavut having the lowest (13.7%).

Table 3
Access to child care facilities within 30 minutes by walking, percent of population by accessibility tercile

	Percent of population by access tercile			
Province and territory	Bottom tercile	Middle tercile	Top tercile	No Access[1]
	percent			
Newfoundland and Labrador	24.0	13.2	2.6	60.2
Prince Edward Island	12.5	18.3	13.4	55.8
Nova Scotia	22.0	13.1	7.8	57.1
New Brunswick	21.8	17.9	9.4	50.9
Québec	19.0	22.6	35.7	22.7
Ontario	20.4	27.6	28.4	23.5
Manitoba	14.1	21.6	34.1	30.2
Saskatchewan	20.6	24.0	14.7	40.7
Alberta	18.0	26.6	31.5	24.0
British Columbia	13.6	19.3	45.6	21.6
Yukon	27.0	13.8	17.3	42.0
Northwest Territories	21.4	12.6	8.1	58.0
Nunavut	10.1	3.6	0.0	86.4
Canada	18.7	24.0	31.1	26.1

1. "No access" is the percentage of the population in areas with an access index value of zero.
Source: authors' computations.

---

6. See: QGIS Web Site.

3.3.2 Access to Healthcare

Nationally, 75.1% of Canada's population can access a healthcare facility within 90 minutes using public transit, with a relatively uniform distribution across terciles (29.4%, 24.1%, and 21.6% in the top, middle, and bottom terciles, respectively). There is, however, significant variation between provinces. The province with the most access within 90 minutes is British Columbia (90.2%), while the lowest is Newfoundland and Labrador (29.4%).

Only two provinces, British Columbia (90.2%) and Ontario (83.2%), are above the nationwide access percentage.

Table 4
Access to healthcare facilities within 90 minutes using public transit during off-peak hours, percent of population by accessibility tercile

| | Percent of population by access tercile | | | |
| | Bottom tercile | Middle tercile | Top tercile | No Access[1] |
Province and territory	percent			
Newfoundland and Labrador	17.3	12.1	0.0	70.6
Prince Edward Island	32.4	1.9	0.0	65.7
Nova Scotia	14.2	18.4	6.7	60.7
New Brunswick	24.2	12.4	0.2	63.2
Québec	20.1	18.9	32.4	28.7
Ontario	24.1	26.8	32.3	16.8
Manitoba	6.5	22.3	31.0	40.1
Saskatchewan	9.5	32.9	7.2	50.4
Alberta	15.7	29.7	27.1	27.5
British Columbia	29.8	24.1	36.3	9.9
Yukon	30.3	32.2	0.1	37.5
Northwest Territories	46.5	0.0	0.0	53.5
Nunavut	0.0	0.0	0.0	100.0
Canada	21.6	24.1	29.4	24.9

1. "No access" is the percentage of the population in areas with an access index value of zero.
Source: authors' computations.

3.3.3 Access to grocery stores

Table 5 and Table 6 below show the percentage of the population falling in a DB with access to the nearest and 3rd nearest grocery stores within 30 minutes of walking time. About 45% of Canada's population in a DB has access to one grocery store within 15 minutes (Table 5) and 14.3% of Canada's population in a DB has access to three grocery stores within 15 minutes (Table 6).

Overall Québec, Ontario, and British Columbia have a higher percentage of their population in DBs with access to grocery stores while the Northwest Territories, Nunavut, and maritime provinces have none or limited access within a 15-minute walk. Generally, the percent of the population that has access falls with the requirement to reach more stores within 15 minutes.

For accessing the nearest grocery store within 15 minutes walking, Québec, Nunavut, Ontario, and British Columbia have the highest coverage at 49.8%, 49.1%, 49%, and 48.4%. Prince Edward Island, Newfoundland and Labrador, and Nova Scotia have the lowest coverage at 18.1%, 19.3%, and 22.6%.

Table 5
Access to nearest grocery store by walking, percent of population above and below 15-minute threshold

Province and territory	Between 15 and 30 minutes	Within 15 minutes	No access[1] within 30 minutes
	percent		
Newfoundland and Labrador	18.6	19.3	62.1
Prince Edward Island	18.3	18.1	63.6
Nova Scotia	19.7	22.6	57.6
New Brunswick	18.9	18.9	62.2
Québec	25.2	49.8	25.1
Ontario	28.6	49.0	22.4
Manitoba	28.5	40.2	31.2
Saskatchewan	28.6	30.2	41.2
Alberta	34.2	37.7	28.1
British Columbia	26.1	48.4	25.4
Yukon	20.9	17.8	61.3
Northwest Territories	30.4	37.6	32.0
Nunavut	23.9	49.1	27.0
Canada	27.5	45.0	27.5

1. "No access" is the percentage of the population in areas with an access index value of zero.
Source: authors' computations.

Regarding access to the third nearest grocery store within a 15-minute walk, Québec (19.7%), British Columbia (19.3%), and Ontario (14.8%) have the highest coverage (Table 5). Northwest Territories and Yukon have the lowest coverage with 1.0% and 0.3% of their populations with access to three grocery stores within 15 minutes. 95.8% of Nunavut's population has no access to three grocery stores within 30 minutes of walking.

Table 6
Access to the third nearest grocery store by walking, percent of population above and below 15-minute threshold

Province and territory	Between 15 and 30 minutes	Within 15 minutes	No access[1] within 30 minutes
	percent		
Newfoundland and Labrador	8.4	2.5	89.1
Prince Edward Island	9.2	3.3	87.5
Nova Scotia	12.5	4.9	82.7
New Brunswick	9.4	1.6	89.0
Québec	26.9	19.7	53.4
Ontario	37.0	14.8	48.2
Manitoba	27.6	9.9	62.4
Saskatchewan	24.1	4.9	71.1
Alberta	30.2	6.7	63.2
British Columbia	31.2	19.3	49.4
Yukon	3.9	0.3	95.8
Northwest Territories	18.4	1.0	80.5
Nunavut	10.6	6.4	83.0
Canada	30.6	14.3	55.1

1. "No access" is the percentage of the population in areas with an access index value of zero.
Source: authors' computations.

3.3.4 Access to cultural and arts facilities

Table 7 shows the level of access to a Cultural and Arts Facility (CAF) within 30 minutes of cycling under the 'all ages and access levels' persona. Approximately 50.5% of Canadians have access to cultural and arts facilities via all ages and abilities cycling infrastructure, with over half of residents of all provinces and territories except for British Columbia (36.2%), Québec (43.0%), Manitoba (47.1%), and Ontario (50.0%) having no access. Almost 30% of British Columbians have access in the top tercile, compared to 18% nationwide.

Table 7
Access to recreational facilities within 30 minutes by bike based on the all ages and abilities cycling persona

Province and territory	Percent of population by access tercile			
	Bottom tercile	Middle tercile	Top tercile	No Access[1]
	percent			
Newfoundland and Labrador	4.2	0.9	3.1	91.9
Prince Edward Island	16.4	1.4	5.6	76.6
Nova Scotia	6.9	4.2	6.7	82.1
New Brunswick	5.9	4.4	14.0	75.7
Québec	18.8	20.4	17.8	43.0
Ontario	15.2	16.6	18.2	50.0
Manitoba	17.6	14.8	20.5	47.1
Saskatchewan	15.5	9.3	9.7	65.4
Alberta	22.0	12.8	11.3	53.9
British Columbia	16.2	17.7	29.9	36.2
Yukon	2.7	5.1	3.7	88.6
Northwest Territories	31.1	0.0	0.0	68.9
Nunavut	0.0	0.0	0.0	100.0
Canada	16.5	16.0	18.0	49.5

1. "No access" is the percentage of the population in areas with an access index value of zero.
**Source:** authors' computations.

4 Case studies

The following case studies illustrate SAM scores in municipalities across Canada and how the measures can be interpreted.

4.1 Halifax

Figure 1 shows the relative amount of spatial access to educational facilities by walking in Halifax Regional Municipality. The highest access is concentrated around the Halifax Harbour, namely the Halifax Peninsula, Dartmouth, and Woodlawn. Access gradually decreases as the city outskirts are approached. Suburban communities such as Lower Sackville and Bedford have reasonable access to educational facilities. For smaller communities, access decreases faster and more abruptly away from access hotspots. The lower access can be explained by the reduced pedestrian and road network, which restricts walking and increases total travel time.

In more rural areas, access via walking is generally non-existent or low, with little to no spread of access to dissemination blocks surrounding educational facilities. Again, this is linked to the smaller and less connected transport networks available in areas away from city centers. Within rural areas, access to educational facilities is restricted to one or two dissemination blocks containing schools, with all neighbouring dissemination blocks having no access. This can be observed in communities like Stillwater Lake and Lawrencetown.

Figure 1
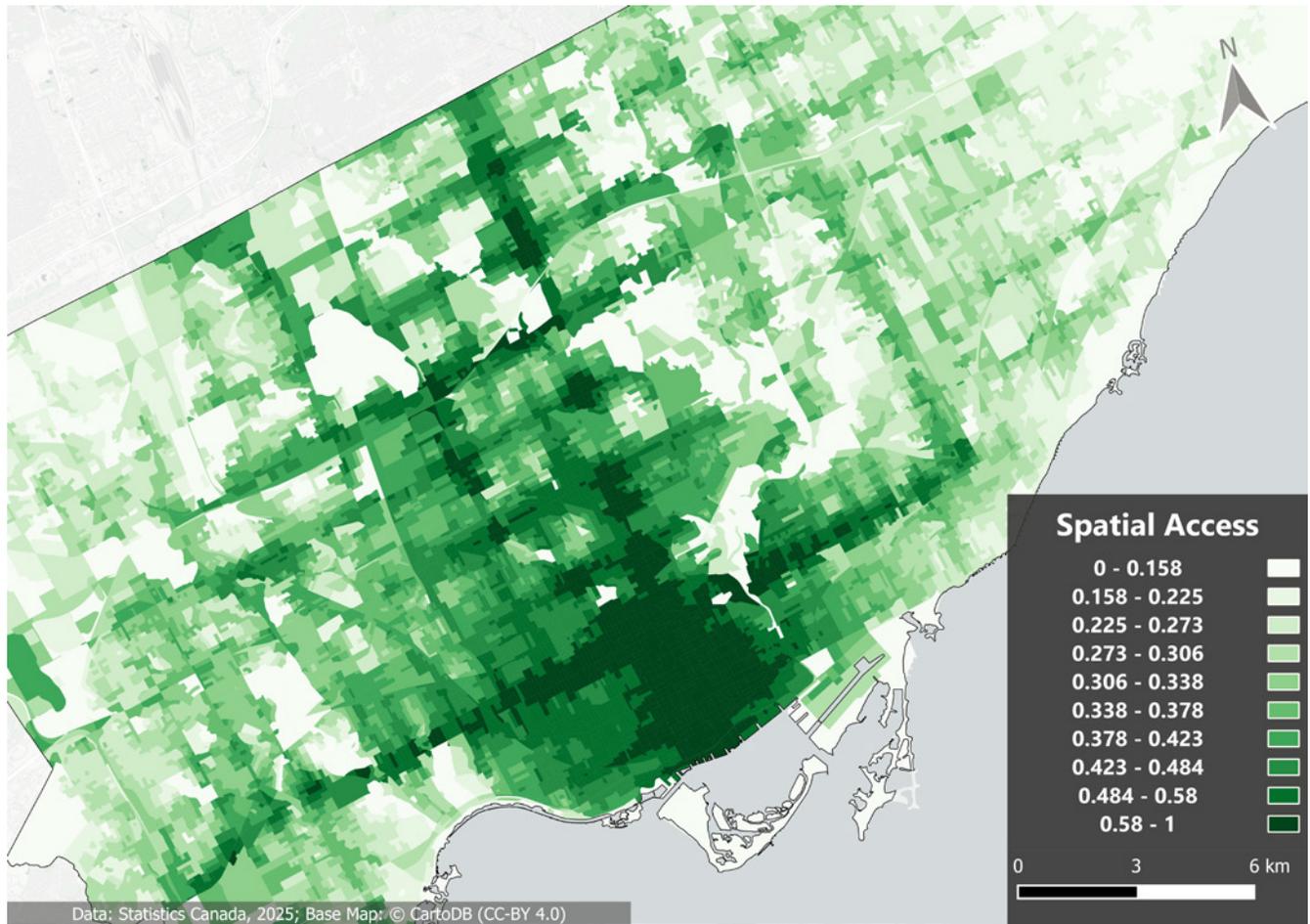**Results of access index to educational facilities by walking in Halifax**
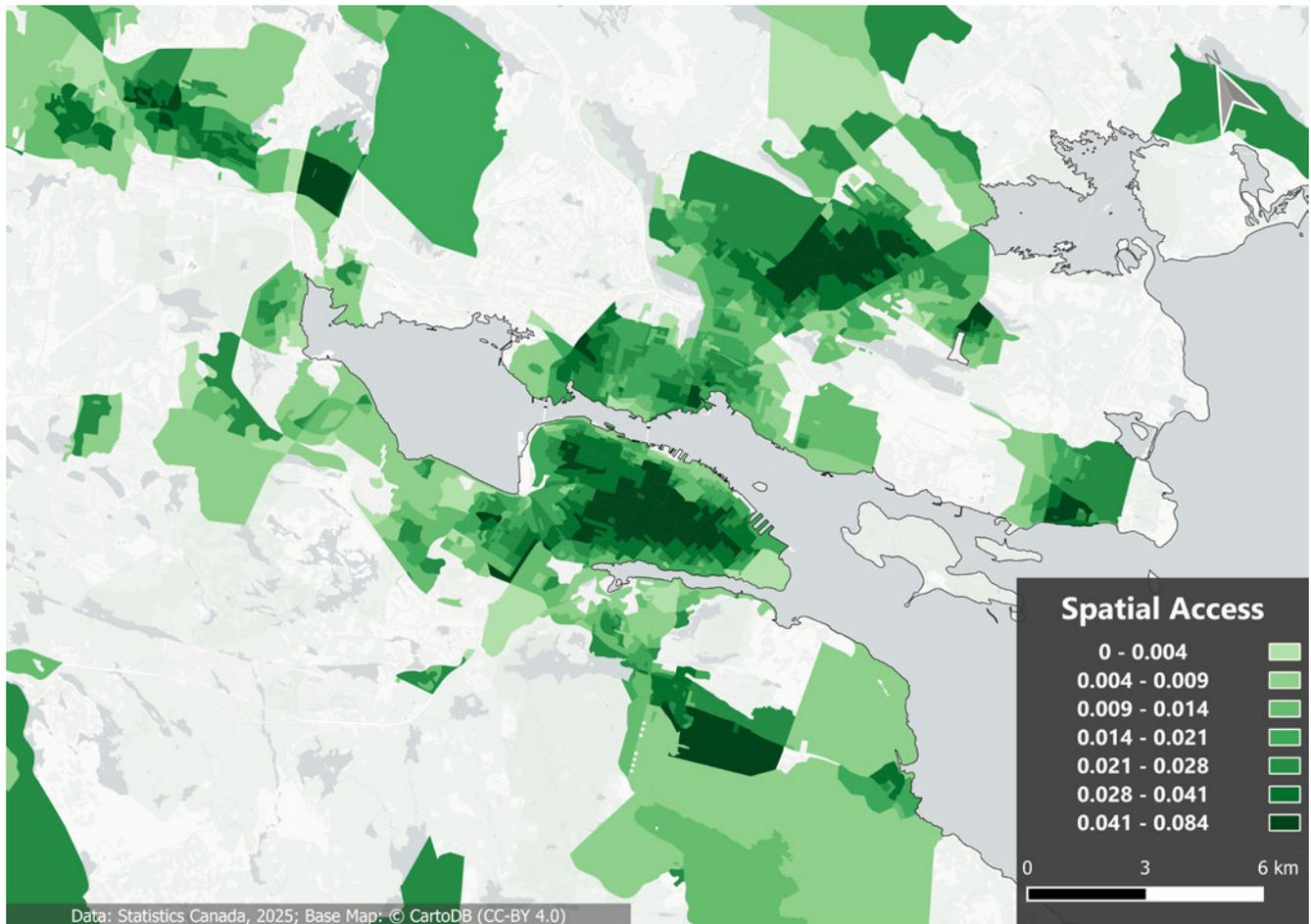
Note: Symbology is based on deciles for the CSD of Toronto (10-quantiles, or ten continuous intervals with equal amounts of observations). Intervals consisting of only zeroes have been removed from the symbology. The index values are scaled between 0 and 1 where 0 is the minimum value for all of Canada while 1 is the maximum value for all of Canada. Since the index values are relative to the minimum and maximum values nationwide, most values appear quite close to 0.
Source: Statistics Canada, Centre for Special Business Projects & © OpenStreetMap contributors, © CARTO.

4.2 Toronto

Figure 2 shows the relative amount of spatial access to employment for those traveling by public transportation in Toronto during peak hours. The downtown core as expected has the highest access. This is logical because of the high density of employment and easy availability of public transportation. Additionally, there is a high level of access along Bloor St, Danforth Ave, Yonge St, as well as the other major roads within the city. These are all roads that have good subway, streetcar, and/or bus coverage. Lower access is also seen around parks and more suburban neighbourhoods. A good example of this is Scarborough, a more suburban part of Toronto, where access is much lower than downtown Toronto and the other neighbourhoods within the city. In general, our expectation that the highest access will be around large employment centres and transit networks is reflected in the spatial access measures.

Figure 2
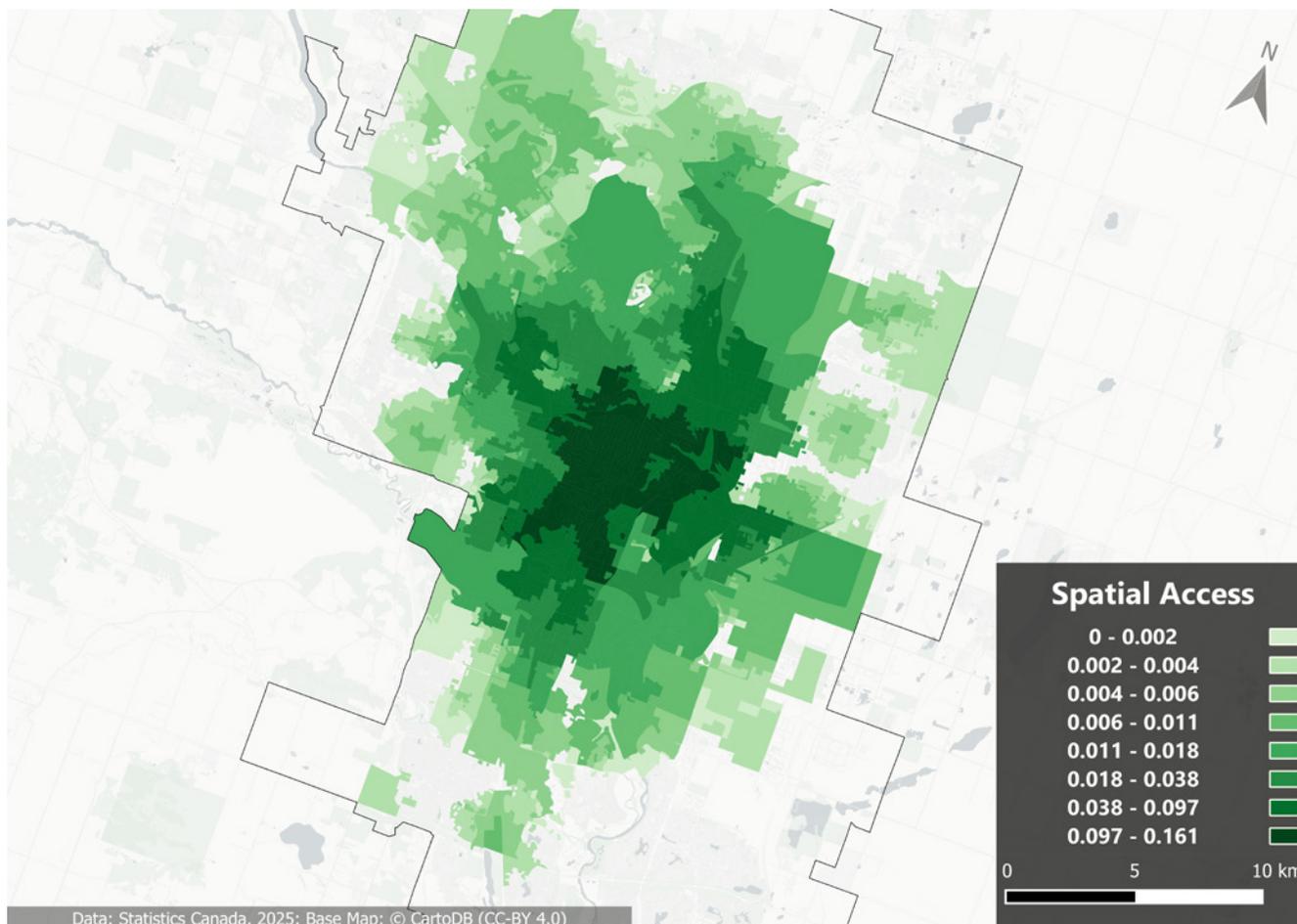**Results of access index to employment by peak transit in Toronto**

Note: Symbology is based on deciles for the CSD of Toronto (10-quantiles, or ten continuous intervals with equal amounts of observations). Intervals consisting of only zeroes have been removed from the symbology. The index values are scaled between 0 and 1 where 0 is the minimum value for all of Canada while 1 is the maximum value for all of Canada. Since the index values are relative to the minimum and maximum values nationwide, most values appear quite close to 0.
Source: Statistics Canada, Centre for Special Business Projects & © OpenStreetMap contributors, © CARTO.

4.3 Calgary

Figure 3 shows the relative spatial access to cultural and art facilities by cyclists fitting the "all ages and abilities" persona. As defined in Table 1, these cyclists have zero tolerance for high stress infrastructure and mostly travel on dedicated cycling infrastructure. Access is greatest in the city center, however, the maximum access index value for an DB is 0.16, which is below the national average. While access declines gradually further from the city center, there are several segments of relatively high access connected to the city center, along dedicated bike friendly infrastructure, such as the Bow River Pathway (West), Elbow River Pathway (Southwest), and the Nose Creek Pathway (North). Lastly, the city outskirts contain no access to cultural and art facilities, even when bike infrastructure is available, likely due to a reduction both in the number of cultural and art facilities and reduced cycling infrastructure.

Figure 3
Results of access index to culture and arts facilities by cycling (all ages and abilities) in Calgary

Note: Symbology is based on deciles for the CSD of Toronto (10-quantiles, or ten continuous intervals with equal amounts of observations). Intervals consisting of only zeroes have been removed from the symbology. The index values are scaled between 0 and 1 where 0 is the minimum value for all of Canada while 1 is the maximum value for all of Canada. Since the index values are relative to the minimum and maximum values nationwide, most values appear quite close to 0.
Source: Statistics Canada, Centre for Special Business Projects & © OpenStreetMap contributors, © CARTO.

5 Discussion and Limitations

This update represents a significant leap forward in the SAM's accuracy and reliability. This overhaul reflects months of intensive work and the integration of new sources particularly with respect to public transit feeds. Likewise, the refinements to cycling routing now provide a more nuanced picture of access by that mode.

While interpretation of the Spatial Access Measures and accompanying limitations generally remain consistent with those of the previous release, these are restated here for the benefit of the reader.

The first set of limitations is related to the OSM network itself. While the OSM network is one of the most comprehensive and complete road networks openly available, it is not a perfect source of information. The network itself is generated from open data sources and from OSM contributors. This means that areas with fewer active contributors will generally have less up-to-date coverage. Moreover, the tagging of networks is not always accurate or complete, even in areas with many active contributors.

The second set of limitations is related to GTFS data. First, schedules do not necessarily reflect the actual frequency of services. There can be any number of occurrences that result in the deviation of a public transit route from its schedule. Some such examples are vehicle breakdown, traffic, car accidents, construction, etc. Thus,

the travel time estimates for transit are based on a best-case situation. That is, all routes are running according to schedule. A second limitation posed by GTFS data is that this type of data is not available in all areas where transit exists. As time goes on, the number of GTFS feeds publicly available has increased but still, not all transit operators provide GTFS data. In addition, since GTFS data is schedule-based, informal forms of public transit are not well-represented. Lastly, GTFS data can be of varying quality.

The third set of limitations is associated with active transportation. Firstly, the typology used to generate travel times by bike are abstractions that do not necessarily reflect any one cyclist. Furthermore, the literature on cyclist typologies generally agrees on some main aspects of the personas used in this analysis, but there is no consensus agreed upon approach. Thus, there will be some disagreement as to specifically which infrastructure and parameters should be specified for each persona within the typology. With respect to bike routing, intersectional segments are included in the network to mitigate issues with short breaks in each of the respective networks. In general, the lengths of these intersectional segments are short but in exceptional cases these could lead to optimistic estimates of access for the persona. For pedestrian routing, while certain costing parameters such as penalizing hills and prioritizing sidewalks focus on comfort and usability, full physical accessibility for all ages and abilities is not accounted for in this analysis. In both cases, there is some potential for measurement error stemming from representative points being snapped to the road network to calculate routing by the routing engine. In most cases, these are non-consequential as the representative points of DBs are often near the network. However, there are some cases where the representative point is further and thus snapping may occur over a greater distance, up to a few hundred metres.

There are also limitations related to the data for the amenity locations. With respect to those based on open data, the quality and quantity of such data varies across municipalities and provinces. This means that the quantity of amenities and consequently, the access in some regions, may be underrepresented relative to regions that have more complete or comprehensive open data sources. This is more apparent in the access to sports and recreational facilities measures but plays a small role in the measures for the other amenities.

Overall, this 2024 update of SAM provides a more nuanced picture of access by cycling and walking as well as the opportunity to view changes in the SAM over time. While there is still room for improvement and expansion of the SAM, this update provides a marked improvement in how potential access to amenities is measured across Canada.
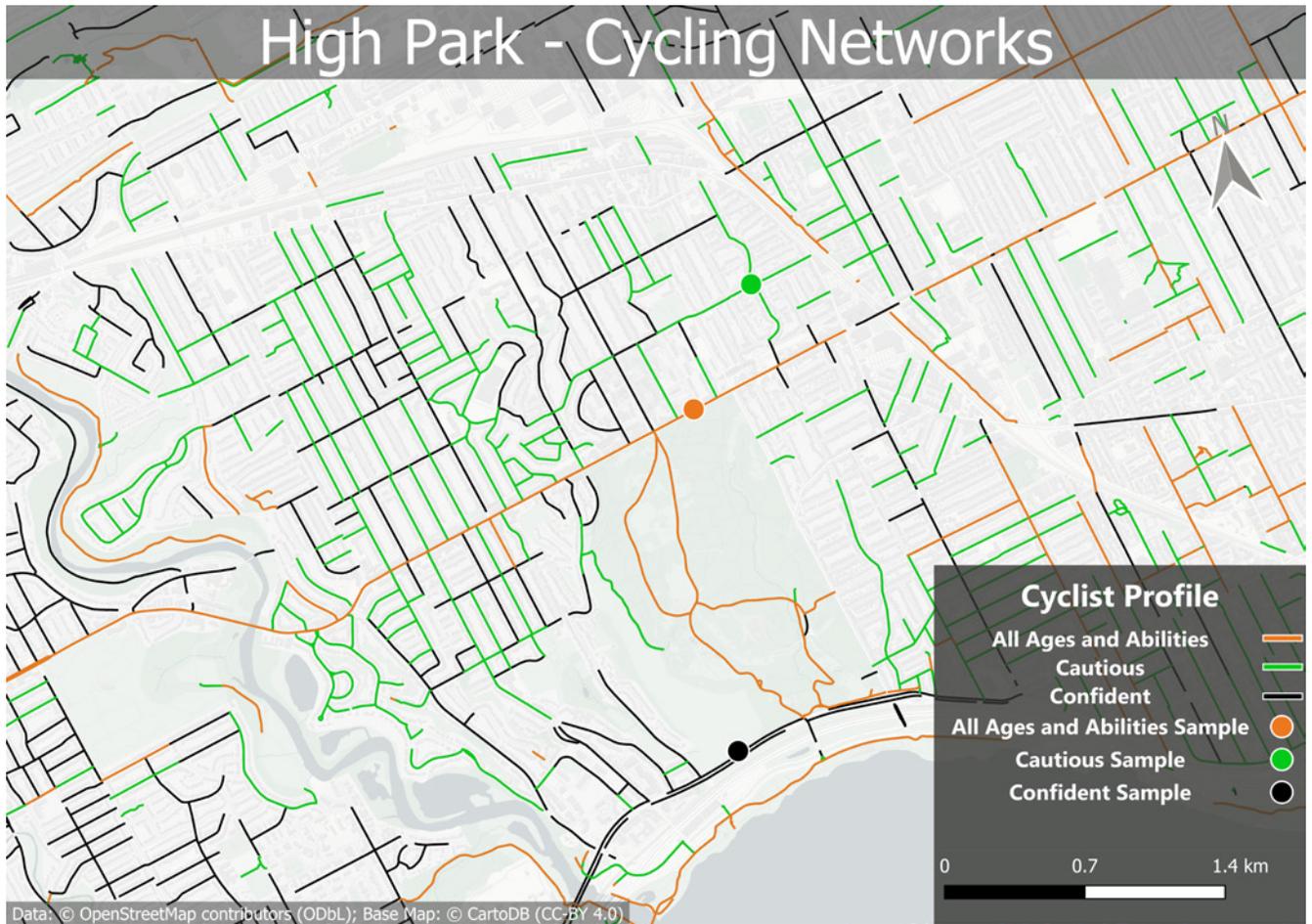
Appendix - Validation of restricted cycling networks

Figure 4
OSM cycling networks in downtown Toronto
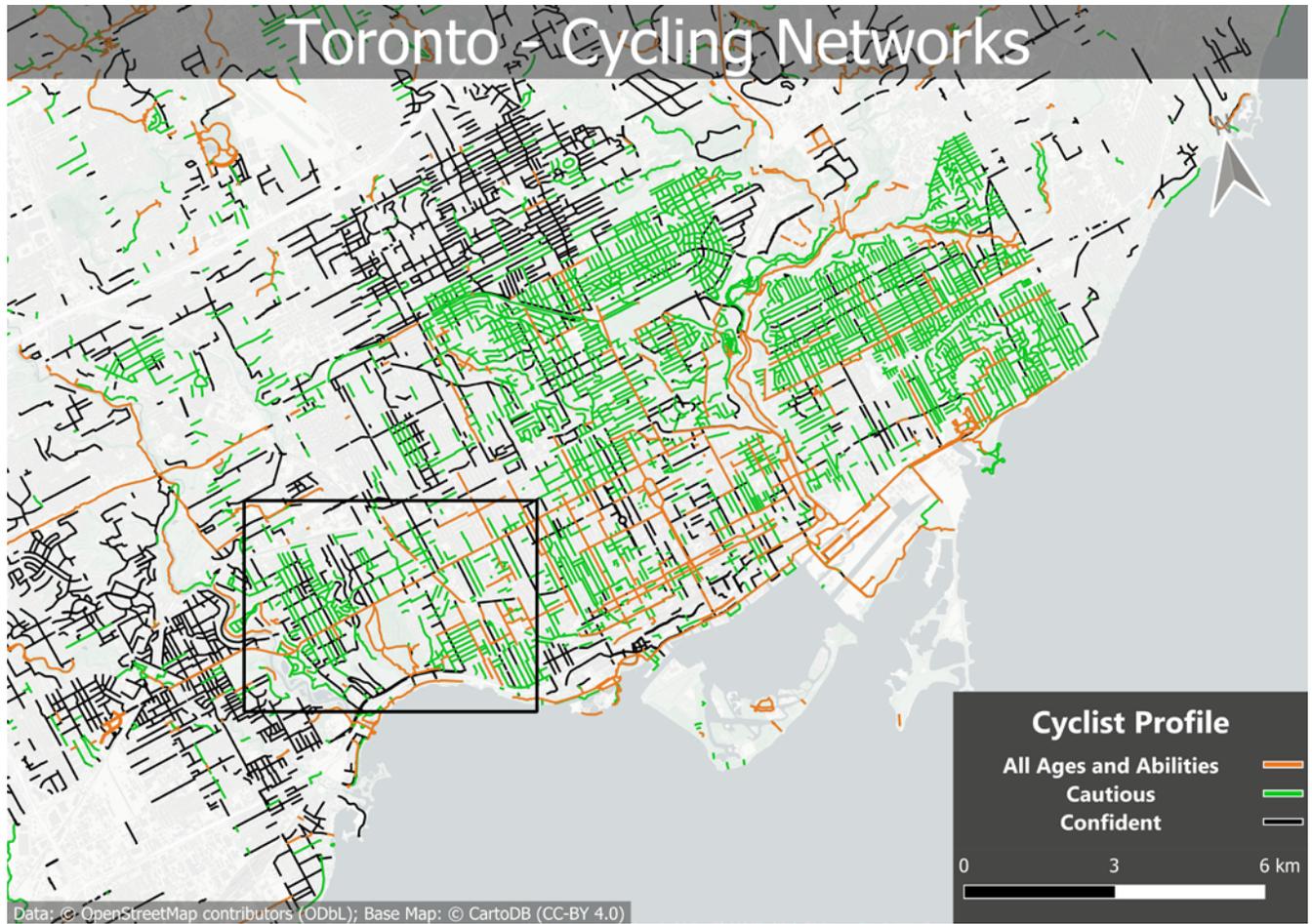
Source: Statistics Canada, Centre for Special Business Projects & © OpenStreetMap contributors, © CARTO.

Figure 5
OSM cycling networks in the Toronto neighbourhood of High Park

Source: Statistics Canada, Centre for Special Business Projects & © OpenStreetMap contributors, © CARTO.

Figure 6
Street view sample of the All Ages and Abilities cycling network in the Toronto neighbourhood of High Park

Source: Statistics Canada, Centre for Special Business Projects & © Google Streetview & Google Maps.

Figure 7
Street view sample of the Cautious Majority cycling network in the Toronto neighbourhood of High Park

Source: Statistics Canada, Centre for Special Business Projects & © Google Streetview & Google Maps.

Figure 8
Street view sample of the Confident cycling network in the Toronto neighbourhood of High Park

Source: Statistics Canada, Centre for Special Business Projects & © Google Streetview & Google Maps.

References

Cabral, L., & Kim, A. (2021). An Empirical Reappraisal of the Level of Traffic Stress Framework. Travel Behaviour and Society, 26, 143-158.

Møller, M. and Hels, T., 2008. Cyclists' perception of risk in roundabouts. Accident Analysis & Prevention, 40(3), pp.1055-1062.

Newstead, N., Giunta, C., Hobbs, K., & Birkett, S. 2024. Active and Public Transportation Spatial Accessibility Measures: Methodology and Key Results. *Reports on Special Business Projects*, Statistics Canada.

Pereira, Rafael H. M., Saraiva, Marcus, Herszenhut, Daniel and Braga, Carlos Kaue. 2021. "R5r: Rapid Realistic Routing on Multimodal Transport Networks with R5 in R." Findings, March. https://doi.org/10.32866/001c.21262.

Reynolds, C.C., Harris, M.A., Teschke, K., Cripton, P.A. and Winters, M., 2009. The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. Environmental health, 8, pp.1-19.

Useche, S.A., Alonso, F., Montoro, L. and Esteban, C., 2018. Distraction of cyclists: how does it influence their risky behaviors and traffic crashes?. PeerJ, 6, p.e5616.

Winters, M., Zanotto, M., & Butler, G. (2020). At-a-glance-The Canadian Bikeway Comfort and Safety (Can-BICS) Classification System: a common naming convention for cycling infrastructure. Health promotion and chronic disease prevention in Canada: research, policy and practice, 40(9), 288.