PEMBINA institute

Cycle Cities

Supporting cycling in Canadian cities

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Photo: Roberta Franchuk, Pembina Institute

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1 Introduction

Across Canada, cycling is growing in popularity as a daily commuting option. It offers a convenient and affordable solution to crowded transit and congested streets in urban areas, and is also growing in some suburbs. However, not all cities are investing in cycling infrastructure to the same degree, particularly when it comes to creating separated lanes and other measures that improve safety and attract new cyclists.

This study compares cycling in five of Canada's largest cities: Toronto, Montreal, Vancouver, Calgary and Ottawa. It analyzes how well cycling networks serve residents in each of these cities, and how effectively each city has responded to the growth in cycling and the demand for safer and more accessible infrastructure that takes cyclists where they want to go.

Key findings

1. Montrealers bike the most, with around 115,000 daily trips, followed by Torontonians with around 96,000 daily trips.

2. Calgary has 578 kilometres of multi-use trails, the most of the five cities studied.

3. Montreal has the most separated cycling lanes — 72 kilometres of separated cycling facilities across the island.

4. 100% of Ottawa and Vancouver's rapid transit stations are within 400 metres of cycling paths.

5. Vancouver has the highest cycling mode share. Over 4% of all trips in the City of Vancouver are by bicycle.

2 Summary of analysis

	Toronto	Montreal	Vancouver	Calgary	Ottawa
Total bicycle infrastructure (on-street and off-street paths) (km)	640	648	289	**1032**	221
Bicycle infrastructure per 100,000 people (km)	24	35	48	**94**	66
On-street bicycle lanes* (painted or physically separated) (km)	128	**234**	62	43	54
Multi-use trails (km)	364	269	42	**578**	167
Percent of rapid transit stations within 400 m of bicycle path	76%	82%	**100%**	89%	**100%**
Crash rate per 100,000 cycling trips	5	**2**	**2**	4	3

*Includes separated bicycle lanes protected from traffic by bollards or medians and non-separated lanes demarcated by a painted line.

Table 1: Comparison of bicycle infrastructure and other metrics in major Canadian cities

Photo: Ken Ohrn

3 Cycling infrastructure

This report compares cycling infrastructure in major Canadian cities. There are many different types of cycling infrastructure that are appropriate to different environmental contexts like residential streets, major arterial roads, and parks. Determining which type of infrastructure is needed throughout a cycling network is crucial to building a comprehensive and cost effective system.

Cycling facilities are chosen based on local context (vehicular traffic, level of cycling in area, etc.) and cost. While these categories could be divided even further, in this report we have categorized bicycle facilities into four categories. The main differences are between how and if these bicycle lanes are separated or shared with other road users — pedestrians and/or vehicles.

3.1 Signed bicycle routes

Signed bicycle routes are on local streets, sometimes traffic calmed streets, that are shared with vehicular traffic. Signed bicycle routes are useful to direct cyclists off of major streets and are easier to implement than designated bicycle lanes as there is no effect on vehicular traffic. These paths are demarcated as cycling routes through painted arrows and bicycle icons ('sharrows' or 'chevrons') on the road, bicycle logos on street signs, or cycling wayfinding signage. These signs help cyclists find bicycle routes and also signal to drivers that they are sharing the road with cyclists. Some cities, like Vancouver, have reduced the speed limit on many local street bicycle routes to 30 kilometres per hour.

'Sharrow' in Toronto

3.2 On-street bicycle lanes (painted or separated)

There are two types of on-street bicycle lanes: painted lanes and physically separated lanes. These designate road space just for cyclists, with the aim of increasing the safety and prominence of cyclists on roadways. They are also important for connecting cyclists directly to major destinations for work, school, and shopping.

Physically separated bicycle lanes run adjacent to a street, but are fully separated from vehicular traffic with bollards, planters, raised level or a median. Physically separated bicycle lanes are often referred to as 'cycle tracks'.

Bi-directional separated cycle track on 7 Street SW in Calgary

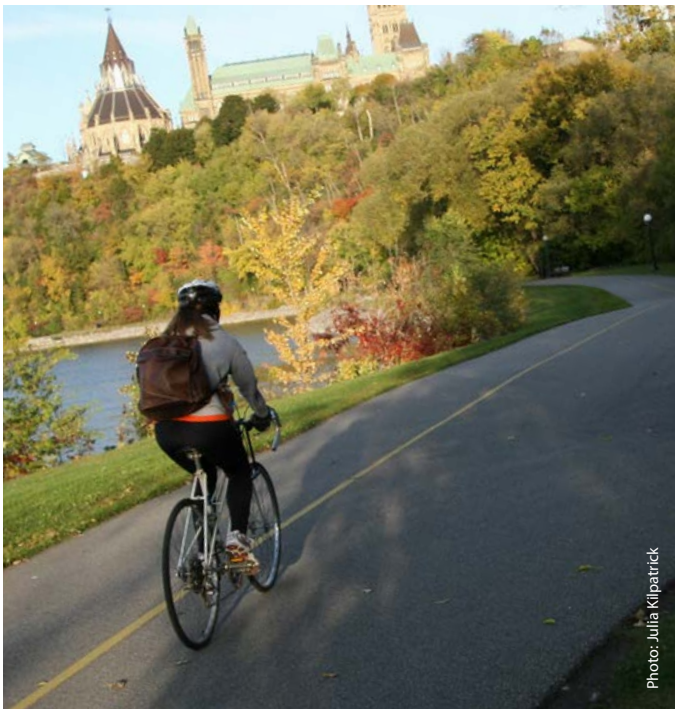
Painted bicycle lanes are only separated from vehicular traffic by painted lanes, pavement colouring or pavement texture. While vehicles are not allowed to cross into bicycle lanes without separation, there is no physical barrier to prevent cars from entering the bicycle lane. A small number of painted bicycle lanes in this category in Vancouver are positioned on the curbside of parked vehicles, with a painted buffer zone. Vehicles may inadvertently cross into the bicycle lanes when parking, but cyclists are generally separated from moving vehicles in between intersections.

Painted bicycle lane on College and Spadina in Toronto

Separated bicycle lane in Montreal

3.3 Multi-use trails

Multi-use trails are paths located off-street that can be used by cyclists, pedestrians and any other non-motorized road user. In most Canadian cities these trails are present throughout the park system and can be used for both recreation and commuting. Since multi-use trails are located off-street they allow cyclists to avoid traffic lights and vehicular traffic, but they often present conflicts with other trail users such as dog walkers, pedestrians and rollerbladers. Multi-use trails do not necessarily route to commuting destinations. Cyclists often need to use the on-street road network in addition to multi-use trails to get to where they're going.



Multi-use trail near Parliament Hill, Ottawa.

4 Paving the way for Cycle Cities

In this study we compared cycling infrastructure and metrics for five major Canadian cities: Toronto, Montreal, Vancouver, Calgary and Ottawa. The goal is to assess the measures these cities are taking to improve cycling infrastructure and look at how these actions have affected the cycling culture in each city. Infrastructure compared includes multi-use trails, separated bicycle lanes, painted bicycle lanes, and signed routes. We also looked at metrics such as cyclist crash rates, number of bicycle shops and mode share, that indirectly indicate cycling culture and awareness.

4.1 The fast lane

Montreal and Toronto have the most kilometres of on-street bicycle lanes of the major Canadian cities. Toronto and Montreal have a similar amount of cycling infrastructure (on-street and multi-use trails), but Montreal has a smaller population, thus a higher supply of bicycle infrastructure per capita. Both Calgary and Toronto have implemented a significant number of downtown bicycle lanes in the past few years. Recently Toronto added the pilot Richmond-Adelaide cycle tracks and the Queens Quay multi-use path. Calgary opened all seven kilometres of their cycle tracks in summer 2015.

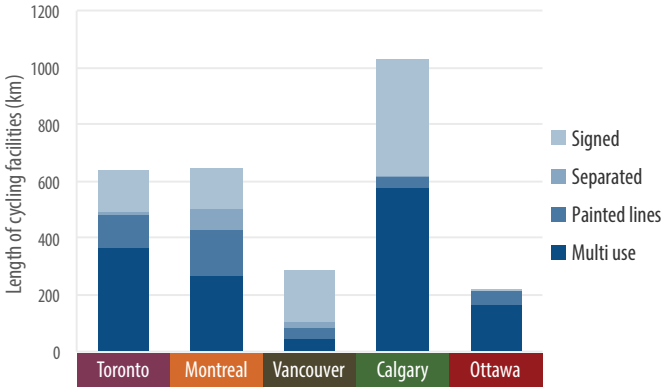


Figure 1: Existing cycling infrastructure in five major cities

Note: Ottawa data combines signed routes with painted lines

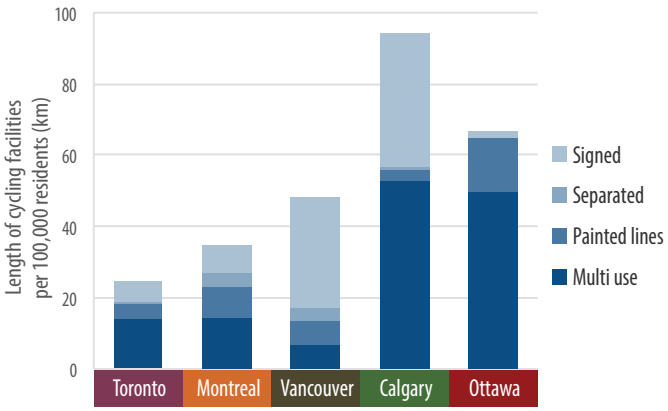


Figure 2: Total cycling facilities by type per 100,000 residents

Note: Ottawa data combines signed routes with painted lines

4.2 Bringing together cycling and transit

The "last mile" refers to the beginning or end segment of a transit commute. In many cases this distance between home and transit is too long to walk but too short for a bus transfer. Providing safe cycling routes or secure cycle parking at the station can motivate more people to complete this first or last segment of their trip by bicycle.

To assess how major transit was linked to the cycling network, we looked at how many transit stations were within 400 metres (i.e. a five-minute walk) of a cycling path. We considered all light rail transit (LRT) and heavy rail (subway, metro) stations as rapid transit stations.

In terms of how cities measure up to the last mile, 100% of Vancouver's SkyTrain stations and Ottawa's O-Train stations were near cycling paths. Over 80% of rapid transit stations in Montreal and Calgary were also near cycling paths. Toronto's subway system was the least integrated with the cycling network; 18 subway stations in Toronto (or 24% of these stations) are more than 400 metres from a cycling path.

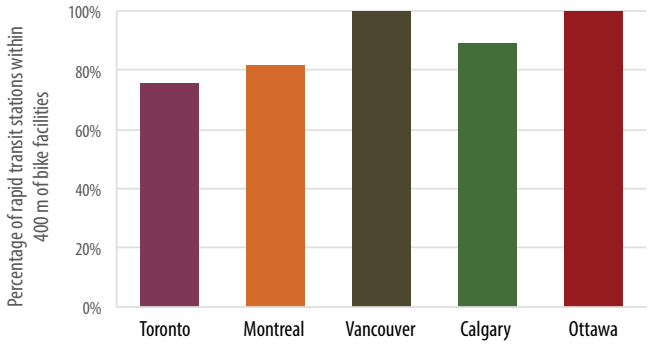


Figure 3: Cycling integration with rapid transit

4.3 Safety first

Safety can be linked to infrastructure and cycling uptake, and provides an indication of how well the cycling network is working for cyclists. Safety can be difficult to compare between cities, as each city is a different size, has a different percentage of cyclists, and has invested different amounts in cycling facilities. However, safety is key to growing the cycling mode share and is a critical indicator of how cycling facilities are performing.

Looking at the total number of annual cycling crashes would be misleading, as the cycling population varies in each city. We estimated total annual cycling trips in each city and divided it by annual crashes involving cyclists. We were unable to compare crashes in each city for the same year, as trip data was available for different years for each city. We used annual crash figures that corresponded with the year trip data was collected in order to provide a more accurate crash rate for each individual city.

Vancouver and Montreal have the fewest crashes, with around two crashes for every 100,000 cycling trips.

It is worth noting that a large number of minor crashes (e.g. doorings, when a cyclist is struck by an opening vehicle door) go unreported. The numbers used here are very likely to under-represent actual crashes, so injury and crash rates could be much higher than reported here. Without better data collection, this can only be a rough indicator to compare cities.

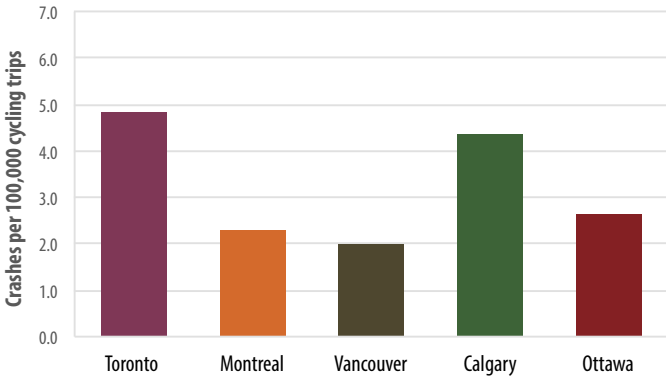


Figure 4: Annual crashes involving cyclists per 100,000 cycling trips

4.4 High maintenance

The number of shops that repair and sell bicycles and gear in a city can be an indicator of the prominence of cycling culture and access to bicycles. Although Toronto has the most bicycle shops in total (98), Vancouver and Ottawa have the most bicycle shops per capita (five per 100,000 residents). Montreal has the fewest bicycle shops per capita (two).

	Bicycle shops	Shops per capita (100,000)
Toronto	98	4
Ottawa	15	5
Montreal	25	2
Calgary	41	4
Vancouver	30	5

Table 2: Bicycle shops in major cities

5 Toronto – gearing up

Toronto has made huge strides in improving cycling infrastructure in the last five years. Before last year, there were no east-west cycling connections south of College Street in downtown Toronto, except for the Waterfront Trail and Queens Quay bicycle lanes. Summer 2014 brought painted bicycle lanes on Bay Street and pilot cycle tracks on Richmond Street and Adelaide Street. This summer the Queen's Quay separated multi-use trail was completed, offering even more safe routes for cyclists to traverse the city. Plus, new bicycle shops continue to open across the city, indicating a growing cycling culture and providing more access for residents to buy or rent bicycles and gear and to access maintenance services.

While there has been great momentum, there is still work to be done. Toronto has the highest cyclist crash rate – there are just under five crashes involving cyclists for every 100,000 cycling trips. Compared to the other cities in this study, Toronto has the lowest bicycle infrastructure per capita. There are only 10.6 km of bicycle lanes with separation in Toronto, which is less than one kilometre for every 100,000 residents.

5.1 The road ahead

The City of Toronto is currently completing a renewed cycling plan to look at connections and infrastructure required to grow and boost the city's cycling network. Toronto's cycling plan was last updated in 2001, and this new plan will be the first to acknowledge the importance of separated lanes and to put cycling in the downtown core, where it is needed most to help combat congestion. The city has consulted with the public over the past two years to help prioritize where cycling infrastructure should be and how the network should grow in the future.

Toronto's official plan has an ambitious target of a 20% cycling mode share for trips within the downtown. City council has approved increasing the 2016 budget for cycling infrastructure from $9.5 million to $13.5 million (a 44% increase) to more quickly implement the cycling plan. However, only $1.8 million (13%) is dedicated to on-street cycling infrastructure, the rest is earmarked for multi-use trails. Plans for 2016 include a Bloor Street bicycle lane pilot and 41 km of new on-street bikeways.[2]


Photo: Nithya Vijayakumar, Pembina Institute

Richmond-Adelaide Cycle Track

The Richmond-Adelaide cycle track was installed as a pilot in summer 2014 from Shaw Street to University Avenue. Cycling volumes on Richmond Street and Adelaide Street tripled after installation of the cycle track, with over 4,200 daily cycle trips. The additional volume of bicycles on Richmond Street and Adelaide Street did not negatively affect motor vehicle travel times, and many drivers were supportive of the presence of the new cycling infrastructure. Since that pilot was so successful, the cycle track was extended east to Parliament Street in 2015 as a pilot.[1]

6 Montreal – leader of the path

Montreal is considered to be one of the best cycling cities in the world[3,4], and can boast the most separated bicycle lanes of all the Canadian cities compared in this study (72 km). Montreal's cycling lanes have increased from 400 km in 2009 to 648 km in 2015[5,6]. Montreal also has some of the longest continuous multi-use trail connections, with some sections along the edges of the island that are 40 to 50 km long (Figure 5).

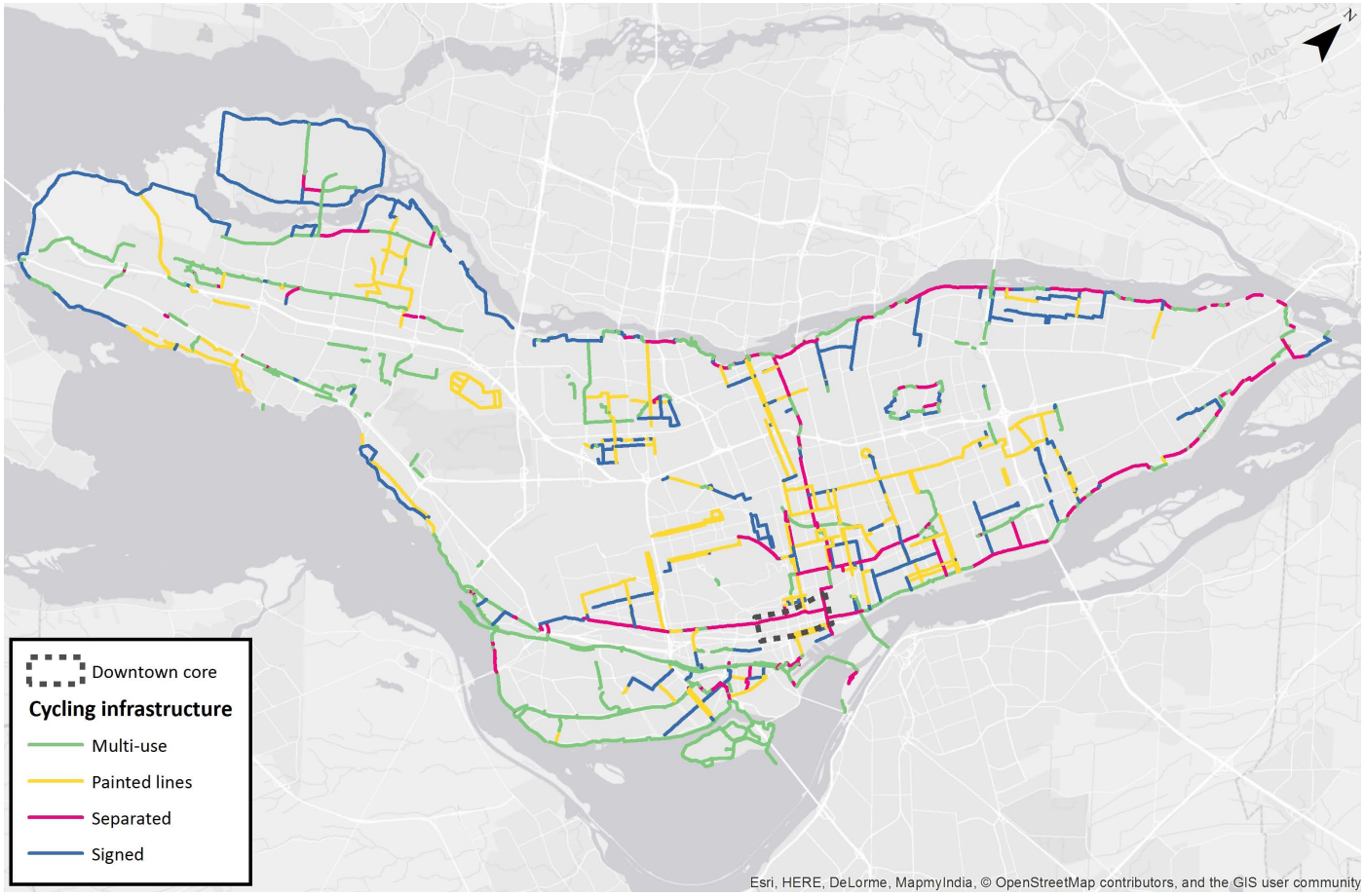


Figure 5: Cycling facilities on the Island of Montreal

The largest concentration of bicycling infrastructure is in the Plateau neighbourhood of Montreal, which is located northeast of the city's downtown. While cyclists can comfortably cycle on bicycle lanes on arterial roads and residential streets outside of the downtown area, there is very little cycling infrastructure downtown.

The main cycling routes through downtown are east-west facilities on Maisonneuve Avenue (separated) and Viger Avenue (painted lane). North-south cycling infrastructure is also limited in downtown Montreal. Besides a separated lane on Berri Street, there are no north-south bicycle lanes that cut through downtown Montreal. Bicycle lanes on St. Urbain Street and University Avenue end at Maisonneuve Avenue. Cyclists who wish to travel north-south in downtown Montreal have no option but to ride with vehicular traffic.

Montreal is working on densifying the cycling network in its central boroughs and connecting scattered segments of cycling infrastructure developed over the previous decades. One of the key challenges is increasing the number of north-south links across multiple railway and freeway corridors. Another challenge is closing east-west gaps between the boroughs and municipalities along the northern edge of the island.

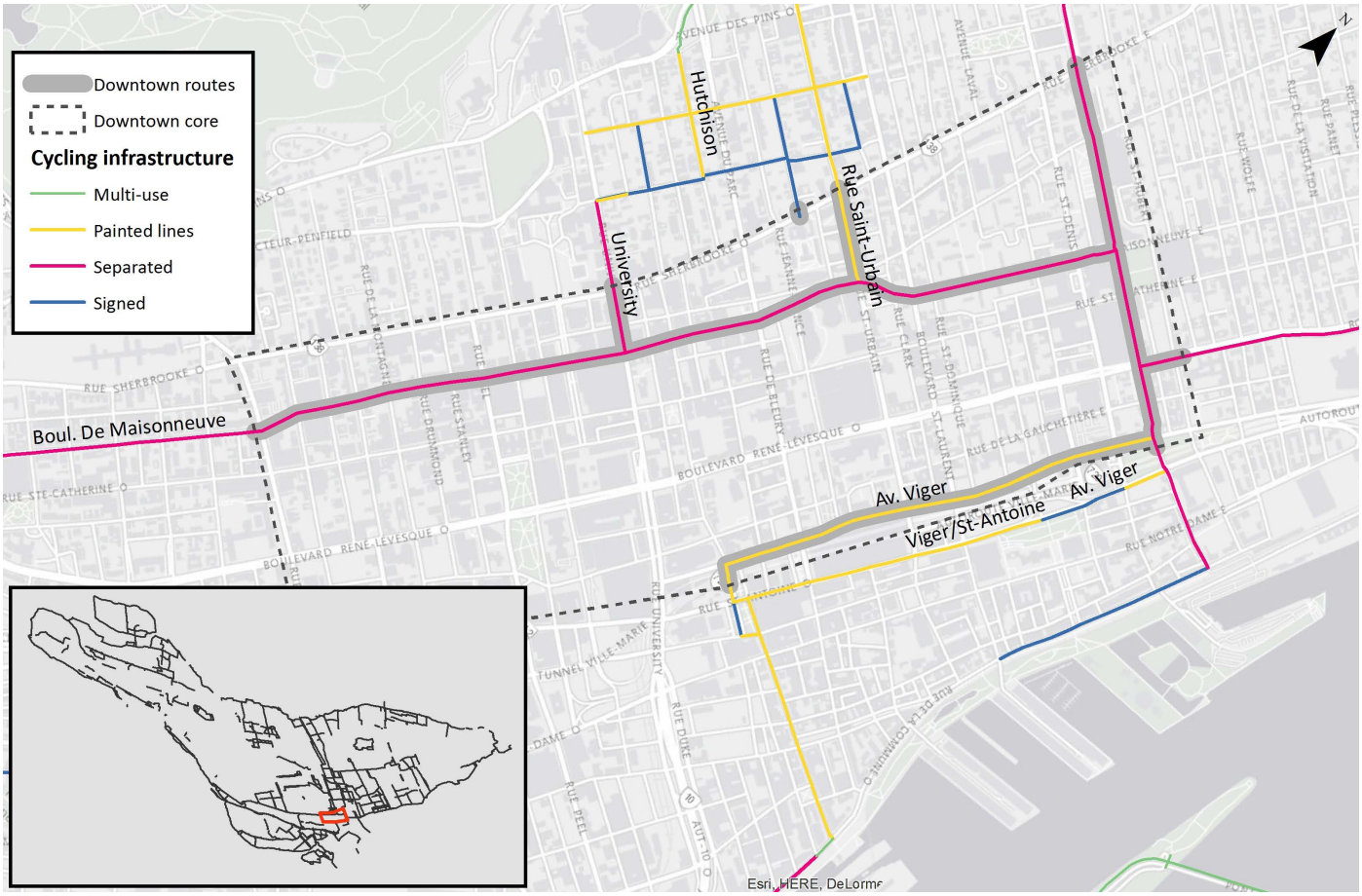


Figure 6: Cycling facilities in Downtown Montreal

Sharing the ride

This analysis does not compare bicycle share systems, since at the time of undertaking this study they existed only in Montreal and Toronto. However, Montreal should be recognized as having the largest bicycle share system in Canada. Bixi has been used as a model for bicycle shares in other North American cities like Washington, D.C., Chicago and New York. Bixi trips increased from around one million trips in 2009 to over four million trips in 2011.[8] Although a small percentage of Bixi users had switched from driving (2%), most users had chosen to use Bixi in place of walking, transit or using a personal bicycle.[9]

7 Vancouver – downtown on two wheels

Vancouver has 37 km of cycling infrastructure in the downtown core, making it easy for cyclists to commute to high-traffic locations such as schools and businesses. Vancouver may be the smallest city by area in this study (see Table 3), but with over 2.5 km of cycling infrastructure for every square kilometre of area, it's the densest network in this Canadian study.

Over the past years, the City of Vancouver created many bicycle routes on local streets, thus avoiding conflict with vehicular traffic. As cycling becomes more popular in Vancouver as a commuting option, rather than just for recreational trips, cyclists are increasingly looking to access main streets that provide access to work and shopping destinations. This creates potential conflict in terms of competition for road space, as installing protected lanes can impact on-street parking and/or traffic lanes. The first physically separated lanes faced significant opposition, as did the trial bicycle lane on the Burrard Bridge. However, the feared loss of business and major traffic congestion as a result of the new lanes did not materialize, and a recent decision to add a second bicycle lane to the Burrard Bridge (returning a sidewalk to pedestrian use) received broad support and very little opposition.

The City of Vancouver has also supported its work by installing bicycle counters. The data from these counters has helped bolster support for adding bicycle lanes. When a public display board was installed in January on the Burrard Bridge, there were questions from the public about why it was needed, and a discussion about whether anybody used the bicycle lanes. In August, the one-millionth trip by bicycle was counted across the bridge, in less than eight months.

Another tool that has worked is painting bicycle lanes green at conflict zones (e.g., an intersection or turning lane where the bicycle lane crosses). These green painted areas alert drivers to the presence of cyclists, and generally raise the profile of the installed cycling infrastructure.

One key challenge for the City of Vancouver in the downtown area is the seawall bicycle path, one of the most popular cycling routes in the city. It is often crowded, and physical constraints prevent widening it in many places. Where the path is shared between pedestrians and cyclists, as on many of the older sections, conflicts can arise with users due to the volume. The solution will likely include providing alternate routes on city streets running parallel to the seawall bicycle path for cyclists who want a faster connection, where the path can not be widened to provide separation for pedestrians and cyclists.

Despite the significantly lower population compared to the other major Canadian cities, Vancouver has the highest cycling mode share for commuting to work at 4.4%. Vancouver, along with Montreal, is also the safest city for cyclists, with around two crashes involving a cyclist for every 100,000 cycling trips.

Vancouver has a great variety of route options for cyclists. Around 43% of cycling routes are multi-use along the water and into Stanley Park. Another 35% of routes are on-street cycling lanes with and without separation. The rest are signed routes on low traffic streets.

Separated bike lanes in Vancouver

8 Calgary – build it and they will come?

While Calgary has the most multi-use trails of the cities studied, it also has the fewest kilometres of on-street cycling infrastructure (43 km). According to the 2011 census, Calgary has the lowest cycling mode share (1.3%) of the cities studied, though it is the largest city by area in the study. In 2011, city council approved a robust cycle strategy, including adding more on-street bikeways and a downtown cycle track network pilot. Since the cycle networks opened in June 2015, there have been over 370,000 trips counted along the three new corridors. Since 2011, cycling trips in downtown have also increased by 35%[10]. City council will vote on whether to keep the cycle track network in late 2016 or early 2017.

8.1 Riding the river

Calgary's multi-use trail system is quite comprehensive, but these trails are poorly connected to Calgary's residential neighbourhoods. The longest continuous paths in Calgary are along the river system. This makes these trails very useful for recreational purposes, but they may be less useful for commuting trips to downtown Calgary or other destinations. Unlike Vancouver's signed routes, which are on traffic-calmed residential streets, most of Calgary's signed bicycle routes (excluding neighbourhood greenways) are on busier, collector roads, which may be a safety or comfort deterrent for cyclists.

As a result of the 2011 cycle strategy, Calgary has made improvements to increase on-street cycling infrastructure including new bicycle lanes (painted and separate), bicycle specific signals, and wayfinding signage, which has finally provided some much needed on-street bicycle infrastructure to access the downtown core from the river path system. There are still opportunities to continue to improve and expand on-street cycling infrastructure to make commuting by bicycle a more attractive option.

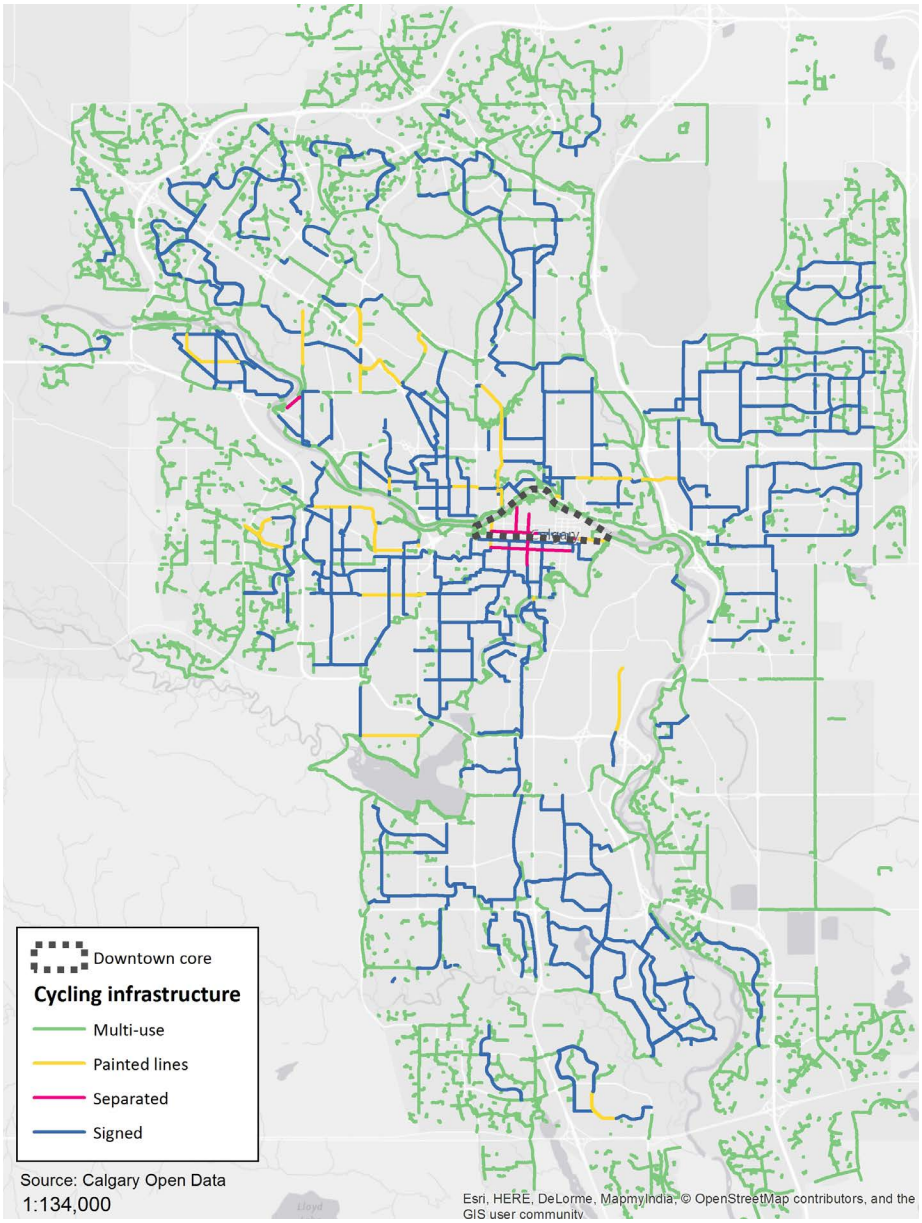


Figure 7: Calgary's bikeways and multi-use trails

9 Ottawa – a ride through the park

The backbone of Ottawa's cycling network is the off-street path system that runs through parks and green space and along the city's rivers and canal system. The majority of Ottawa's bicycle infrastructure consists of paths — 167 km of bicycle paths are multi-use trails, while there are only 54 km of on-street bicycle lanes with and without separation.

Outside of the city centre there are long stretches of bicycle lanes that allow cyclists to cycle anywhere from 6 to 15 km separated from vehicular traffic. However, there is less infrastructure for cycling downtown. Within the urban core of Ottawa, there are less than 2 km of physically separated bicycle lanes. The 7 km of multi-use trails that are within the downtown core only run around the periphery of downtown. Cycling through Ottawa is easy with the multi-use trail network, but accessing major employment destinations via cycling routes is more difficult given the limited on-street infrastructure downtown.

Ottawa has been investing more in cycling connections recently, such as bicycle lanes on bridges, in an effort to build a grid. Increasing on-street cycling connections through Ottawa will improve access to major destinations.

Cyclist on the Rideau Canal cycling path, Ottawa

Appendix A. Comparison of cities

	Toronto	Montreal	Vancouver	Calgary	Ottawa
Area (km2)	630	500	115	825	550
Population	2,615,000	1,870,000	603,500	1,097,000	333,143
Longest off-road path					
Longest E/W segment (km)	19.00	50.00	16.50	8.00	22.00
Longest N/S segment (km)	11.30	12.00	11.00	14.00	10.00
Longest on-street path					
Longest E/W segment (km)	7.7	12.00	16.5	8.00	2.9
Longest N/S segment (km)	11.3	12.00	11.00	5.00	4.5
Transit integration					
Rapid transit stations near bicycle paths	76%	82%	100%	89%	100%
Cycling infrastructure					
Multi use	364.00	269.00	42.00	578.00	167.00
Separated	10.60	72.40	23.00	7.00	5.07
Painted lines	117.00	162.00	39.00	36.00	49.00
Signed	148.00	145.00	185.00	411.00	0
Total (km)	639.60	648.40	289.00	1032.00	221.07
Cycling infrastructure per 100,000 people					
Multi use	13.92	14.39	6.96	52.69	50.13
Separated	0.41	3.87	3.81	0.64	1.52
Painted lines	4.47	8.66	6.46	3.28	14.71
Signed	5.66	7.75	30.65	37.47	0
Total	24.46	34.67	47.89	94.07	66.36
Downtown core					
Multi use	3.60	0	6.80	2.20	7.00
Separated	4.50	6.00	8.50	3.30	1.00
Painted lines	8.60	1.80	12.60	1.40	6.00
Signed	4.75	0.40	9.20	1.00	0
Total (km)	21.45	8.20	37.10	7.9	14.00
Bicycle mode share					
Census NHS Survey 2011 (trips to work)	2.2%	2.9%	4.4%	1.3%	2.5%
Daily bicycle trips	96,084	115,100	66,800	19,476	37,570
Annual bicycle trips	26,903,520	32,228,000	18,704,000	5,453,280	10,519,600
Total crashes (annually)	1302	743	373	238	277
Crash rate per 100,000 trips.	4.84	2.31	1.99	4.36	2.63
Number of cycling shops	98	25	30	41	15
Cycling shops per 100,000	3.7	1.5	5.0	3.7	4.5
Density of network	1.02	1.30	2.51	1.25	0.40

Table 3: Comparison of city data

	Toronto	Montreal	Vancouver	Calgary	Ottawa
Total bicycle infrastructure (on-street and off-street paths) (km)	640	648	289	1032	221
Bicycle infrastructure per 100,000 people (km)	24	35	48	94	66
On-street bicycle lanes* (painted or physically separated) (km)	128	234	62	43	54
Multi-use trails (km)	364	269	42	578	167
On-street bicycle lanes per 100,000 people* (km)	5	13	10	4	16
Longest off-road path (km)	20	50	16.5	14	22
Longest on-street path (km)	11	22	15	8	4.5
Percent of rapid transit stations within 400 m of bicycle path	76%	82%	100%	89%	100%
Bicycle infrastructure (off-street and on-street paths) in downtown core (km)	21	8	37	8	14
Number of bicycle shops	98	25	30	41	15
Crash rate per 100,000 cycling trips	5	2	2	4	3

*Includes separated bicycle lanes protected from traffic by bollards or medians and non-separated lanes demarcated by a painted line.

Table 4: Comparison of bicycle infrastructure and other metrics in major Canadian cities

Appendix B. Methodology

B.1 Geography

For each city, our analysis used the level of geography that corresponds to the core transit system's service area.

City	Census Geography	Area (sq. km)	Population
Toronto	Toronto census subdivision	630	2,615,000
Montreal	Montreal census division	500	1,870,000
Vancouver	Vancouver census subdivision	115	603,500
Calgary	Calgary census subdivision	825	1,097,000
Ottawa	Ottawa wards 11-18	550	333,143

Table 5: Geography of study areas

There are geographic and population challenges in comparing Vancouver and Ottawa to other cities. Metro Vancouver, comprising 21 municipalities, a treaty First Nation, and an electoral area, has a population of 2.5 million. Data on cycling infrastructure in municipalities that border the City of Vancouver (North Vancouver, West Vancouver, Burnaby, Richmond, and the electoral area including the University of British Columbia) were not publicly available, and so we were only able to use cycling infrastructure data in the City of Vancouver proper for comparison purposes. This is also why the area of Vancouver used in this study is much smaller than the rest of the cities (Table 3).

Similarly, the Ottawa census subdivision includes some fairly rural areas. Including the entire subdivision in the analysis would result in comparing a rural cycling experience to the urban experience in the other comparison cities. As such, we only included Ottawa wards 11-18, which lie within the greenbelt and were considered urban.

The cities of Ottawa and Vancouver are also significantly smaller than the rest of the study cities with populations of only 330,000 and 600,000 respectively. By comparison, Toronto and Montreal are amalgamations of neighbouring municipalities, making these cities much larger than Ottawa and Vancouver. Similarly, the City of Calgary covers a large geographic area, as city boundaries extend much further than existing development, allowing Calgary to continue to grow outward. Edmonton was not included in this analysis as data on their cycling network was not publicly available at the time of analysis.

B.2 Length of infrastructure

B.2.1 Total length of infrastructure

The length of cycling infrastructure was calculated using spatial data publicly available for each city[11]. Each city had categorized the types of cycling facilities available. These categories were standardized for comparison.

- Toronto data is from the 2015 Cycling Network GIS shapefile from the City of Toronto Open Data catalogue. The GIS shapefile included the following facility types: bicycle lanes, contra-flow bicycle lanes, cycle tracks, informal dirt footpath, major multi-use pathway, minor multi-use pathway, park roads cycling connections, sharrows, and signed routes.
- Ottawa data is from the 2015 Cycling Network GIS shapefile from the Ottawa Open Data catalogue. The GIS shapefile included the following facility types: bicycle lane, path, paved shoulder, segregated bicycle lane, and suggested route. Paved shoulder and suggested route were excluded from the analysis. The figures for Ottawa combine signed routes and painted bicycle lanes, although signed routes are present in Ottawa.
- Montreal's data was from the 2015 Cycling Network GIS shapefile from the Montreal Open Data catalogue. The GIS shapefile included the following infrastructure types: signed route, paved shoulder, one-way painted bicycle lane, on-street bicycle path with separation, off-street separated bicycle path, on-street elevated bicycle path, and multi-use trail.

- Calgary data were from the 2015 Bikeways and 2015 Pathways GIS shapefiles from the Calgary Open Data catalogue. Calgary categorizes their bicycle infrastructure as follows: bicycle lane, cycle track, neighbourhood greenway, on-street bikeway, shared lane, local trail and regional trail. Local trails were excluded from the analysis.
- Vancouver's cycling network data was from the 2015 Cycling Network GIS shapefile from the City of Vancouver Open Data catalogue. The GIS shapefile included the following facility types: local street, painted lanes, separated lanes, and shared lanes.

The longest continuous segment was estimated by manually selecting routes and calculating the length of segments without breaks. Continuous routes could comprise different types of facilities, but the vertices of each facility type must connect to be considered a continuous route.

B.2.2 Length of infrastructure in the downtown core

The downtown core is the majority of commuting trips, so cycling infrastructure is important to facilitate bicycle trips to downtown. For this indicator we drew boundaries around each city's downtown. We defined downtown as the main business and commercial area of the city. Table 4 lists the boundaries used to designate the downtown cores for the cities in the study.

We took the sum of cycling infrastructure within these boundaries to compare between cities.

City	North	East	South	West
Toronto	Bloor St.	Jarvis St.	Front St.	Spadina Ave.
Montreal	Sherbrooke	St. Hubert St.	Viger Ave.	Guy St.
Vancouver	Vancouver Harbour	Main St.	False Creek	Chilco St.
Calgary	Bow River	Elbow River	9th Ave SW	Bow River
Ottawa	Ottawa River	Queen Elizabeth Dr.	Highway 417	Bronson Ave.

Table 6: Boundaries for downtown

B.3 Transit integration

Transit integration was calculated by identifying the number of rapid transit stations in the study area that were within 400 m of a cycling facility.

In the case of Calgary, some discretion was used to select LRT stations that fit this criteria. Calgary has an extensive multi use trail system, but many of the trails are disconnected and could not be used for commuter trips. Some LRT stations were near multi use trails, but these trails were either too short or not connected to bicycle trails and were therefore not considered as "bicycle connected".

B.4 Crash rate

Crash rate was estimated by taking the total number of crashes in each city and dividing by the estimated total number of annual cycling trips using crash data from corresponding years. Annual cycling trips was estimated using each city's travel survey, and crashes were reported by City of Toronto's Traffic Safety Unit.[12] See Section B.7 for the year travel surveys were published for each city.

The Toronto data from the Traffic Safety Unit is summarized from Motor Vehicle Collision Reports obtained from the Toronto Police Service; it includes crashes not involving motor vehicles (bicycle collisions with other bicycles, pedestrian and objects, along with falls and unknown causes). Toronto data is from January 1, 2013 to September 30, 2013 and thus captures data from only 75% of the year. The City of Toronto collected similar data from other jurisdictions for their reports.

Vancouver crash data is reported by ICBC for 2011 and includes all crashes that involve bicycles in the City of Vancouver. Date ranges and data characteristics from other cities could not be verified.

Crash data for bicycling is difficult to gather and methodologies vary across jurisdictions. It is widely suspected that crashes are underreported.

B.5 Bicycle mode share

Bicycle mode share was taken from the 2011 National Household Survey mode of transportation question. The NHS survey only accounts for commuting trips from home to work and thus underestimates trips made to other destinations. The bicycle mode share corresponds with the geographic areas described in Table 5.

B.6 Bicycle shops

Total number of bicycle shops was estimated using Open Street Maps data. Data was extracted for the level of geography for each study city. We used the tags "amenity" or "shops" and filtered for bicycle shops. Google maps was used to verify the Open Street Maps data.

For Toronto, a spatial layer of bicycle shops was provided by the City of Toronto.

B.7 Cycling trips

Cycling trips were obtained from travel surveys or counts conducted in each city. We used the most recent data available for each city. For all cities we obtained a daily trip value and converted to an annual value by multiplying the value by 280. The annual cycling trip values were used to estimate a crash rate. We ensured that trip values corresponded to the geographic area of study.

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Montreal – Agence Metropolitain de Transport, 2013. Origin-Destination Survey

Vancouver – Translink, 2011. Metro Vancouver Regional Trip Diary Survey.

Calgary – City of Calgary, 2013. 2013 Bicycle Count.

Ottawa – TRANS Committee, 2012. 2011 Origin-Destination Survey: Bicycle Profile.

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10. City of Calgary, Downtown Cordon Count. http://www.calgary.ca/Transportation/TP/Pages/Planning/Transportation-Data/Central-Business-District-Cordon-Count.aspx
11. There may be a margin of error between actual length of infrastructure and length of infrastructure estimated using GIS analyses. This is because GIS shapefiles may measure centre line distance of infrastructure, or double count length for two-way cycling lanes. In some cases this can lead to under or overcounting infrastructure length.
12. City of Toronto Traffic Safety Unit, Cyclist Collision Summary Leaflet September 2013. http://www1.toronto.ca/City Of Toronto/Transportation Services/Road safety/Files/pdf/BIKE2013Sept.pdf.

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