Liveability: Who's experiencing it and where is it?

Defining Liveability Through Spatial Urban Metrics and Citizen Input

Master of Urban Planning Supervised Research Project, McGill University

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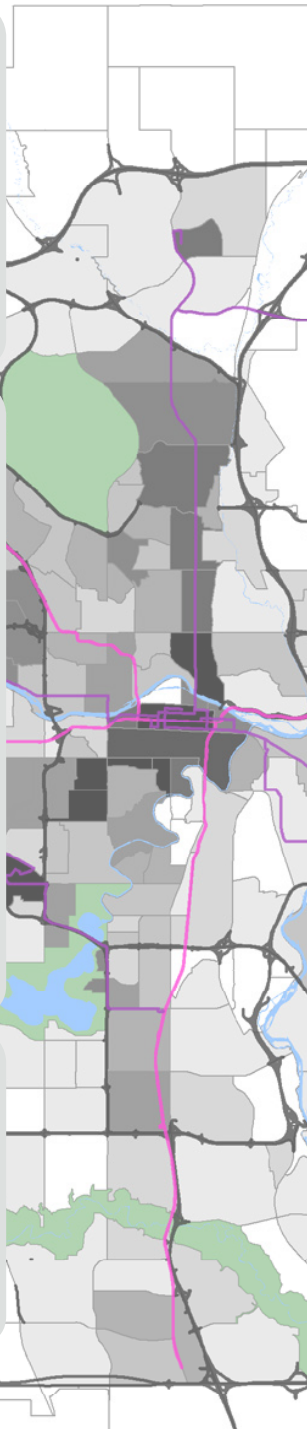
Context

The presence of essential amenities, such as grocery stores, schools, and employment, within attainable walking and cycling distances promotes healthier and more sustainable lifestyles. Transportation networks with strong connectivity, safe route options, and proximate amenities are needed to foster local accessibility and liveability. Liveability is the ability to access opportunities to improve one's quality of life; it is a relative term that captures concepts of accessibility, mixed land-use, and equitability.

Background

During a Transportation Demand Management strategy update, The City of Calgary sought to improve methods to measure the availability of sustainable/active transportation choices. Using GIS network analyses and location data for employment zones, grocery stores, parks, schools, and transit service, a Calgary Liveability Index was created. However, further analysis was needed to determine how the measured liveability values compared to perceptions of liveability and experiences by Calgary residents.



Liveability Index Validation

This study uses a geolocated travel behaviour survey to evaluate how liveable Calgarians find their neighbourhoods, answering questions on trip satisfaction, mode choice, and their dominant considerations when choosing a home location. When assessing how well the original Calgary Liveability Index reflects perceptions of liveability, it is important to consider what makes a liveable built environment based on varying cultural, lifestyle, sociodemographic, and household structure components. To accommodate different views of liveability, this research uses population stratification techniques, finding eight distinct typologies of travel behaviour and transportation needs. Results suggest travel typologies with car-focused mode-shares tend to have larger gaps between measured and perceived liveability, while those who predominantly walk, bicycle, or take public transit tend to be more perceptive to accessibility and the built environment's impact on their lifestyle and travel needs.

Recommendations

It is recommended that:

- the current Liveability Index scores are considered to be a valid indicator for predicting the availability of sustainable transportation choices and identifying areas of high need and high demand for improved liveability
- further investment and continued analysis of collected survey data is used to improve the Liveability Index

KEYWORDS

Accessibility, Liveability, Active Transportation, Factor-Cluster Analysis, Urban Metrics, Travel Behaviour Segmentation

INTRODUCTION

Accessibility is the potential of opportunities for interaction in a region with a certain mode choice (Hansen, 1959). As a counterpart or alternative to mobility, which focuses on the ease movement, accessibility highlights the ease of reachable land-use activity from a location using a specific transport system (Dalvi & Martin, 1976). In the absence of mixed land-uses, high mobility often will not equate to high accessibility (Shen, 1998). Increasingly, accessibility is becoming a prominent theme in transportation planning, with trends towards more complex and disaggregated measures of accessibility (K Geurs, Kevin, & Reggiani, 2012). In many cities, where reduced car-dependency is a key planning objective, planners and policy makers are using accessibility concepts as a more comprehensive performance measure for equitable, sustainable, and efficient transportation systems (Boisjoly & El-Geneidy, 2016). Accessibility can be measured at local or regional scales. In more local contexts, accessibility is often linked to liveability.

Liveability is closely related to accessibility and is another concept gaining traction in community and transportation planning (Godschalk, 2004). Liveability is an individual's ability to access opportunities to improve their quality of life at a local scale (Appleyard, Ferrell, Carroll, & Taecker, 2014); it is a relative term that captures concepts of accessibility, mixed-use, equitability, and quality of life. A further consideration of working towards the provision highly liveable urban environments includes that an individual's pursuit of quality of life satisfaction should not unduly detract from the liveability of others (Appleyard et al., 2014). Manaugh and El-Geneidy (2012) mapped convex hauls, representing the smallest polygon created by an individual's origins and destinations; where smaller, less-dispersed convex hauls (travel behavior) are suggested to be preferable, representing more liveable conditions. However, the authors highlight the necessary distinction between those who have access to more

sustainable transportation choices, and those who travel locally due to a lack of choice (Manaugh & El-Geneidy, 2012). Liveability initiatives should include the provision of local essential amenities, safe transportation options for all modes, and equitable access to opportunities.

During an update to the Transportation Demand Management (TDM) strategy, The City of Calgary sought to improve methods to measure the availability of sustainable/active transportation choices to Calgary residents. A multivariate "Liveability Index" of local accessibility measurements was developed and mapped to visualize areas of high and low accessibility to essential destinations and amenities (liveability). Using these spatial local accessibility measurements and a city-wide survey, this research looks to improve the evaluation criteria for identifying areas of both high need and demand for improved liveability. However, perceptions of liveability are dependent on an individual's cultural, sociodemographic, and lifestyle aspects (D'Arcy, Tsolacos, Thériault, Des Rosiers, & Joerin, 2005). To address the varying ideas of liveability in the survey analysis, a population stratification was performed through a factor-cluster analysis to develop typologies of travel behaviour, perceptions, and experiences. By identifying themes of travel behaviour and transportation needs among survey respondents, the factor-cluster segmentation results shed light on who and where perceptions of liveability are most in line with measured accessibility to essential destinations and amenities.

Perceived liveability is explored group by group, comparing summary data to travel behavior and spatial accessibility measurements around cluster member home locations. This research finds that travel typologies with car-focused mode-shares tend to have larger gaps between measured and perceived liveability, while those who predominantly walk, bicycle, or use public transit tend to be more perceptive to accessibility and the built environment's impact on their lifestyle and travel needs. Differences between the planner/transport researcher defined liveability and perceptions of liveability in the general public are shown to exist. However, simply tuning the Calgary Liveability Index to match the average ratings of access from survey respondents is not recommended. Instead, the current urban metrics of liveability, which are most reflective of the needs and experiences of the City's most

vulnerable (pedestrians, cyclists, and transit riders), should be seen as a useful indicator for high need and demand of improved liveability. Furthermore, the spatial distribution of cluster member home locations and each typology's personalized definition of liveability should be considered when planning for active transportation in the City of Calgary.

LITERATURE REVIEW

Accessibility as an Indicator for Liveability

The effect of the built environment on quality of life & happiness is undoubtedly culturally and contextually specific. Research on accessibility has shown there are statistically significant differences in perceptions of accessibility structure, depending on trip purposes and household profiles (D'Arcy et al., 2005). Large families for example will have different accessibility interests than childless households. However, looking at ten major cities, Leyden, Goldberg, and Michelbach (2011) used ordered logit models to determine that access to employment opportunities, public transit, cultural and leisure facilities, libraries, and childhood/childcare amenities were significant factors in predicting perceptions of happiness.

Research looking at liveability as a social determinant of health found that crime and safety; education; employment and income; health and social services; housing; leisure and culture; local food and other goods; natural environment; public open space; transport; and social cohesion and local democracy were relevant identifiers for liveable environments (Miller, Witlox, & Tribby, 2013). Further work from the World Health Organization reported transportation noise and traffic accident data to be important indicators for health and wellbeing (Dora & Phillips, 2000). Walkscore, commonly used in real estate advertising and by researches to measure local accessibility or liveability, attempts to capture many of these considerations in their data. Access to grocery stores, restaurants, shopping, coffee shops, banks, parks, schools, books (either libraries or book stores), and entertainment are included in Walkscore data (WalkScore, 2011). Additionally, varying weights are applied to the various amenity categories, attempting to reflect each amenity's relative importance to walking trip generation (WalkScore, 2011).

The Economist's "Liveabilty Index," which looks at both citizen's needs and business/economic considerations, found that cost of living, public transport and roads, safety and security, and culture and nightlife were the main neighborhood components to liveability (Economist, 2010). A similar, survey driven metric from Gallup Inc. focuses on respondents' general satisfaction with their community, feelings of their area getting better as a place to live, access to clean water, perceptions of their area as a safe place to exercise and walk alone at night, and access to affordable fruits and vegetables as their "basic access" components to the Gallup Inc. "Well-Being Index" (Gallup, 2014). Another leading metric for quality of life/liveability is the Mercer "Quality of Living Ranking," which uses 39 weighted factors, predominately to develop compensation plans for international employees assigned to locations with differing living conditions. The Quality of Living Ranking uses specific neighborhood scorings on housing, medical facilities, educational facilities, infrastructure, crime, cultural and recreational attractions, and availability of goods and services (Mercer, 2016). Both surveys seeking to better understand residents' perceptions and spatially measured studies on liveability have been conducted, and the two often inform one another. Table 1 summarizes the components of several liveability urban metrics and academic studies.

	Index/Study					
Included Amenities	WalkScore	Economist Liveability Index	Gallup Inc. Well-Being Index	Mercer Quality of Living Ranking	Leyden, Goldberg, and Michelbach (2011)	Miller, Witlox, & Tribby (2013)
Employment Opportunities					O	O
Grocery Store	O	O	O	O		O
Schools	O	O		O	O	O
Parks	O			O	O	O
Public Transit		O			O	
Medical Facilities				O		
Restaurants	O					O
Shopping	O					O
Cafes	O					
Books (stores/libraries)	O				O	
Entertainment/Cultural Attractions	O	O		O	O	O
Banks	O					
Transportation Infrastructure Quality	O	O		O		
Safety and Security		O	O	O		O

Table 1: Liveability Metric and Studies and their included measures/variables

Measuring Accessibility

Geurs & Van Wee (2004) describe measuring accessibility from both land-use and transportation perspectives. Land-use aspects focus on the amount, quality, and spatial allocation of opportunities, while also considering the balance between supply and demand for an amenity/opportunity (competition). Transportation components to accessibility look at the cost, in time, monetary requirement, or value of time, to traverse the distance between an origin and destination using a given mode (Geurs & Van Wee ,2004). The simplest accessibility metric is the cumulative opportunity measure (land-use measure). This measure counts the number of reachable destinations within a given travel time; this indicator highlights the amount, rather than the distance to amenities (Handy & Niemeier, 1997). Gravity-based indices however, focus on travel time and cost as a measure of impedance to opportunities, and the closer an opportunity to an individual or activity zone, the more it contributes to the accessibility value (Handy & Niemeier, 1997). Iacono, Krizek, and El-Geneidy (2010) suggest gravity measures of accessibility are preferable for non-motorized transportation modes, especially if travel

impedance values are adapted to reflect the disutility felt by cyclists, pedestrians, and public transit passengers.

Studies looking at access to neighborhood amenities use both gravity and cumulative accessibility indices. The prevalent multivariate amenity index, WalkScore, has been used in several studies, and uses a cumulative scoring system at varying buffer distances, with decaying weight with distance (Carr, Dunsiger, & Marcus, 2010; Manaugh & El-Geneidy, 2011; Winters, Teschke, Brauer, & Fuller, 2016). To measure neighborhood access to playgrounds in Edmonton, AB, Smoyer-Tomic, Hewko, and Hodgson (2004) used both gravity and cumulative methods. Firstly, a minimum-distance criterion was calculated using postal code centroids to the nearest playground (gravity-based). Secondly, a cumulative "coverage" metric was calculated, by summing the number of playgrounds within an 800 metre buffer around postal code centroids (Smoyer-Tomic et al., 2004). Furthermore, the coverage metric considered competition aspects by weighting each postal code centroid by its population.

Similar to the methods used by Smoyer-Tomic et al. (2004), a food accessibility study in Winnipeg, MB used dissemination block centroids and network distances to supermarkets to visualize the region's food desserts (Wiebe, Distasio, & Shirtliffe, 2016). Additionally, Wiebe et al. (2016) developed a social deprivation weighting scheme to highlight areas of both high need and low access to retail food opportunities. Looking at employment accessibility and unique weighting strategies, Shen (1998) used a gravity-based measure of travel time to low-wage jobs, but added a competition weighting based on the ratio of the opportunities to the number of opportunity seekers.

Hedonic prices analysis has also been used to evaluate accessibility measures and the value of certain amenities to home buyers. Chin and Foong (2006) used hedonic price analysis to determine the value of accessibility to quality schools. Their study computed both private car and public transit travel times between activity zones to the region's top 60 schools, and used the mean as the impedance value for their gravity-based metric. Other common neighborhood variables in hedonics with positive effects on

land value are proximity to subway and public transit stations, freeways or onramps, proximity to shops, and bike-share stations (Chau & Chin, 2002; El-Geneidy, van Lierop, & Wasfi, 2016). In a study of pedestrian accessibility to transit stations, Zielstra and Hochmair (2011) used GIS network buffers to measure the amount of pedestrian friendly segments of network data within the generated buffers, based on categorized OpenStreetMap data. Additionally, network buffers were created with full network and pedestrian-only data sets, and their change in size compared. In a hedonic study of neighborhood transit accessibility, Lewis-Workman and Brod (1997) used shortest path network distance from homes to nearest transit stations. Amongst several control variables, their models indicate that reduced network distances to transit stations has a significant effect on residential property values (Lewis-Workman & Brod, 1997).

Many studies have accurately measured accessibility for individual components of liveability. However, few academic studies have sought to combine multiple accessibility metrics for various destinations relevant to comprehensively measuring a liveable built environment, such as the proprietary Walk Score indices. This study takes inspiration from the many accessibility analyses that predate it and seeks to produce a multivariate metric that reflects liveability in the City of Calgary. The input variables for the measure are informed by a mix of previous survey research on quality of life/liveability and transportation research that offers insights on specific amenities and their influence on travel behaviour choices and their value to home buyers. Among current research, predominant built environment aspects related to liveability include food, park space, and education access, with employment and public transit access being key necessities that are often harder to measure or less often included in general liveability definitions. Entrainment and cultural attractions are also commonly included in liveability research and urban metrics, but is a more 'luxury' component to liveability. This study uses employment, food, park space, school, and transit access to measure liveability, with additional measurements used to assess entrainment/cultural attraction access. Furthermore, through the collection of the geolocated travel behaviour survey, this study combines citizen input with the spatial liveability measures informed by transportation research. The two versions of liveability shed light on

the spatial distribution of amenity rich areas and the differing experiences of liveability by Calgary residents.

DATA

City of Calgary Liveability Index

This study predominately used data available from the City of Calgary geospatial database to measure the liveability of the built environment throughout Calgary, leading to the generation of a "Calgary Liveability Index." This index is a cumulative active transportation accessibility score at the community level. To measure accessibility for active transportation, two unique GIS transportation networks were generated, representing the mobility options available to pedestrians and cyclists. For the pedestrian network, expressways, skeletal roads, and other roads known to be unusable by pedestrians were removed from the network data. To add pedestrian specific mobility options, the City's detailed pathway data was merged into the network. Similarly, a cycling network was produced by removing the same streets as the pedestrian network, but with further network data removed for streets assumed to be too uncomfortable/unsafe for the average urban cyclist. The provision of cyclist specific mobility options in the dataset was modeled by merging the pathway and bikeway network data into the stripped-down network.

From these networks, separate local walking and cycling accessibly measurements were conducted for a variety of essential amenities including food, employment, park space, and education. To measure and visualize areas with walkable and bikeable access to these essential destinations, non-overlapping network buffers were calculated using ArcMap's network analyst tools. Varying buffer radii were used for the different destinations, based on previous transportation research on active transportation. These walking and cycling buffers were generated on their unique network datasets, where the custom networks altered the shape and size of the generated network buffers to represent walkable and bikeable catchment areas to the selected destinations.

The separate pedestrian and cyclist network buffers for grocery store, employment, park, and four categories of school access (ECS, elementary, junior high, and senior high) created fourteen layers of polygon data. To turn these into a community level score, each non-overlapping network buffer layer was intersected with the community boundary polygons in ArcMap (see Figure 1). The surface area of each network buffer fragment from the intersect was calculated and the sum of the network buffer fragment surface areas were calculated within each community. Each community network buffer surface area sum was then divided by the total surface area of the community boundary; this gave a percentage of coverage by the network buffers for each community. A community fully covered by network buffers for a given amenity would receive a value of 1.00 and a community with no network buffer surface area falling within its boundaries would receive a score of 0. The metric produces a continuous variable between 0 and 1 that reflects the amount of buffer coverage in each community. In this way, a community boundary fully covered by the walk buffers to grocery stores for example, would reflect that 100% of the community has walkable access to grocery stores. Figure 1 shows examples from central Calgary of 800 m walk buffers to grocery stores intersected with community boundaries with highlighted examples of communities with high and low food access.

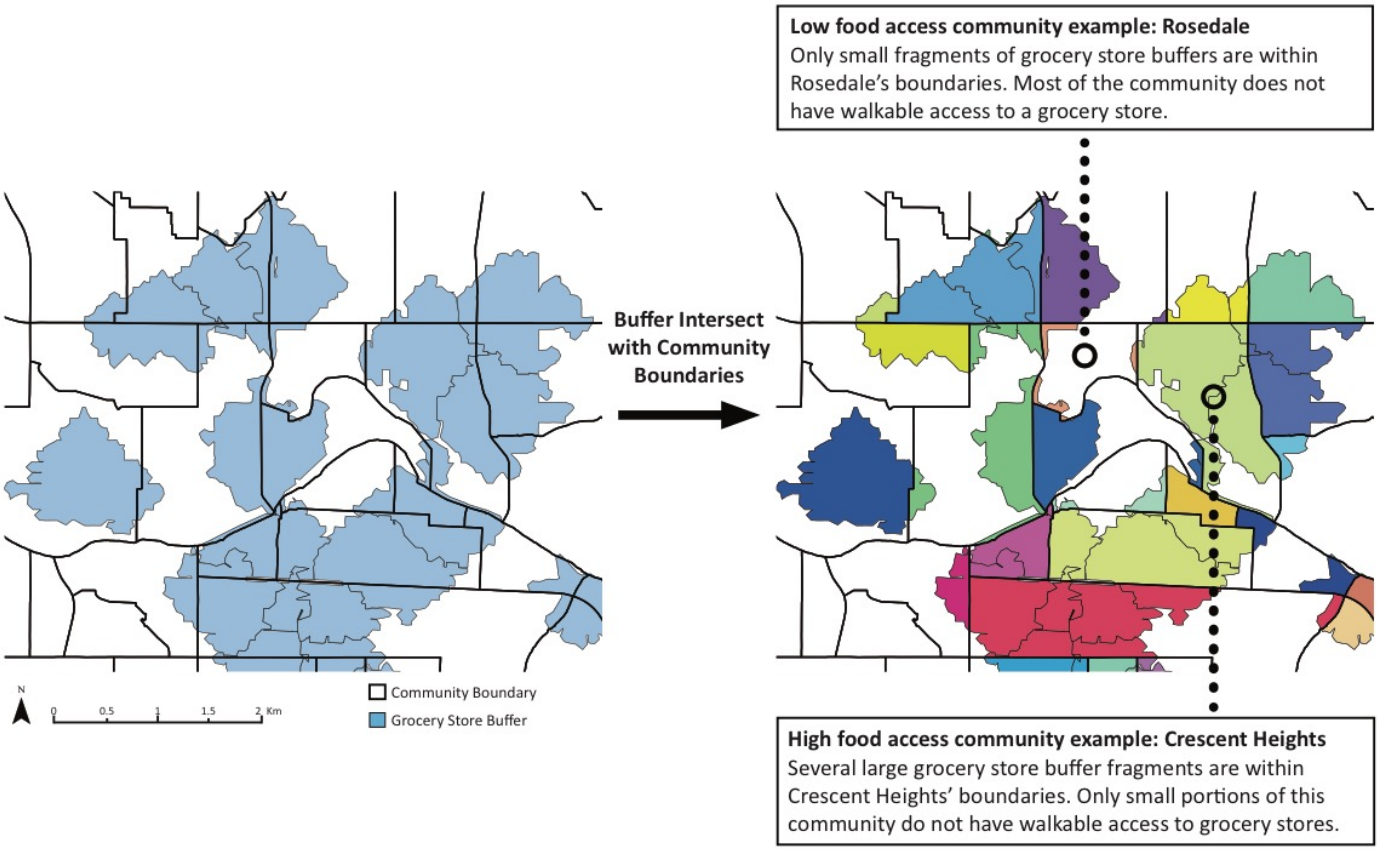


Figure 1: Demonstration of grocery store buffer intersect with the City of Calgary Community boundaries, used to convert buffer fragment surface areas and community boundary surface areas into a community level accessibility score

Each community had eight separate values from 0 to 1 representing their walkable and bikeable access to employment zones, grocery stores, parks, and schools. These eight variables and a transit utility metric were then averaged together for an overall liveability score for each community. The varying buffer sizes used in the accessibility score that reflect how far people generally walk and bike to different destinations provided an indirect, but built in weighting scheme to the presence of the different amenities measured in the Liveability Index. Additionally, the combined walk and bicycle access scores for each amenity provides a simple to understand distance decay aspect, where overlapping portions of cycling and walking buffers are both combined into the urban metric. The specifics of each component of the Liveability Index are discussed in more detail below.

Liveability Index: Grocery Access Scores

Research on food deserts (areas of poor access to retail food opportunities) was used to inform the buffer distances to grocery store locations. Though several distances are often used to generate a decaying measure with distance, 800 m is often considered a walkable distance to grocery stores (Bader, Purciel, Yousefzadeh, & Neckerman, 2010). Assuming a walking speed of 5 km/h and an average cycling speed of 20 km/h, roughly equivalent travel times by bicycle were calculated to be 3000 m. The City of Calgary GIS Business License file was used to identify grocery store locations and their centroids used to run the 800 m buffer calculation on the pedestrian network, and the 3200 m buffer calculated using the cyclist network dataset. Figure 2 shows the 800 m walk buffers and associated community scores.

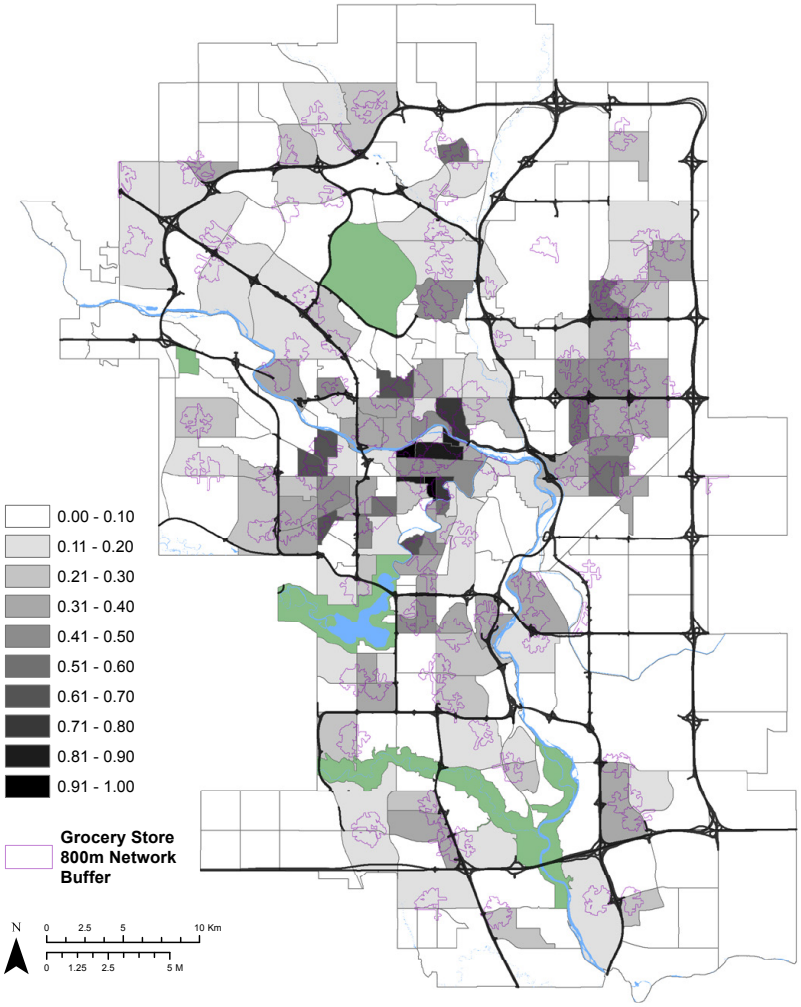


Figure 2: Calgary Liveability Index Example: community grocery access scores

Liveability Index: Employment Access Scores

For employment, previous research has shown that that individuals will walk 993 m on average to work locations and 1,789 m at the 85th percentile (Larsen, El-Geneidy, & Yasmin, 2010). Between the mean and 85th percentile distances, the Liveability Index used a value of 1200 m for the buffer radii to employment locations, which is approximately a 15-minute walk assuming an average walking speed of 5 km/h. An approximately equivalent cycling travel time distance of 5000 m was used for the cycling buffer. To identify major employment areas in Calgary, job density calculations were performed for the City's TAZ boundaries. The TAZs were then filtered for the boundaries with the top 80% job density values; these boundaries were identified as employment zones, and their centroids used to generate the 1200m and 5000m buffers on the pedestrian and cyclist networks.

Liveability Index: School Access Scores

Research on mode choice for children traveling to their schools has shown that students will predominantly use more sustainable transportation options when they live less than 1 km from their schools (29% driving as driver or passenger) (Wen et al., 2008). However, since the buffer sizes were intended to represent school aged individual's active transportation accessibility for a variety of ages, a slightly shorter distance of 800 m was used; an approximate equivalent bicycle travel time distance of 3500 m was used for the bicycle school access score. School locations were provided the City's GIS data and schools were separated into early childhood, elementary, junior high, and high schools, where in some cases, overlapping points were created where schools offered multiple categories of grade brackets. Network buffers were generated separately for each category. Full scores were only possible if walkable/bikeable access was provided for all four school categories, representing accessible education for the complete school aged life of students.

Liveability Index: Park Access Scores

To assess park accessibility, pervious research on walking to neighbourhood parks found that families would permit children to walk to parks within 400 m (Wolch, Wilson, & Fehrenbach, 2005). 400 m was

used for the pedestrian buffer radii around park entrances, using the pedestrian network. An approximately equivalent bicycle travel time distance of 1750 m was used for the bicycle network buffers calculated using the cyclist network data. Park polygon centroids were determined to not accurately represent park access points in the network and were especially problematic with larger parks serving multiple communities. To approximate the location of park entrance lactations, the City's park polygon GIS data was first filtered to exclude small greenspaces under 2000 m^2 (generally representing greenspaces that would not function as trip generators). Then, the network junctions (intersection points) within 15 metres of a park polygon (surface area > 2000 m^2) were selected. These selected junctions were used to run both the pedestrian and cyclist buffers, where most park catchment areas were measured/visualized with multiple, non-overlapping 400/1750 m buffers.

Liveability Index: Transit Quality Score

To evaluate transit stops in Calgary, GTFS stop location and route data was used in conjunction with revenue operating (ROH) data from the City's annual transit reports was used to develop a transit utility score. Revenue operating hours are the number of hours that in-service vehicles are circulating a given transit route per day. ROH was used as a proxy variable for transit quality, sensitive to both service frequency and service hours; high ROH values are found along routes with frequent, 24 hour service, while lower values are found along routes with infrequent, peak-time only service. The weekly sum of ROH generated at each bus and LRT stop in Calgary was calculated. To prevent longer routes from collecting higher scores than shorter routes, the values were normalized by route length for the transit utility metric (creating ROH/Km values). With the transit stop locations and their associated ROH/Km values plotted in ArcMap, the sum of the transit stop ROH/Km values within each of Calgary's communities was found. The community ROH/Km sums were normalized against the top performing community (highest ROH/Km sum) with several identified extreme ROH/Km community sums ignored in the calculation. The top performing community and the outliers above it took a value of one, with community scores ranging between 0 and 1, proportional to their ROH/Km sums. Figure 3 shows the map of transit utility scores for Calgary's communities.

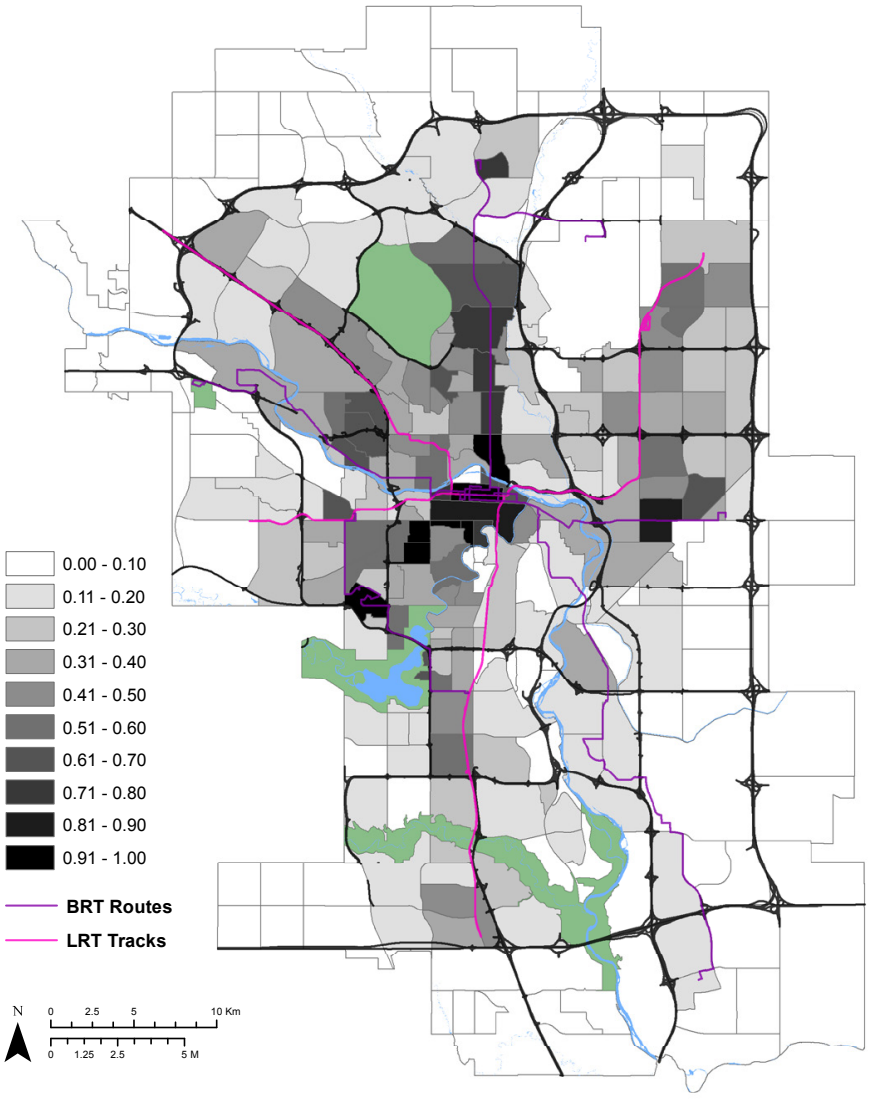


Figure 3: Calgary Liveability Index Example: community transit utility scores

Home Location Network Distance to Amenities

Using respondents' geolocated home locations, the network distances to several amenities and destinations were calculated for each survey participant. The purpose of developing this variable was to help understand home choice decisions based on proximity to points of interest in Calgary. The shortest distance was used as the cost variable in the network analysis to provide a more realistic idea of proximity than straight line distances. This analysis did not attempt to model routes based on known mode choices from the survey.

When provided, the shortest network distances to respondents' specified work, postsecondary school, preferred grocery store, and visited park locations were calculated. Additionally, using bus and LRT stop locations in Calgary, the distance from each respondents' home location to the closest bus and LRT stops were calculated using ArcMap's Closest Facility network analyst function. Similarly, the network distances to the nearest early childhood, elementary, junior high, and high school locations were calculated for each provided home location. The City of Calgary's GIS Business License data was used to separate business locations into Entertainment and Goods/Services categories; the network distances to the nearest five entertainment destination and the nearest five goods/services destinations were also calculated for each survey respondent. Figure 4 shows the average distances and the 85th percentile distances to the aforementioned amenities for all provided home locations.

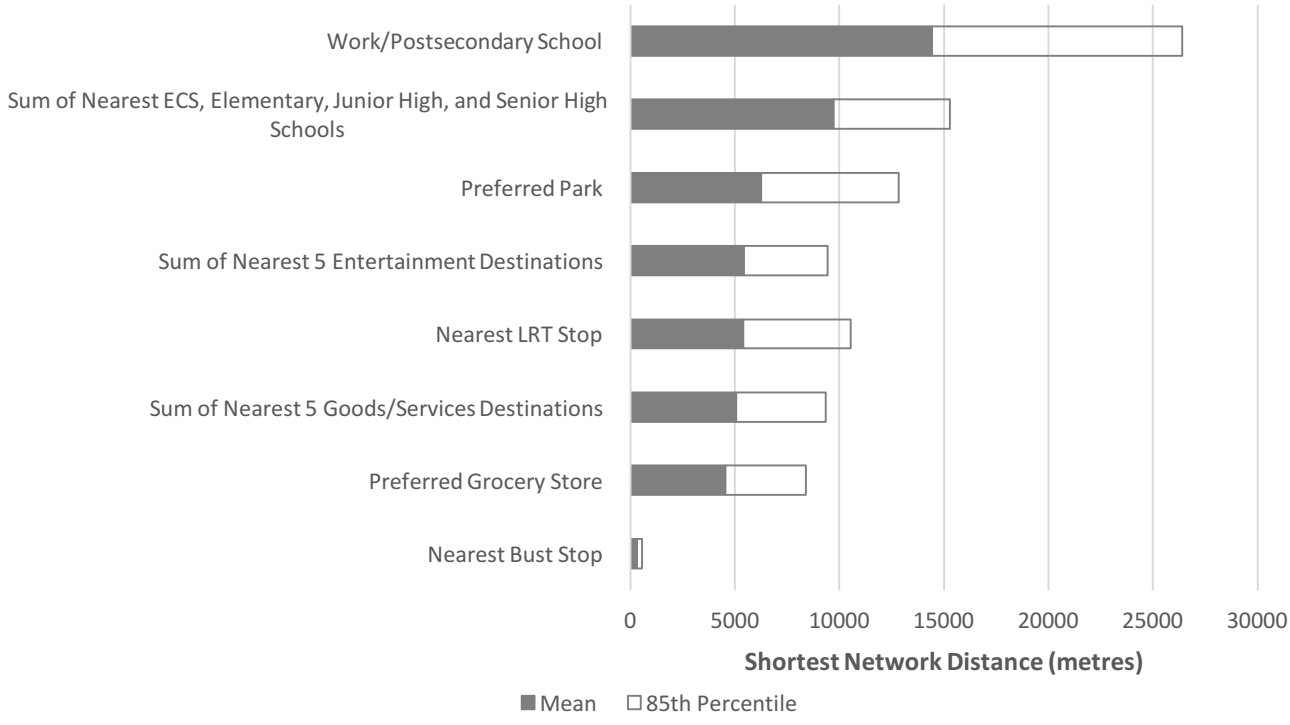


Figure 4: Average Network Distances to Essential Amenities from Provided Home Locations

Calgary Liveability Survey

The survey data component of this study was collected via an online survey, promoted through various online venues, relevant to residents of Calgary. Draw prizes were offered as incentives to participate. Numerous community associations, recreational groups, schools, and other groups based in Calgary were asked to circulate a descriptive and promotional email to their membership. Furthermore, links to the survey were circulated in social media amongst Calgarians and posts were made on online forums for Calgary interest groups. The data collection period ran for 28 days, from February 2nd, 2017 to March 2nd, 2017; 1,061 full responses were collected. However, after further analysis of the data and due to the requirements of the study, a final sample size of 711 was used for the population stratification analysis. Calgary's total population in 2015 was 1.4 million (StatsCan, 2016).

The survey asked respondents to locate several key travel destinations such as their home, work, and preferred grocery store locations by dragging and dropping a pin on a map. Respondents were also asked to rank several lists of factors in order of importance when considering their home location choice, such as proximity to local amenities, neighborhood characteristics, and property aspects. Additionally, the survey asked detailed mode choice and ordinal ranked travel convenience questions for a variety of trip types, including work, groceries, recreation, needs of children, and cultural/entertainment destinations. The mode choice questions in the survey offer much higher detail data on travel choices within communities and to essential destinations than typical work commute mode share information. Further detail was gained by asking warm, dry and cold, wet weather condition travel questions.

Previous research has shown that question order can have an effect on the considerations participants have when answering attitudinal questions (Gandelman, Piani, & Ferre, 2012). The Calgary Liveability survey question order was randomized for warm, dry and cold, wet condition and trip satisfaction questions, with options appearing in different orders depending on a respondent's random assignment to one of two groups. The survey also included many optional socioeconomic and household structure

questions, which collected information on aspects such as education level, income, number of children in the household, number of cars owned by the household, and age.

ANALYSIS

Principle Component Factor Analysis

The statistical software, SPSS was used to conduct a principal components analysis (PCA) of all questions in the survey relevant to travel behavior and perceptions. PCA groups correlating variables into factors that explains the variability in the data. The created factors become a new set of linearly uncorrelated variables, helping to reduce the number of variables in the analysis (Krizek & El-Geneidy, 2007). Varimax rotation, which maximizes the sum of the variances of the squared loadings, was used to identify survey questions with factor loadings greater than 0.5 and less than -0.5. Variables with factor loadings above/below the 0.5/-0.5 threshold were iteratively removed from the PCA in order of their insignificance; leading to a set of factors with all factor loadings above 0.5 or below -0.5. Table 2 shows the grouped survey question variables, their factor loadings, and assigned grouping names. The fourteen factors are then used in following analysis to define segments of the population based on travel behavior and perceptions.

Question/Variable	Sub Questions/Variable		Factor Loading
Satisfaction with Grocery Trips			
Please rate your level of agreement with the following statements about your trip to your preferred grocery store	I am satisfied with the travel time of my trip	(cold, wet conditions)	.861
	I am satisfied with the travel time of my trip	(warm, dry conditions)	.852
	Overall, I am satisfied with my trip	(warm, dry conditions)	.840
	Overall, I am satisfied with my trip	(cold, wet conditions)	.839
	The cost of my trip is reasonable	(cold, wet conditions)	.838
	The cost of my trip is reasonable	(warm, dry conditions)	.837
	The travel time of my trip is consistent	(warm, dry conditions)	.798
	The travel time of my trip is consistent	(cold, wet conditions)	.775
Convenience to Reach Entertainment			
How convenient is it for you to reach the following destinations	Retail options (clothing stores, book stores, etc.)	(cold, wet conditions)	.852
	Cultural & entertainment attractions (theatres, restaurants, etc.)	(cold, wet conditions)	.834
	Retail options (clothing stores, book stores, etc.)	(warm, dry conditions)	.824
	Cultural & entertainment attractions (theatres, restaurants, etc.)	(warm, dry conditions)	.815
	Recreational locations (gyms, community centre,)	(cold, wet conditions)	.791
	Recreational locations (gyms, community centre,)	(warm, dry conditions)	.773
Distance to CBD (-) and Proportion of Trips Taken by Walking (+) and Driving (-)			
Recoded variable of mode choice questions for all destinations	Proportion of all trips, mode choice: walk	(cold, wet conditions)	.886
	Proportion of all trips, mode choice: walk	(warm, dry conditions)	.865
	Proportion of all trips, mode choice: drive	(warm, dry conditions)	-.734
	Proportion of all trips, mode choice: drive	(cold, wet conditions)	-.733
Created variable	Network distance to CBD from reported home location		-.565
Convenience to Reach Transit			
How convenient is it for you to reach the following destinations	Bus stops	(warm, dry conditions)	.787
	Bus stops	(cold, wet conditions)	.781
	LRT stops	(warm, dry conditions)	.756
	LRT stops	(cold, wet conditions)	.745
Liveable Neighbourhood			
Please rate how easy it is for you to travel by the following modes of transportation in your neighbourhood	Cycling		.749
	Walking		.729
How would you rate the overall liveability of your neighbourhood (ability to access your essential amenities)		(warm, dry conditions)	.633
		(cold, wet conditions)	.616
Car Ownership (+), Transit Ridership (-)			
Select all the following that apply to you	I have a driver's license		.735
	I have access to a privately owned car (not car-share)		.706
Recoded variable of mode choice questions for all destinations	Proportion of all trips, mode choice: transit	(cold, wet conditions)	-.637
	Proportion of all trips, mode choice: transit	(warm, dry conditions)	-.633
Proportion of Trips Taken by Bicycle			
Recoded variable of mode choice questions for all destinations	Proportion of all trips, mode choice: bike	(cold, wet conditions)	.899
	Proportion of all trips, mode choice: bike	(warm, dry conditions)	.893
Occupation: Employed (+), Student (-)			
What describes you best? (Please choose the option applies to you the most)?	Student		-.907
	Employed		.900
Transit Enjoyment			
How much do you agree with the following statements?	I enjoy riding the LRT		.857
	I enjoy riding the bus		.849
Home Choice: Quality of Transport Network/Systems			
When choosing your current home location, please rank at least the top 3 factors in order of importance to you and others living in the home:	Top Choice: Quality of the Transportation Network/Systems		.881
Age and Years Spent at Current Home Location			
What year were you born?	Recoded variable for age (years)		.848
In what year did you start living in your current residence?	Recoded variable for years spent in home		.833
Importance of Health and Enjoyment When Planning Trips			
How important are the following statements when planning any trip?	The overall enjoyment of the trip		.725
	The long-term effect on my health		.723
Home Choice: Quality of the Property (+), Presence of Nearby Amenities Property (-)			
When choosing your current home location, please rank at least the top 3 factors in order of importance to you and others living in the home:	The presence of nearby amenities		-.873
	The quality of the property		.744
Home Choice: Character of the Neighbourhood			
When choosing your current home location, please rank at least the top 3 factors in order of importance to you and others living in the home:	The character of the neighbourhood		.946

Table 2: PCA Factor Loadings

K-Means Cluster Analysis

The fourteen PCA factors were used in a K-Means cluster analysis is SPSS. This two-step, factor-cluster process, has been shown to effectively segment survey responses into thematic groupings (clusters) of common trends within the PCA factors (Damant-Sirois, Grimsrud, & El-Geneidy, 2014; Song & Knaap, 2007; van Lierop & El-Geneidy, 2015). In this study, the generated factor scores for each variable used in the PCA factors were used to identify groups of Calgarians with similar travel behaviours, experiences, and perceptions. By minimizing the intragroup differences, while maximizing intergroup differences between clusters, the cluster analysis in SPSS highlights common themes in the survey findings. The number of clusters created by the analysis is preselected and the process is an iterative, exploratory approach to evaluating the qualitative groupings. As suggested by Damant-Sirois et al. (2014), the analysis was run for three to eight clusters, where the analysis offering the best qualitative descriptions of identified groupings is used for further examination. While many other studies on market segmentation are more focused, such as cyclist or transit rider specific studies, this study attempted to categorize a full range of individual travel behavior typologies. This broader scope led to an eight-cluster stratification used for the analysis.

Figure 5 shows the eight clusters of travel behaviour, experiences, and perceptions in Calgary, with the cluster typology names displayed above. Additionally, each cluster's proportion of representation in the sample is listed below the names. The plotted cluster centres represent the relative predominance of the fourteen factors in segmenting the clusters. Positive values indicate a positive association with the cluster and negative values indicate a negative association. For example, in the first group, the factor named "Proportion of Trips Taken by Bicycle" is highly associated with this first group, in a positive direction; this suggests the group is predominantly defined by their atypically high amount of cycling trips. Factors with both negative and positive factor loadings represent cases where included variables are correlated, but in opposite directions. For example, when positive, the factor named "Car Ownership (+), Transit Ridership (-)" indicates high rates of possessing a driver's license and having access to car, but a low proportion of trips taken by transit. However, negative values in this factor indicate a high

proportion of trips taken by transit, low driver's licensing rates, and less access to a car. As can be seen in figure 5, the dark blue bar representing "Car Ownership (+), Transit Ridership (-)" is highly associated with the two transit rider clusters.

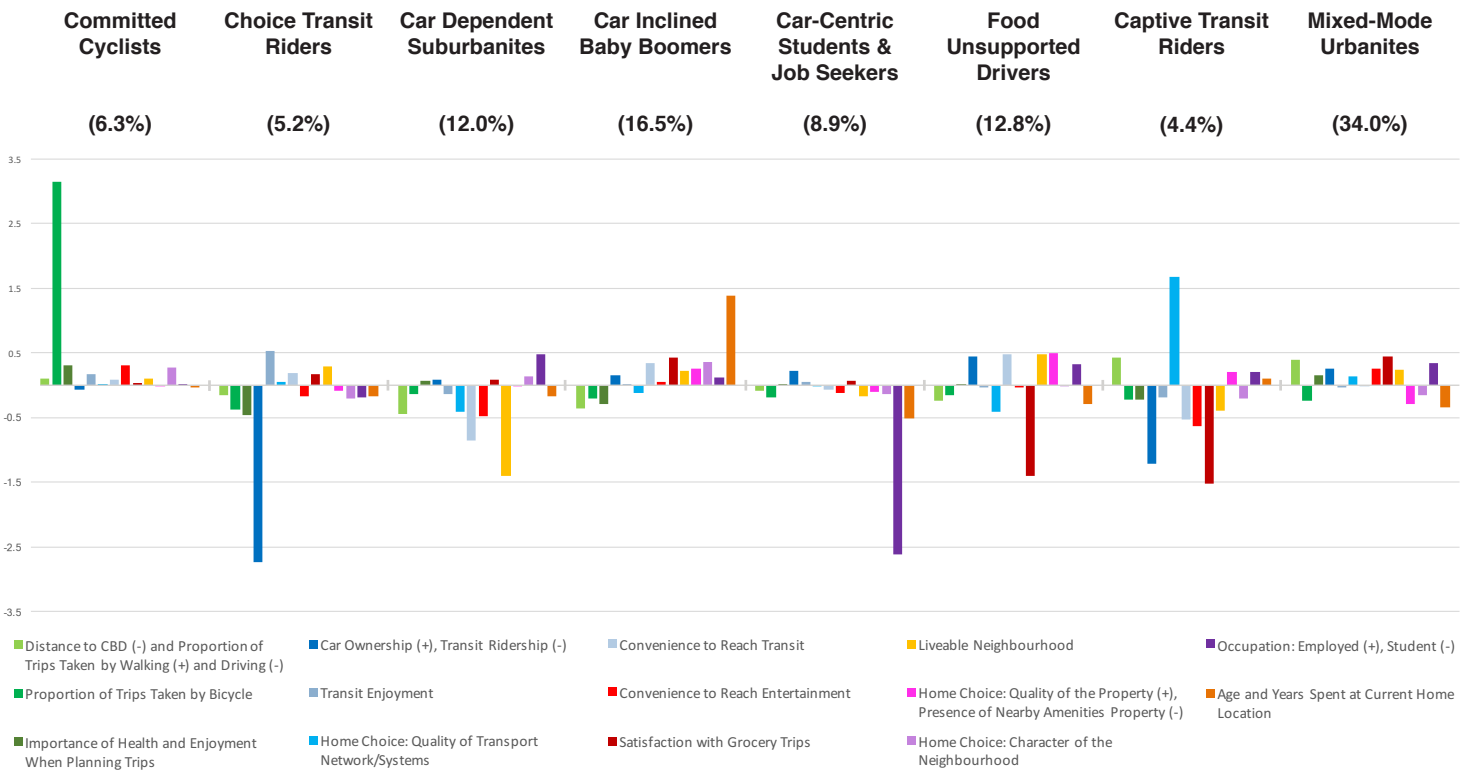


Figure 5: K-means Travel Behaviour and Liveability Typology Cluster Centres

The eight-cluster model and the identified travel typologies can then be used to extract summary statistics and data specific to each group. Eight, one-page 'data compositions' were created for each group which summarizes information unique to each group. The data compositions help to further understand the lifestyle, sociodemographic, and spatial difference between the eight travel typologies. The following annotated example explains the included data and its layout location for the data compositions (see Figure 6).

Home Choice Considerations

- Most frequently reported top consideration when choosing a home location, given the options: presence of nearby amenities, quality of the property, character of the neighbourhood, or quality of the property
- Top three considered amenities when choosing a home location, given the options: proximity to work/school, partner's or spouse's work/school, children's school/ preschool, grocery stores, retail, recreation locations, culture/entertainment attractions, parks, public transit stations, cycling infrastructure, and freeways/arterial roads

Cluster Analysis Profile

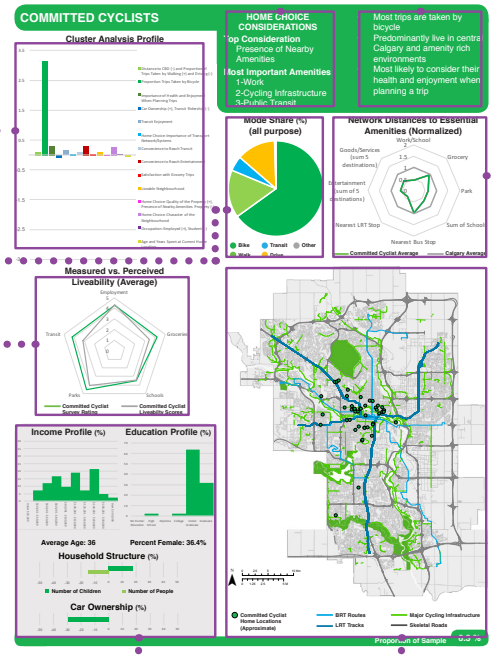
- K-means cluster centre plot from the factor-cluster analysis for the travel typology

General Notes

- Key qualitative and quantitate observations for the cluster

Mode Share Pie Chart

- Transportation mode choice distribution for all trips reported in the survey including trips in warm, dry and cold, wet conditions to work/postsecondary school, grocery stores, social gatherings, children's school, retail needs, culture & entertainment attractions, recreational destinations, and parks



Normalized Network Distance to Essential Amenities Radar Chart

- Chart of cluster and full-sample average network distances to eight key destinations, including work/postsecondary school; preferred grocery store; preferred park; sum of ECS, elementary, junior high, and high schools; nearest bust stop; nearest LRT stop; sum of nearest five entertainment destinations; and sum of nearest five goods/services destinations
- Note: Cluster averages are normalized against the Calgary average by dividing the cluster average by the full sample average for each destination, highlighting clusters that travel exceptionally above or below the average distances traveled by Calgarians

Measured vs. Perceived Liveability Radar Chart

- Chart of average Calgary Liveability Index scores spatially joined to the cluster members' home locations for employment, grocery, school, and park access scores, and transit utility score, combined with respondents' average rated convenience in warm, dry and cold, wet conditions to work/postsecondary school, preferred grocery store, children's school, preferred park, and bus/LRT stops
- Note: Average Liveability Scores are normalized to 1-5 scale for comparison to the ordinal survey scale

Sociodemographic Frame

- Contains summary data for the cluster, including income and education distributions, average age, gender split, number of children and people in the household (normalized against the full-sample average), and number of cars owned by the household (normalized against the full-sample average)

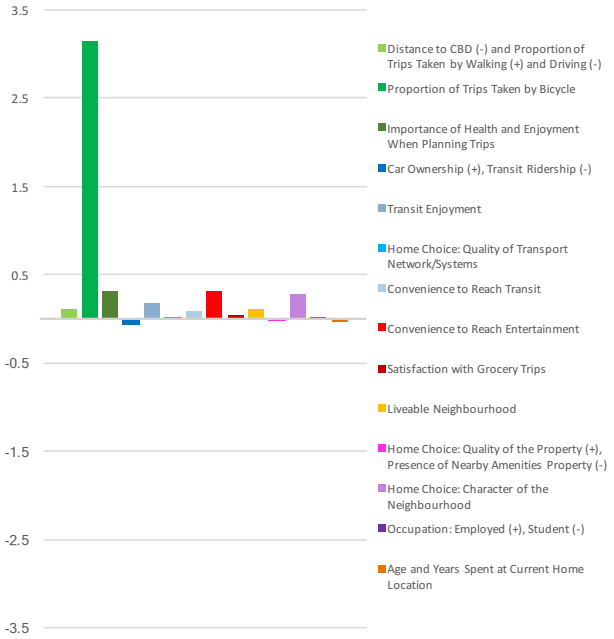
Home Location Map

- Map of approximate home locations of survey cluster members

Figure 6: Annotated data composition example

COMMITTED CYCLISTS

Cluster Analysis Profile



HOME CHOICE CONSIDERATIONS

Top Consideration

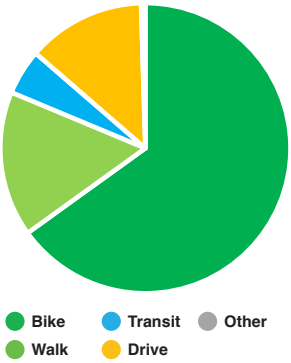
Presence of Nearby Amenities

Most Important Amenities

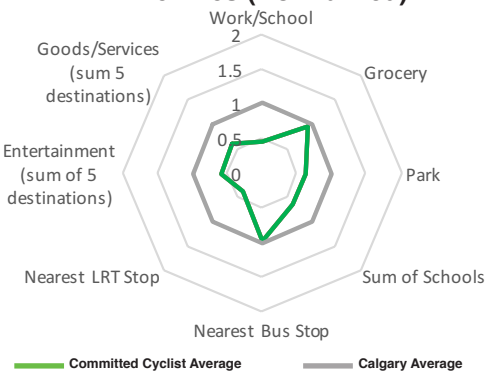
1-Work
2-Cycling Infrastructure
3-Public Transit

- Most trips are taken by bicycle
- Predominantly live in central Calgary and amenity rich environments
- Most likely to consider their health and enjoyment when planning a trip

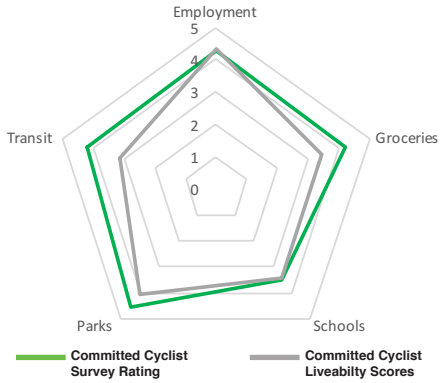
Mode Share (%) (all purpose)



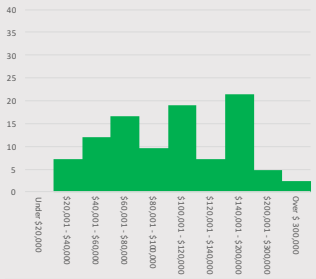
Network Distances to Essential Amenities (Normalized)



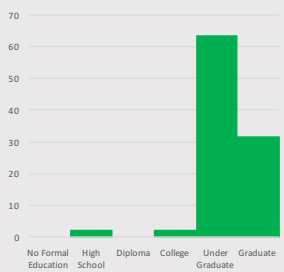
Measured vs. Perceived Liveability (Average)



Income Profile (%)



Education Profile (%)

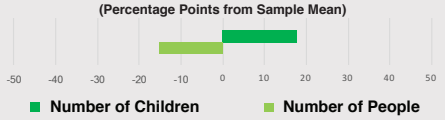


Average Age: 36

Percent Female: 36.4%

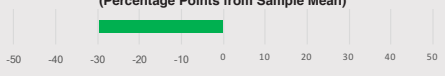
Household Structure

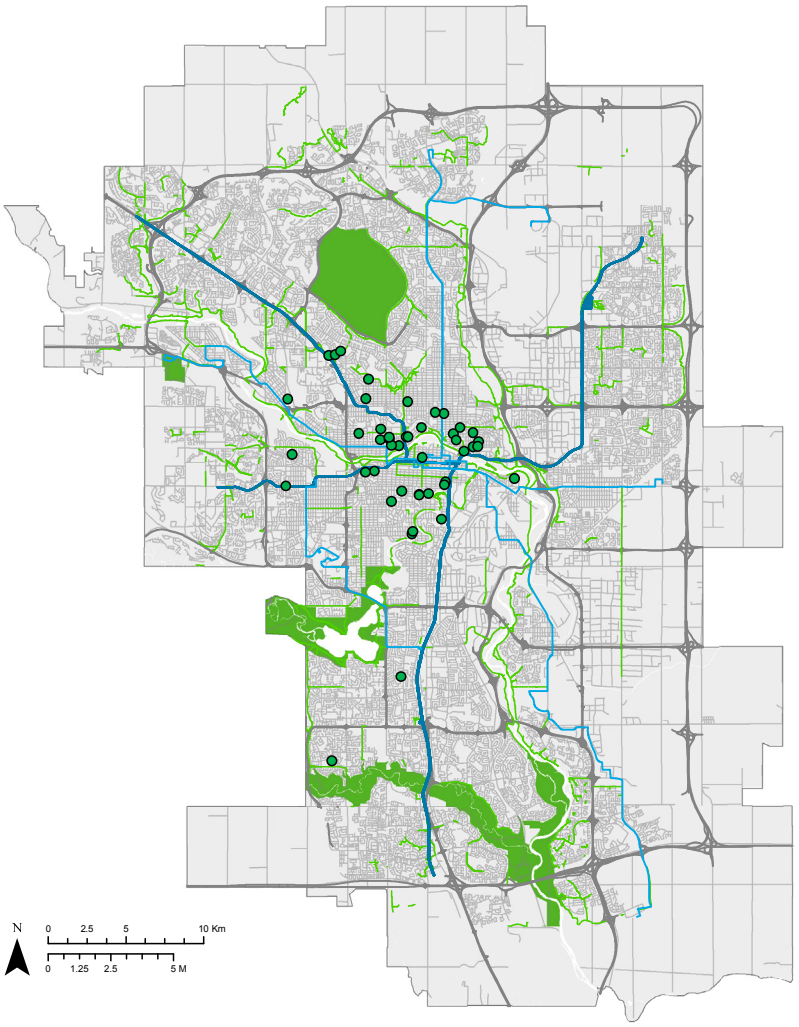
(Percentage Points from Sample Mean)



Car Ownership

(Percentage Points from Sample Mean)





Proportion of Sample **6.3 %**

Figure 7: Committed cyclist data composition

Committed Cyclists

Committed cyclists (6.3% of the sample) are primarily segmented from the other groups by their all trip purpose mode share, which is dominated by bicycle trips. This group also tends to live in amenity rich environments, as seen in the committed cyclist's network distances to essential amenities, which are generally far below the Calgary average. The committed cyclists seem to be acutely aware of liveability concepts in their lifestyle, with "presences of nearby amenities" emerging as the group's top home choice location consideration. Further highlighting their strong interest and reliance on cycling, the group's second highest rated amenity is access to cycling infrastructure, with work, and public transit access ranking as their highest and third most important destinations. In line with expectations, the committed cyclist home locations are tightly clustered around central Calgary and downtown. Both the spatially joined liveability scores for employment, grocery, school, park, and transit access and the rated convenience to these destinations by committed cyclist are quite high; suggesting this group would likely be responsive to, and mindful of changes in liveability in their communities and throughout the City of Calgary.

Interestingly, the committed cyclists are not particularly young on average (second highest average cluster age). They also have a slightly higher than average number of children, but a lower number of total individuals in the household; suggesting committed cyclists may often be a part of small families. They are also highly educated with a mid to higher income profile. As expected, their car ownership rates are far below the Calgary average.

MIXED-MODE URBANITES

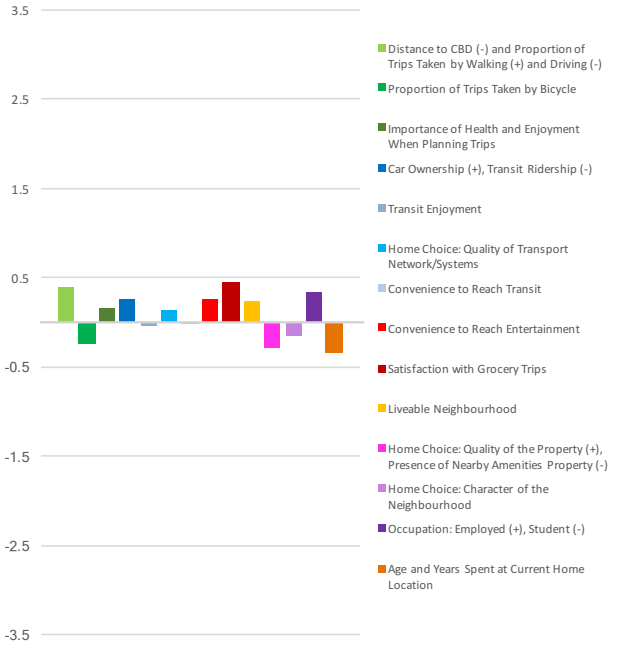
HOME CHOICE CONSIDERATIONS

Top Consideration
Presence of Nearby Amenities

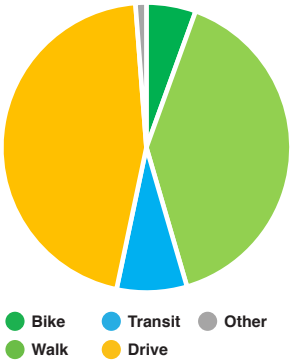
Most Important Amenities
1-Work
2-Grocery Stores
3-Public Transit

- Most trips taken by active transportation (walking, cycling, public transit)
- Predominately live in Central Calgary and more amenity rich areas further from the CBD
- Most likely to consider local amenities over property aspects when choosing a home location

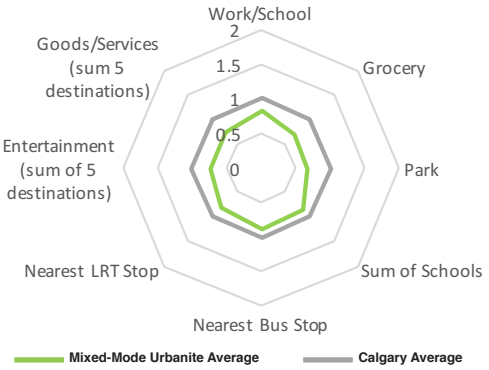
Cluster Analysis Profile



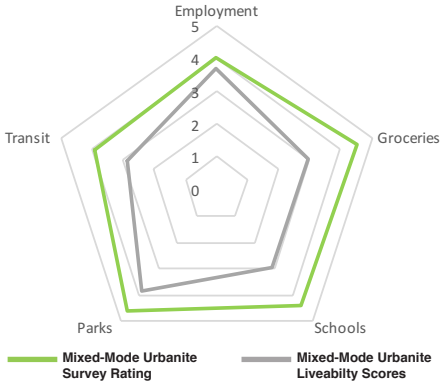
Mode Share (%) (all purpose)



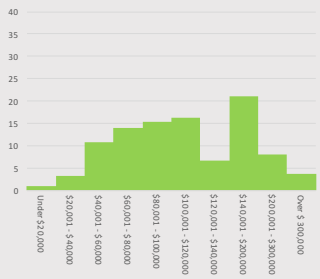
Network Distances to Essential Amenities (Normalized)



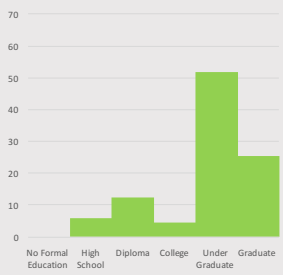
Measured vs. Perceived Liveability (Average)



Income Profile (%)



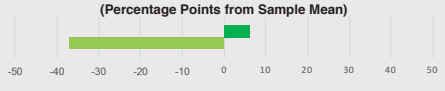
Education Profile (%)



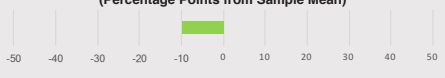
Average Age: 34

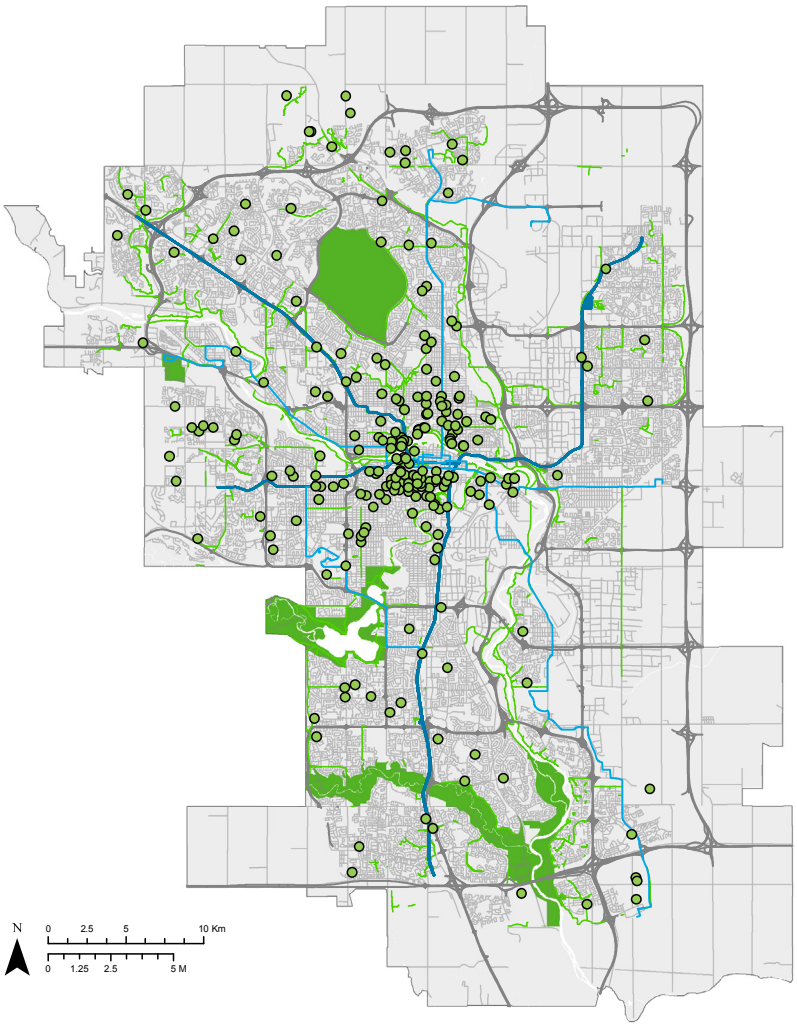
Percent Female: 44.5%

Household Structure
(Percentage Points from Sample Mean)



Car Ownership
(Percentage Points from Sample Mean)





Proportion of Sample **34.0 %**

Figure 8: Mixed-mode urbanite data composition

Mixed-Mode Urbanites

Mixed-mode urbanites (34.0% of the sample) have the highest positive expression of the "Distance to CBD (-) and proportion of trips taken by walking (+) and Driving (-)" factor. They also have high rated convenience to reach entertainment destinations and are more amenity focused than property quality focused in choosing home locations. Looking beyond the cluster centre results, as expected, mixed-mode urbanites' top consideration when choosing a home location is the presence of nearby amenities. Their highest priority amenities to have proximate to their home locations are work, grocery stores, and public transit stations. This group generally lives in amenity rich environments, as can be seen in their network distances to essential amenities, which are all below the Calgary average. The easy access to essential amenities that mixed-mode urbanites experience supports a more balanced mode share, with an exceptionally large proportion of walking trips. This group also has relatively high transit and cycling ridership, as well as one of the largest proportions of "other" modes of transport (e.g. skateboards). Though mixed-mode urbanite home locations have fairly widespread representation throughout Calgary, the group's homes are densely clustered around central Calgary/downtown.

Mixed-mode urbanites are also highly educated with a mid to higher income profile. Their car ownership rates are below the Calgary average. Their mix of slightly higher than average numbers of children in the household with lower than average numbers of total individuals suggests this group is predominantly comprised of small families.

CAR DEPENDENT SUBURBANITES

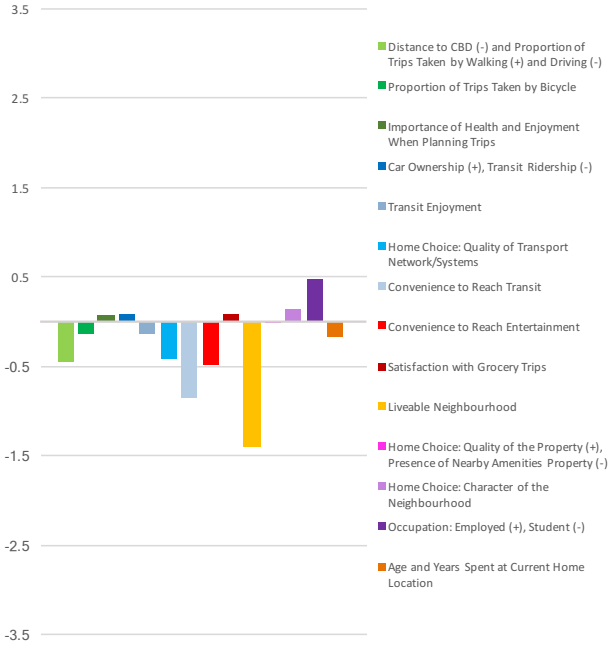
HOME CHOICE CONSIDERATIONS

Top Consideration
Quality of the Property

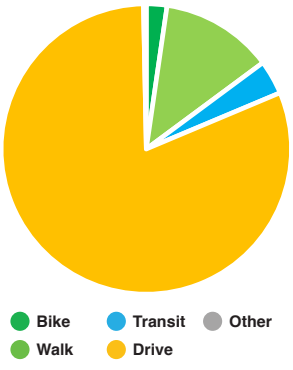
Most Important Amenities
1-Work
2-Grocery Stores
3-Parks and Greenspace

- Most trips taken by car
- Predominantly live in Calgary's peripheral neighbourhoods, in amenity scarce environments
- Least likely to repot high liveability, bikeability, and walkability for their neighbourhood

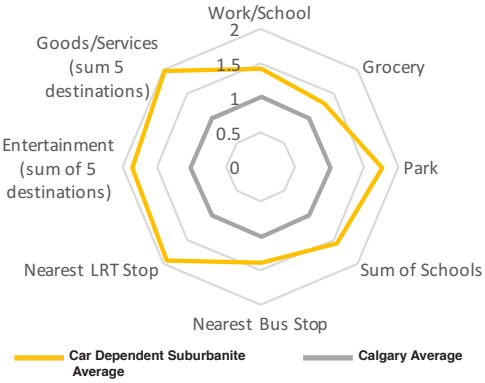
Cluster Analysis Profile



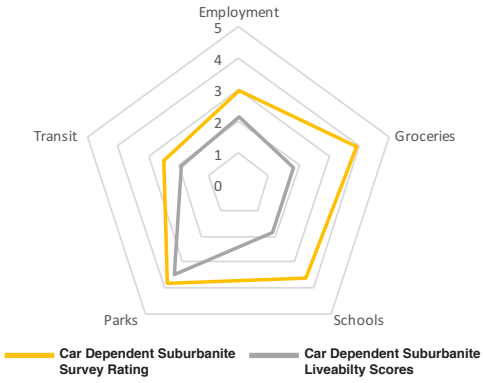
Mode Share (%) (all purpose)



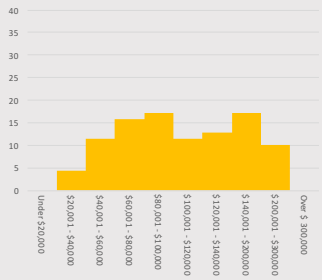
Network Distances to Essential Amenities (Normalized)



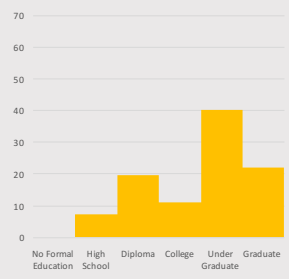
Measured vs. Perceived Liveability (Average)



Income Profile (%)



Education Profile (%)

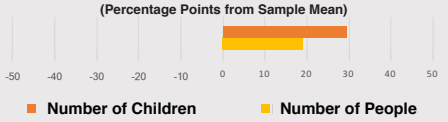


Average Age: 33

Percent Female: 42.2%

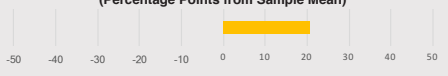
Household Structure

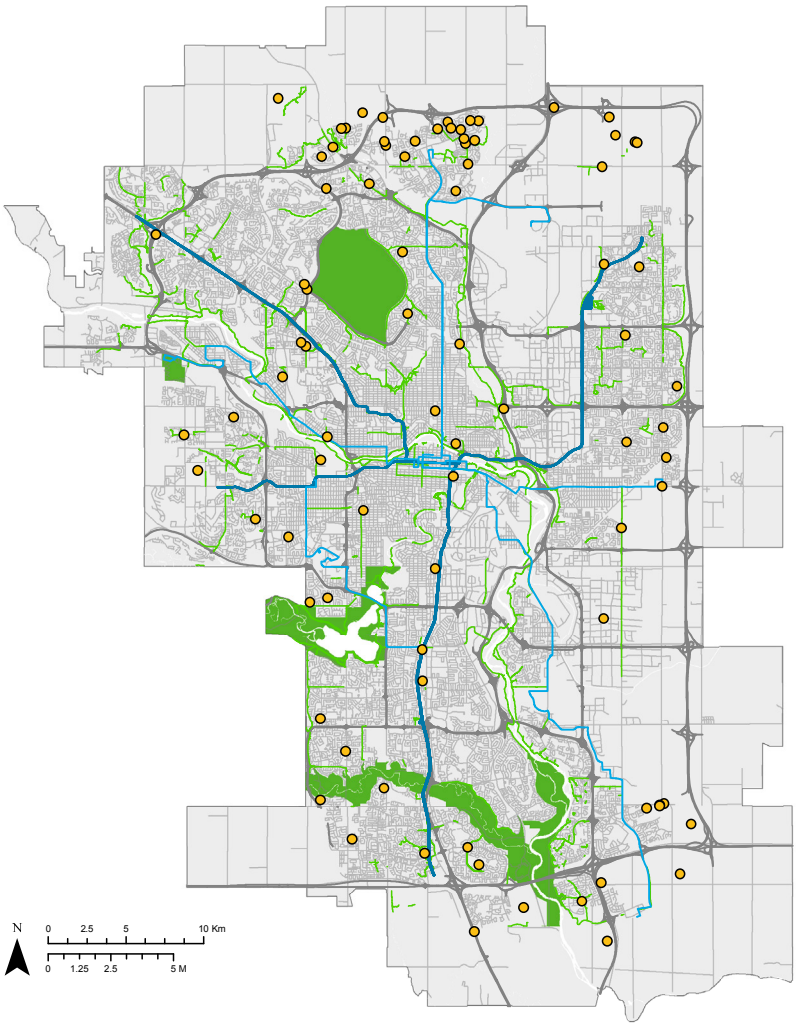
(Percentage Points from Sample Mean)



Car Ownership

(Percentage Points from Sample Mean)





Proportion of Sample 12.0 %

Figure 9: Car dependent suburbanite data composition

Car Dependent Suburbanites

Car dependent suburbanites (12.0% of the sample) are primarily segmented from the rest of the sample by their relatively low ratings of their neighbourhood's liveability, walkability, and bikeability. From their cluster analysis profile, car dependent suburbanites also report low access to transit and are dissatisfied with their trip to the grocery store. In line with expectations, the reported amenity scarce environments are reflected in the car dependent suburbanite's network distances to essential amenities, which are often 50% to 100% above of the Calgary average. The group's distant proximity to goods/services, entertainment destinations, and LRT stops are particularly high; suggesting car dependent suburbanites do not live in mixed land-use environments. As seen on the map of car dependent suburbanite home locations, there are very few living near central Calgary/downtown. This group has cluster members located throughout Calgary's outer neighbourhoods with a cluster in the northern edge of the City and many living south of Fish Creek Park. With the group's poor access to essential amenities and disconnect from central Calgary, unsurprisingly, the car dependent suburbanite's all-purpose mode share is car dominated.

With the car dependent suburbanite's top housing choice priority being the quality of the property, the group's car dependence is likely self-imposed. Despite work, grocery stores, and parks rated as their top ranked proximate amenities when choosing a home location, car dependent suburbanites don't seem to locate near these destinations. The difference between their reported convenience to reach the amenities measured in the Liveability Index is relatively large, with their "perceived liveability" much higher than their "measured liveability." Car dependent suburbanites seem to be disconnected from concepts of liveable neighbourhoods. Highly educated and holding moderate to high incomes, car dependent suburbanites could likely afford to live in more amenity rich environments, but are choosing areas with more desirable properties. This group also has higher numbers of children and individuals in the household, suggesting car dependent suburbanites are often a part of larger families.

CAR INCLINED BABY BOOMERS

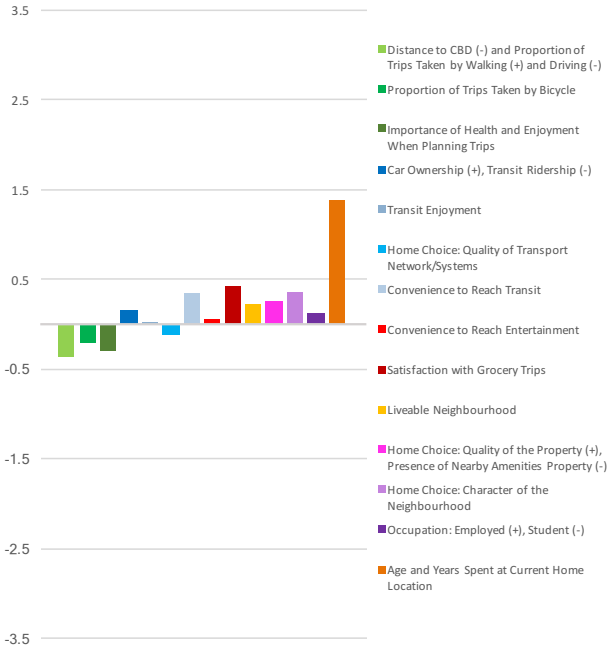
HOME CHOICE CONSIDERATIONS

Top Consideration
Character of the Neighbourhood

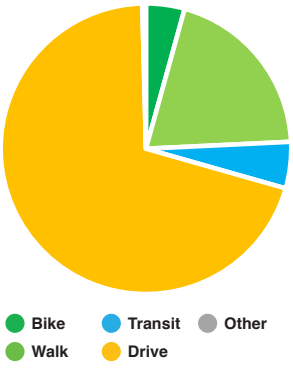
Most Important Amenities
1-Parks and Greenspace
2-Work
3-Children's School

- Most trips taken by car
- Predominantly live in Calgary's peripheral neighbourhoods, in areas with moderate access to essential amenities/ destinations
- Most likely to be content in neighbourhoods with generally low liveability

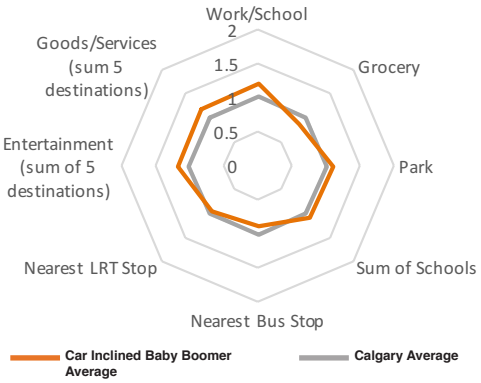
Cluster Analysis Profile



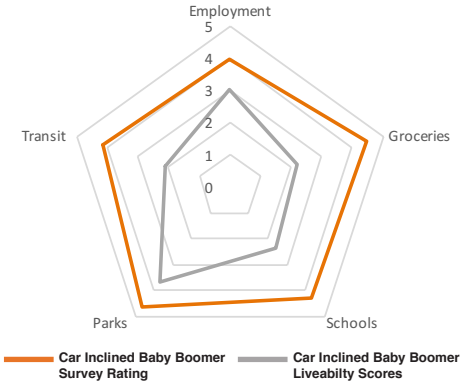
Mode Share (%) (all purpose)



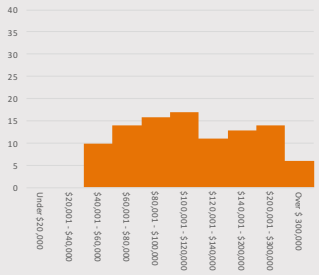
Network Distances to Essential Amenities (Normalized)



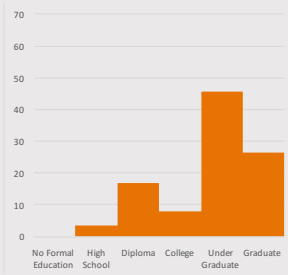
Measured vs. Perceived Liveability (Average)



Income Profile (%)



Education Profile (%)

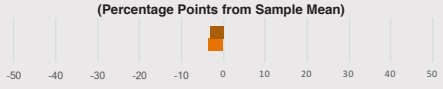


Average Age: 50

Percent Female: 45.1%

Household Structure

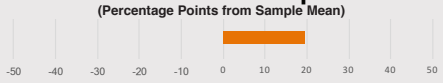
(Percentage Points from Sample Mean)

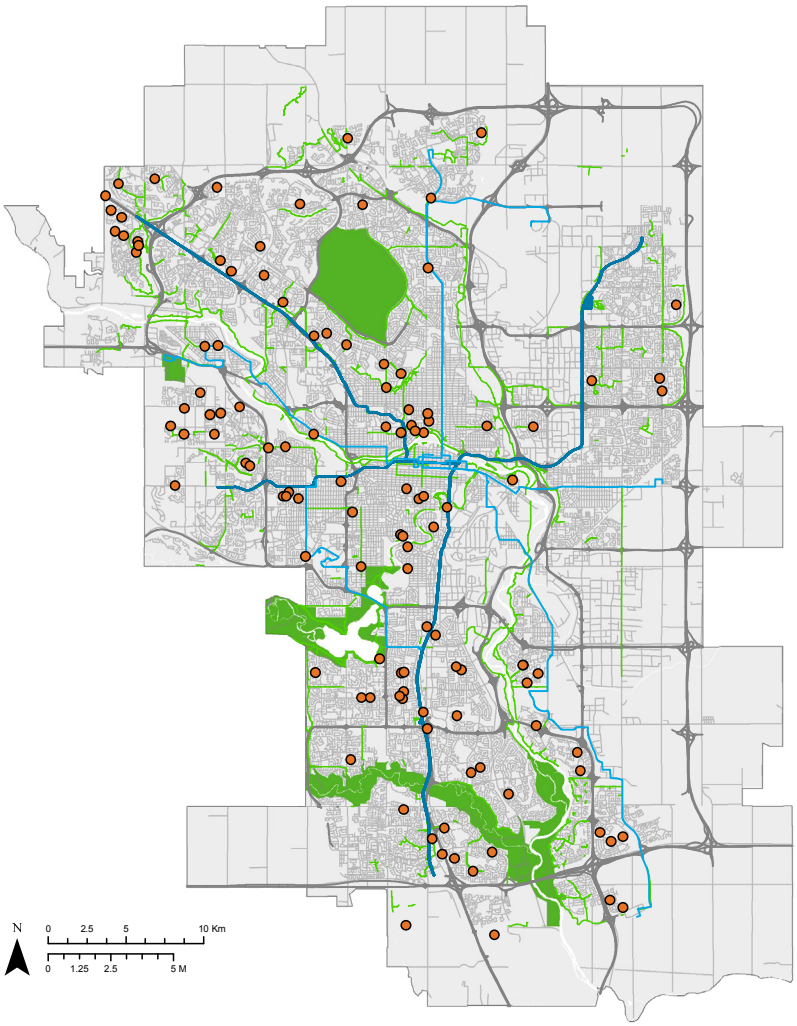


Number of Children Number of People

Car Ownership

(Percentage Points from Sample Mean)





Proportion of Sample **16.5 %**

Figure 10: Car inclined baby boomer data composition

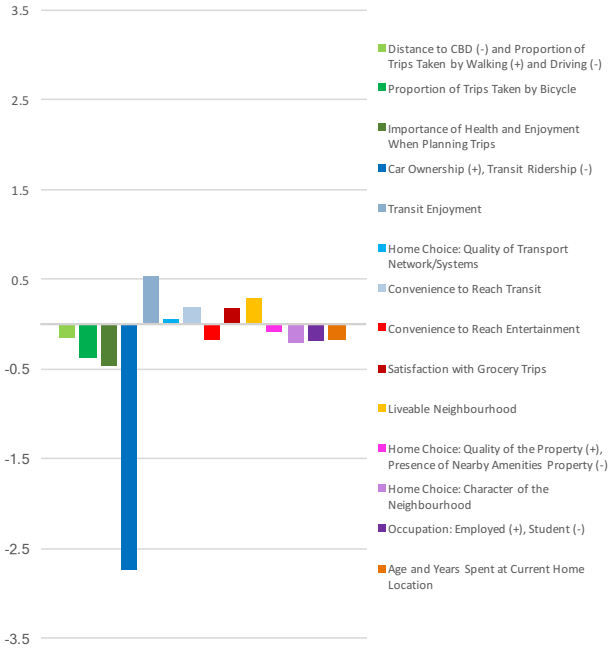
Car Inclined Baby Boomers

Car inclined baby boomers (16.5%) have the highest positive expression of the "Age and Years Spent at Current Home Location" factor, indicating they are older and have not moved recently. The group's average age of 50 years is much higher than other groups (average age of other seven clusters is 32 years). Though the group's car-focused mode share is similar to the car dependent suburbanite's mode share, car inclined baby boomers report higher satisfaction with their trip to the grocery store and rank their neighbourhoods as more liveable, walkable, and bikeable. Compared to the car dependent suburbanites, this group seems to be living in environments more befitting to their needs, with their network distances to essential amenities more in line with the Calgary average. Despite their more proximate amenities, this group still drives for the majority of their trips, leading to the "car inclined" name. Contrary to the group's smaller network distances, their Liveability Index scores are relatively low. This suggests that that car inclined baby boomers are living in areas were the community level Liveability Index scores are lower, but are living in the more amenity rich environments within these lower, measured liveability areas. As seen in the map, car inclined baby boomers are represented throughout Calgary with less representation in the north east.

Car inclined baby boomers generally hold the highest incomes of all the clusters and are highly educated. The group lives in small households with both numbers of children and individuals in the household below the Calgary average. However, their second most important proximate amenity when choosing a home location is access to their child's school; suggesting cluster members are generally members of families whose children have left home. Despite lower numbers of people in the home, car inclined baby boomer households own more cars than the Calgary average.

CHOICE TRANSIT RIDERS

Cluster Analysis Profile



HOME CHOICE CONSIDERATIONS

Top Consideration

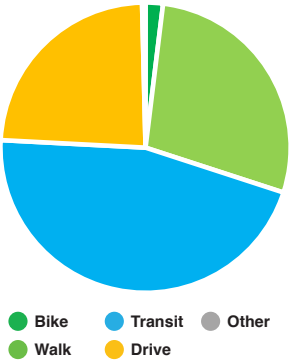
Presence of Nearby Amenities

Most Important Amenities

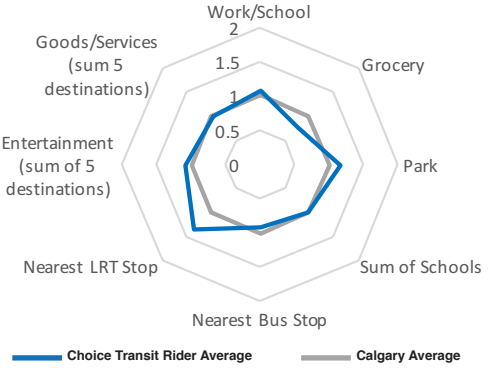
1-Public Transit
2-Work
3-Grocery Stores

- Most trips taken by public transit
- Predominantly live along major LRT and BRT routes in areas with moderate access to essential amenities/destinations
- Most likely to report higher satisfaction with and enjoyment of transit trips

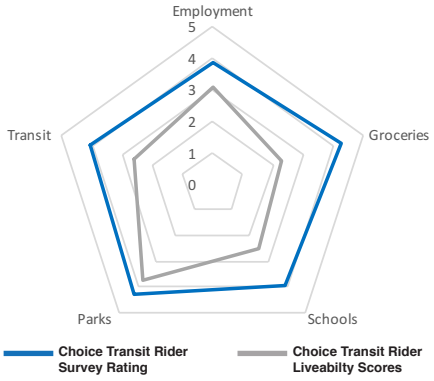
Mode Share (%) (all purpose)



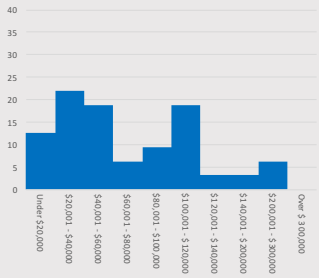
Network Distances to Essential Amenities (Normalized)



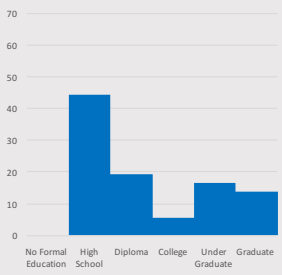
Measured vs. Perceived Liveability (Average)



Income Profile (%)



Education Profile (%)

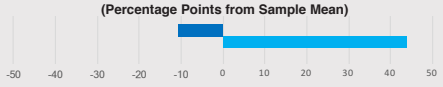


Average Age: 29

Percent Female: 45.7%

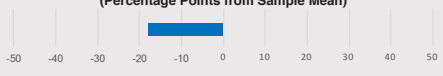
Household Structure

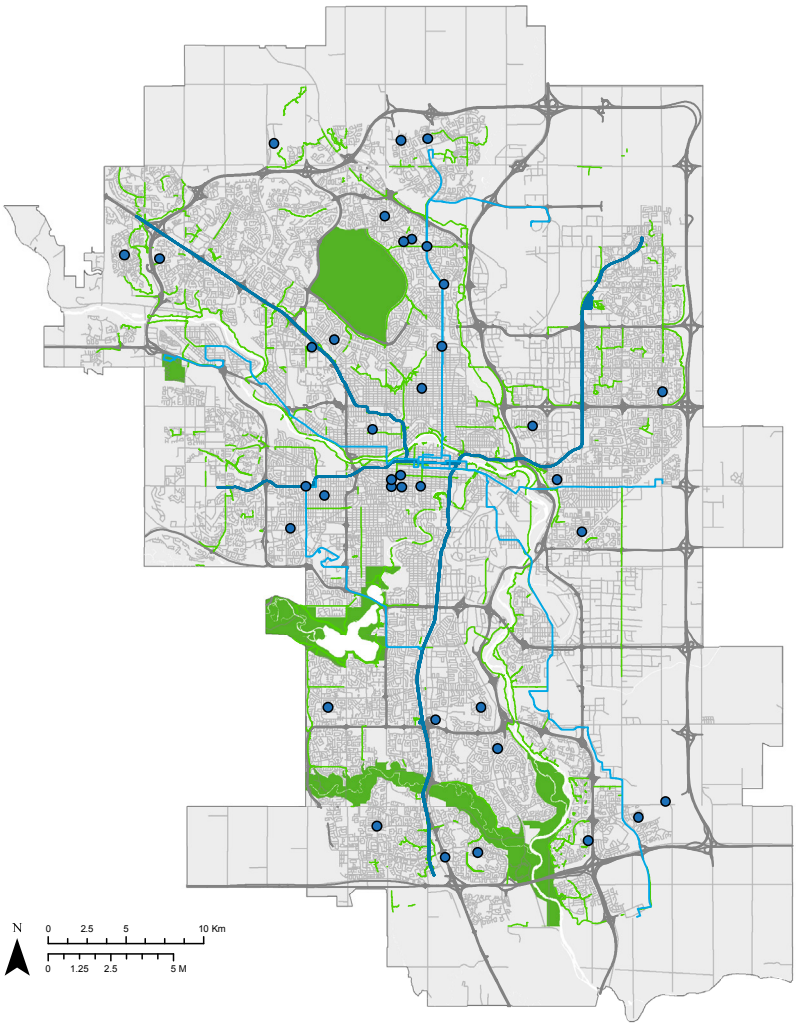
(Percentage Points from Sample Mean)



Car Ownership

(Percentage Points from Sample Mean)





Proportion of Sample **5.2 %**

Figure 11: Choice transit rider data composition

Choice Transit Riders

Choice transit riders (5.2% of the sample) are primarily segmented from the rest of the sample by their very high transit ridership rates. The group also reports much higher levels of enjoyment when riding the bus or LRT than other groups and rate their access to public transit as their most important proximate amenity when choosing a home location. With their enjoyment and prioritization of transit in their lifestyles, these individuals seem to be pro-transit, rather than transit reliant. Reflecting previous research on transit rider market segmentation, this cluster is named "choice" transit, with a second transit focused cluster (discussed below) named "captive" transit riders (Jin, Beimborn, & Greenwald, 2004; van Lierop & El-Geneidy, 2015). Choice transit rider's top general consideration in home location is the presence of nearby amenities and generally report living in more liveable, walkable, and bikeable communities. Despite prioritizing transit access in their home choice locations, choice transit riders travel further than the average Calgarians to reach LRT stops, but are closer than the average network distance to reach bus stops. As expected, many choice transit rider home locations are found along BRT routes (predominantly the north/south route connecting central and northern Calgary). There is also a cluster of home locations southwest of downtown and many more along LRT and major bus routes.

Choice transit riders are relatively young (average age = 29 years) with a higher prevalence of students in the group, and have a slightly more modest income profile than other groups. They also have much lower car ownership rates and have a large portion of active transportation in their all-purpose mode share (predominate walking).

CAPTIVE TRANSIT RIDERS

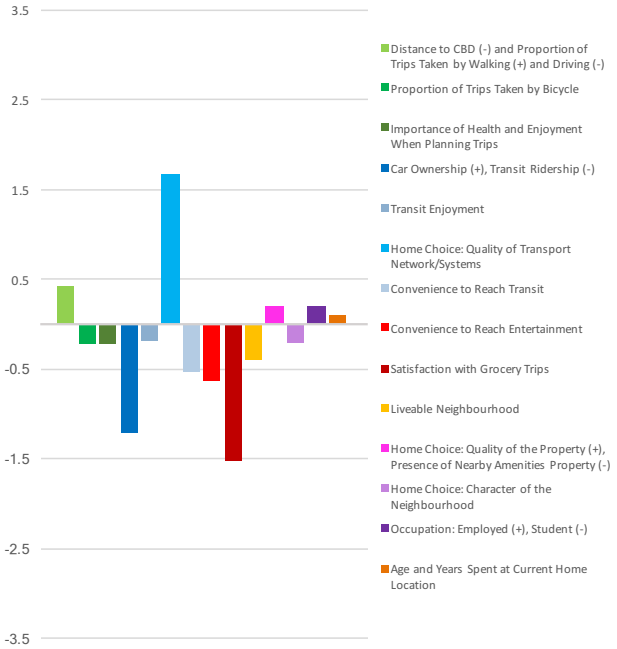
HOME CHOICE CONSIDERATIONS

Top Consideration
Quality of Transportation Network/Systems

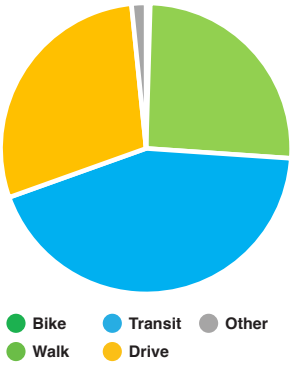
Most Important Amenities
1-Public Transit
2-Work
3-Parks and Greenspace

- Most trips taken by public transit
- Predominantly live along major tranist routes in areas with moderate access to essential amenities
- Most likely to consider the quality of transport systems/ networks when choosing a home location and to report dissatisfaction with transit

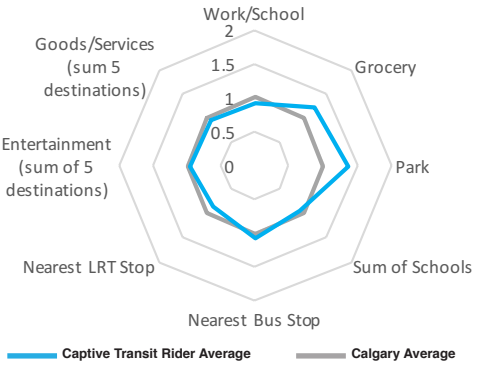
Cluster Analysis Profile



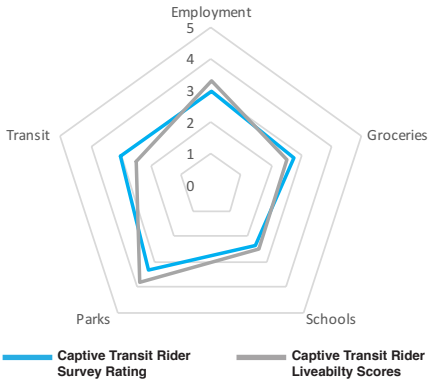
Mode Share (%) (all purpose)



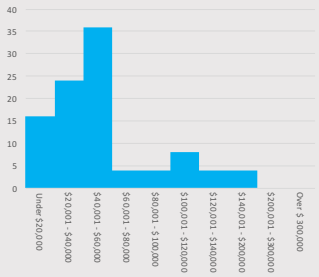
Network Distances to Essential Amenities (Normalized)



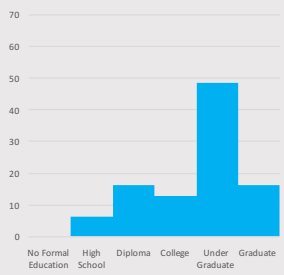
Measured vs. Perceived Liveability (Average)



Income Profile (%)



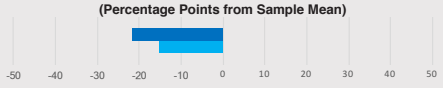
Education Profile (%)



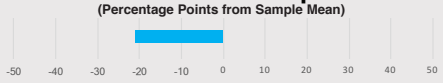
Average Age: 35

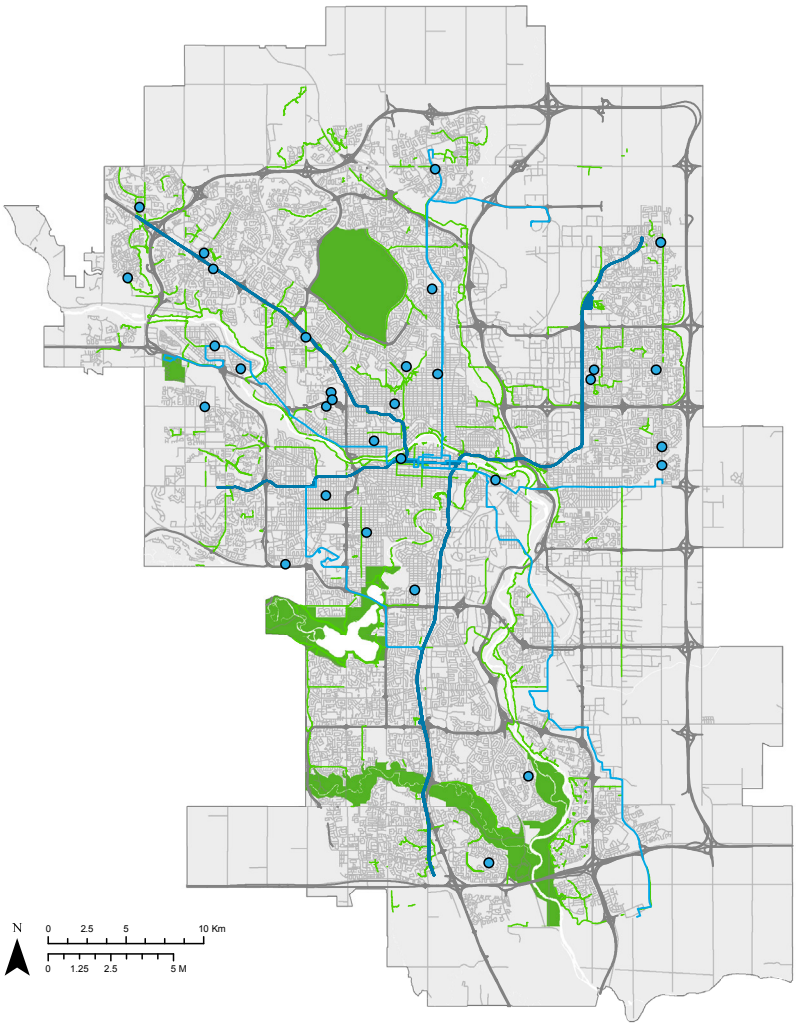
Percent Female: 56.7%

Household Structure
(Percentage Points from Sample Mean)



Car Ownership
(Percentage Points from Sample Mean)





Proportion of Sample **4.4 %**

Figure 12: Captive transit rider data composition

Captive Transit Riders

Captive transit riders (4.4% of the sample), like choice transit riders, show high transit ridership and low car ownership in the cluster profile. However, unlike choice transit riders, captive transit riders report very low enjoyment when riding the bus or LRT; in fact they have the second lowest rating of transit enjoyment of all the clusters, second only to car dependent suburbanites. With their dislike of, and high reliance on transit, captive transit riders also report dissatisfaction with their trip to the grocery store and rate their neighbourhood's liveability and access to a variety of amenities relatively lower than other groups. A further factor leading to the 'captive' nature of this transit rider group is the cluster's high association with their top consideration when choosing a home location being the quality of the transport network/system. With low car ownership rates, this group seems to be more transit dependent than choice transit riders. Furthermore, their average age is six years higher than the choice transit group and their incomes are lower. They are also more employed, whereas, choice transit riders are more likely to be students. With these sociodemographic factors in mind, captive transit riders are more likely to be "stuck" in a transit dependent lifestyle than having chosen one.

As expected, the home locations of captive transit riders tend to be along the LRT and BRT routes in Calgary, predominantly in less central locations. Captive transit riders tend to have similar network distances to essential amenities to the Calgary average, with above average distance to their preferred grocery stores and parks. However, both their measured Liveability Index scores and reported convenience to reach essential destinations are generally lower.

CAR-CENTRIC STUDENTS & JOB SEEKERS

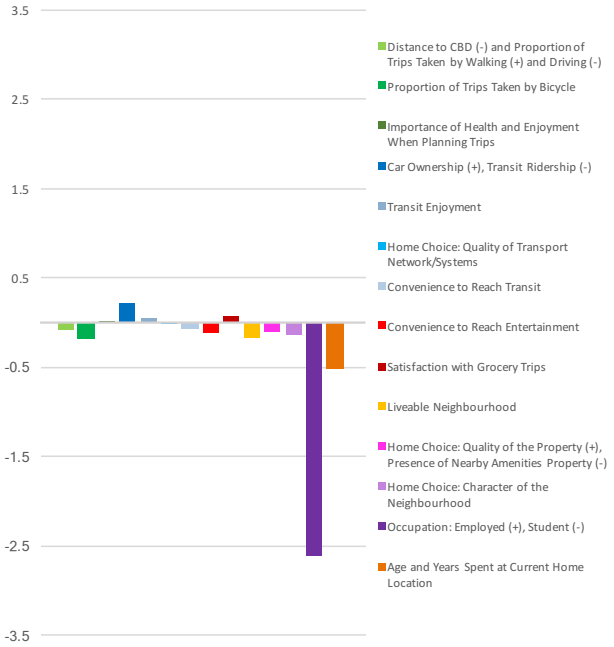
HOME CHOICE CONSIDERATIONS

Top Consideration
Presence of nearby amenities

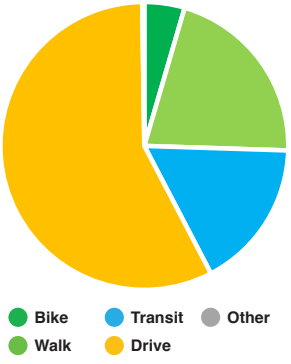
Most Important Amenities
1-Work
2-Public Transit
3-Grocery Stores

- Most trips taken by car, walking, and public transit
- Predominantly live near postsecondary school campuses and along major LRT and BRT lines
- Generally report lower liveability and poorer access to amenities and destinations for their neighbourhoods

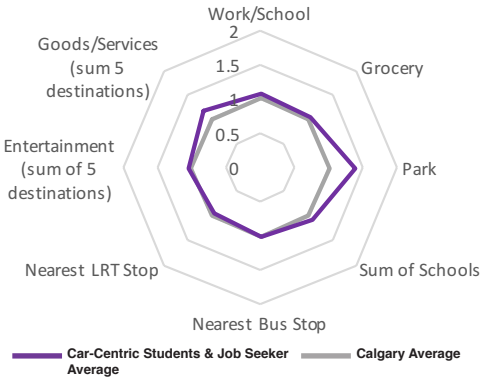
Cluster Analysis Profile



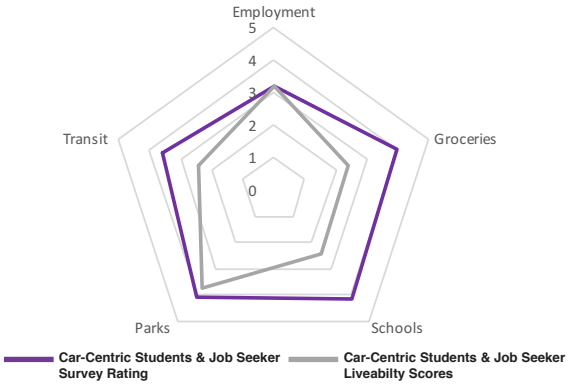
Mode Share (%) (all purpose)

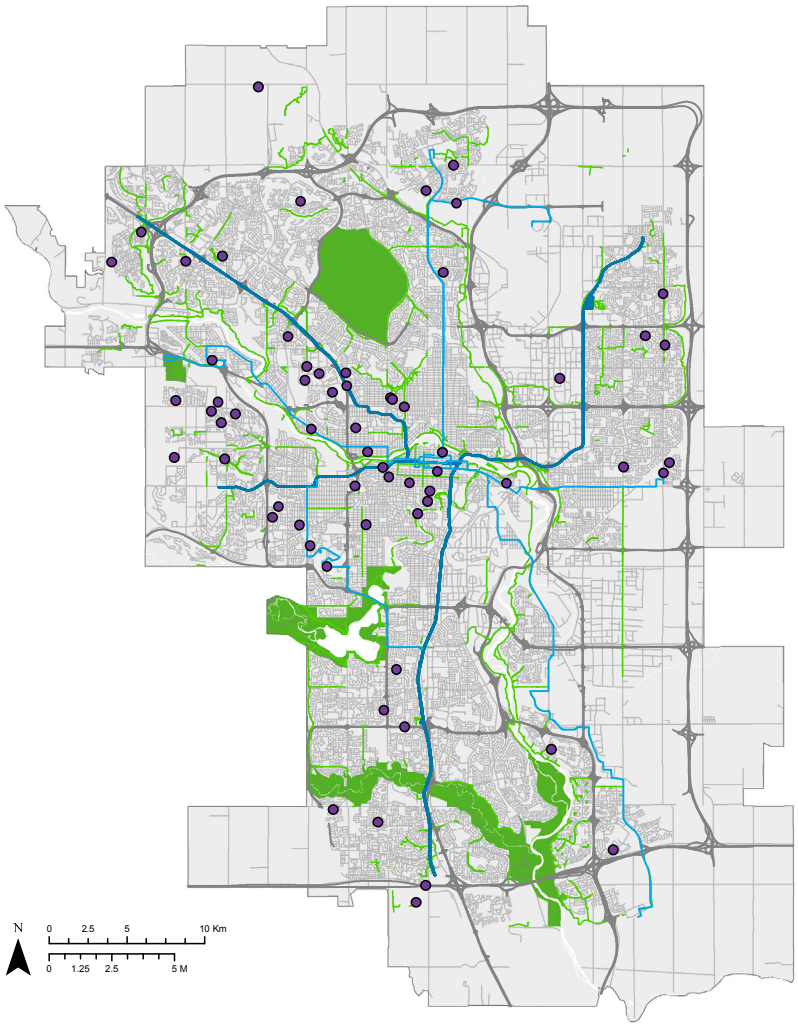


Network Distances to Essential Amenities (Normalized)

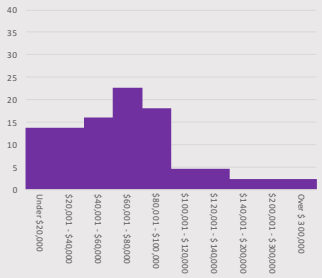


Measured vs. Perceived Liveability (Average)

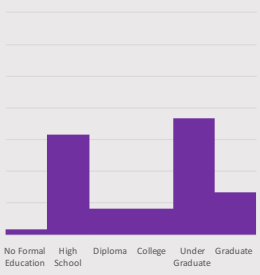




Income Profile (%)



Education Profile (%)

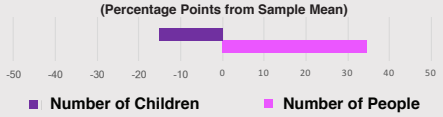


Average Age: 25

Percent Female: 38.3%

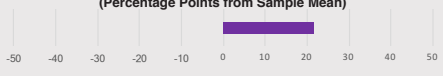
Household Structure

(Percentage Points from Sample Mean)



Car Ownership

(Percentage Points from Sample Mean)



Proportion of Sample **8.9 %**

Figure 13: Car-centric students & job seeker data composition

Car-Centric Students & Job Seekers

Car-centric students & job seekers (8.9% of the sample) are primarily segmented from the rest of the sample by their very low proportion of employed individuals and high proportion of students in the cluster. The factor "Age and Years Spent at Current Home Location" is also negatively associated with car-centric students & job seekers and the group's average age of 25 years is much lower than other groups. Further suggesting the prevalence of a student population in the group, car-centric students & job seeker home locations have a high representation proximate to the University of Calgary, Alberta College of Art and Design and SAIT college campuses northwest of downtown Calgary. This group also has fewer children, but higher numbers of individuals in the household than the Calgary average, suggesting car-centric students & job seekers tend to live in larger households with roommates. Though the group does have a relatively modest income profile, there are many cluster members reporting incomes between $60-$100,000 per year. Additionally, atypical of student populations, car-centric students & job seeker car ownership rates are above the Calgary average. With these aspects in mind, it seems there are also many individuals in this group that may be unemployed/underemployed and making travel choices similar to those of student populations. With Calgary's unemployment and office vacancy rates at an all-time high since the 2007 economic crash, it is not unexpected to have some Calgarians switching to regressive travel behaviours (CBC, 2016).

Surprisingly, car-centric students & job seekers' dominant travel mode is driving, but also have the largest proportion of transit trips, next to the choice and captive transit rider groups. When choosing a home location, car-centric students & job seekers' top consideration is the presence of nearby amenities and rate work/school, public transit, and grocery store access as their most important proximate amenities. The group's network distances to essential amenities are generally in line with Calgary averages, but more distant for parks and good/services destinations. Additionally, with lower measured Liveability scores, this group generally does not live in strongly amenity rich environments.

FOOD UNSUPPORTED DRIVERS

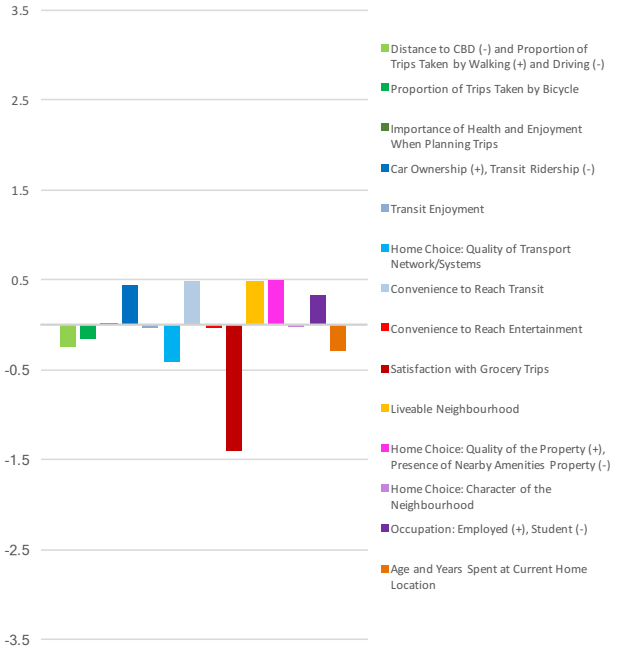
HOME CHOICE CONSIDERATIONS

Top Consideration
Quality of the Property

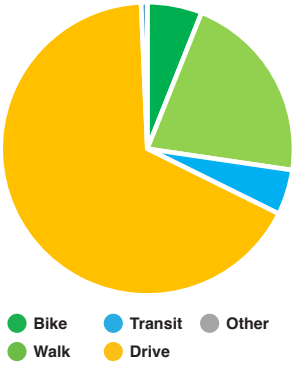
Most Important Amenities
1-Work
2-Partner's Work
3-Public Transit

- Most trips taken by car
- Generally live closer to Calgary's core than in peripheral areas, but distantly from their preferred grocery store
- Less likely to live in larger households of families or roommates and generally report dissatisfaction with their grocery trip

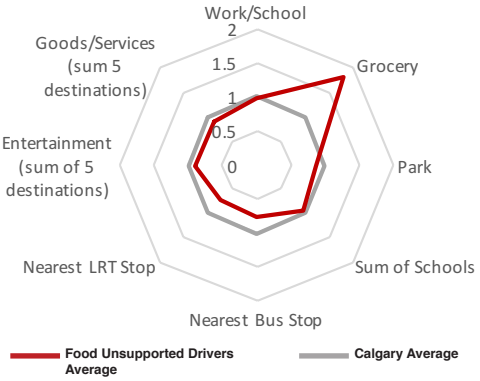
Cluster Analysis Profile



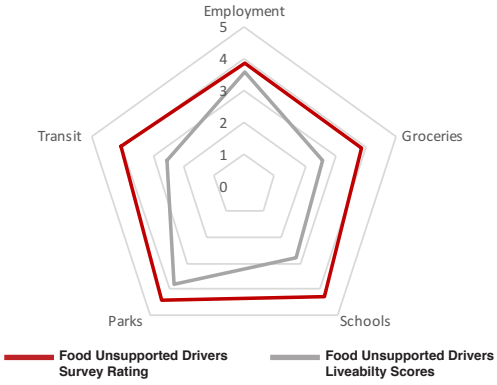
Mode Share (%) (all purpose)



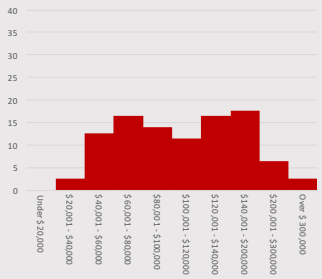
Network Distances to Essential Amenities (Normalized)



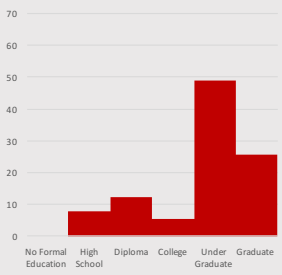
Measured vs. Perceived Liveability (Average)



Income Profile (%)



Education Profile (%)

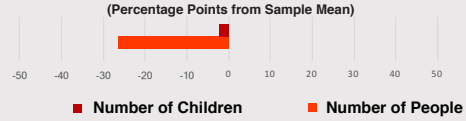


Average Age: 34

Percent Female: 34.8%

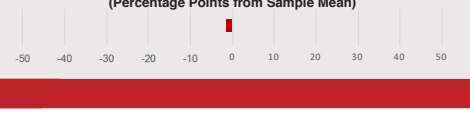
Household Structure

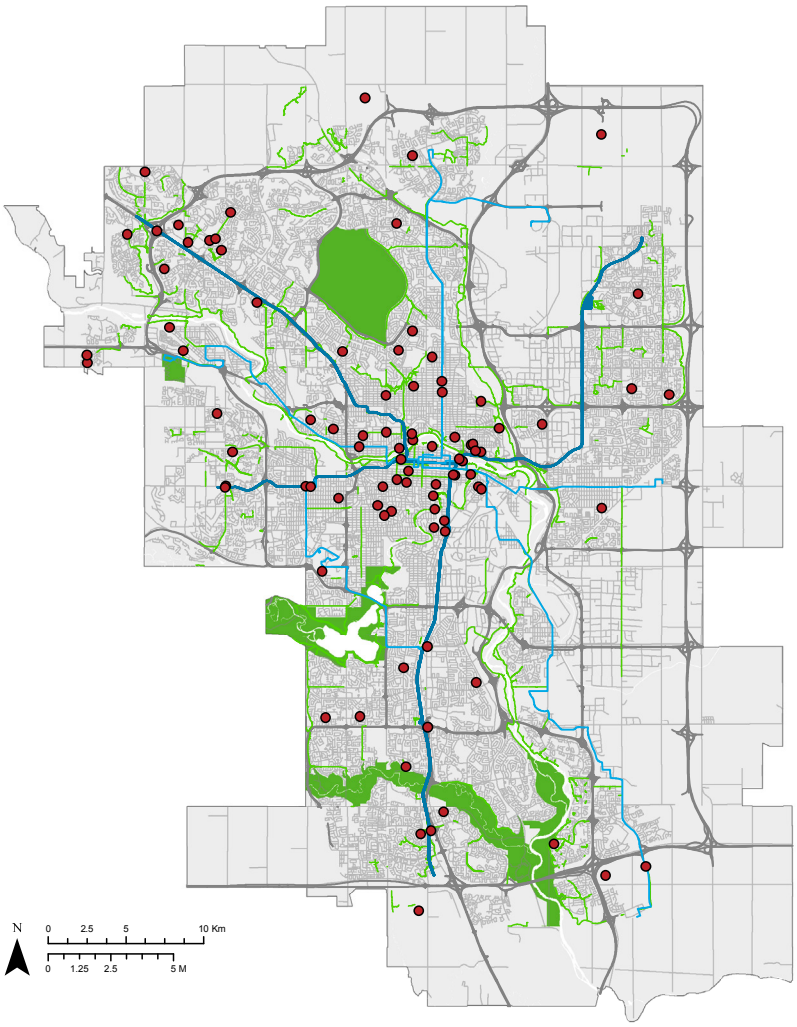
(Percentage Points from Sample Mean)



Car Ownership

(Percentage Points from Sample Mean)





Proportion of Sample 12.8 %

Figure 14: Food unsupported driver data composition

Food Unsupported Drivers

Food unsupported drivers (12.8% of the sample) are predominantly characterized by their strong dissatisfaction with their grocery store trip. Conversely, this group generally rates their access to transit and the liveability, bikeability, and walkability of their neighbourhoods more highly. Food unsupported drivers tend to live in more amenity rich environments with their network distances to essential amenities all below the Calgary average, except for the network distance to their preferred grocery store. Food unsupported drivers, on average, travel almost twice the Calgary average distance to reach their grocery store (8,215.6 m). However, food unsupported driver home locations are not necessarily in areas with poor access to retail food options, suggesting their less local travel behaviour is not necessarily due to a lack of choice. Despite having many amenities closer to food unsupported drivers' home locations, this group is largely car dominant in their all-purpose mode share. Compared to car dependent suburbanites, car unsupported drivers are much different in family structure, yet similar in most other sociodemographic aspects. Food unsupported drivers have fewer children and total individuals in the home on average, suggesting cluster members are more likely to live alone or with a partner. Additionally, they are the only group to report their partner's work as an important proximate amenity when choosing a home location.

Food unsupported drivers have a moderate to high income profile and are generally highly educated. Cluster members of this group do not seem to fit the definitions of people living in food deserts (areas without access to retail food opportunities), or food mirages (lower-income areas, served by unaffordable, luxury grocers) (Wiebe et al., 2016). Food unsupported drivers' top consideration when choosing a home location is the quality of the property. Grocery store access is not highly prioritized by this group. It is probable that food unsupported drivers have specific dietary preferences (health food stores, ethnics specialty shops, etc.) or are loyal to specific stores (e.g. Costco). Such cultural preferences or brand loyalty could explain why food unsupported drivers are not utilizing more locally provided retail food opportunities.

DISCUSSION

The Liveability Gap

As seen in each travel typology's radar charts of measured vs. perceived liveability, the liveability index and survey responses can provide varying descriptions of the built environment around respondents' home locations. Where some group's survey responses display average answers that mirror the Liveability Index scores spatially joined to their home locations, others seemingly disagree or are less aware of concepts of liveability and accessibility. To summarize and visualize the eight liveability radar charts, Figure 15 shows a box plot of each group's survey responses and Liveability Index score averages. The box plots show the interquartile range or IQR (values bounding the range of the 25th and 75th percentile, representing the middle 50% of the data) and the sample means (see Figure 15). To further discuss themes of liveability among similar travel typologies, the eight groups have been categorized into active, transit, car, and car/transit travelers.

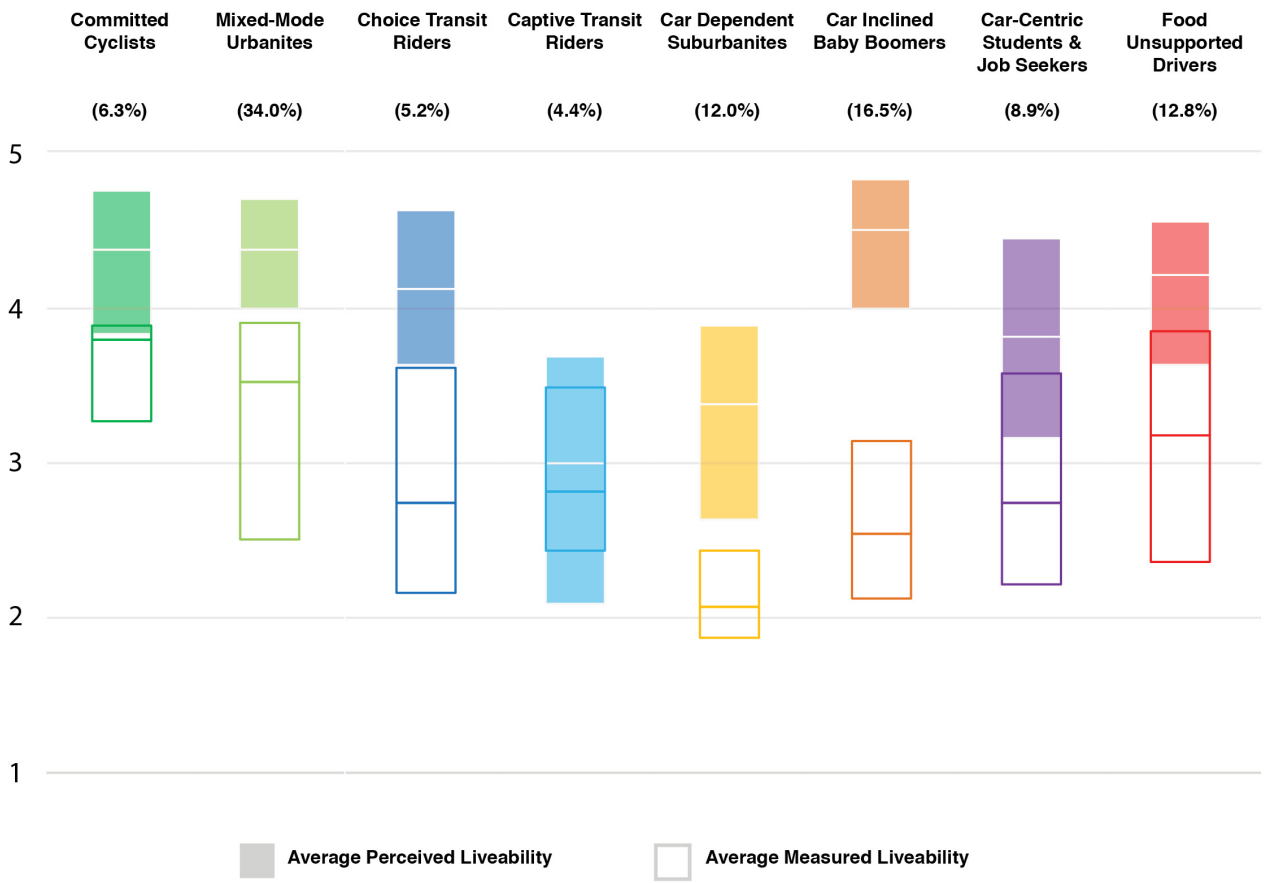


Figure 15: Box plot of measured vs. perceived liveability

Active Travelers: Committed Cyclists and Mixed-Mode Urbanites

Both committed cyclists and mixed-mode urbanites tend to live in central Calgary, in amenity rich environments. As seen by the hollow boxes in Figure 15, these two groups live in areas with the City's highest measured Liveability Index scores. Additionally, their reported convenience to reach the same amenities in the Liveability index are relatively high, with both group's rating their neighbourhood's liveability in the top three among the eight travel typologies (Car Inclined Baby Boomers report the highest rated neighbourhood liveability). While the IQR of measured and perceived liveability metrics overlap for committed cyclists, there is a small gap in the IQRs for the mixed-mode urbanites. Compared to the committed cyclist's network distances to amenities, which are generally far below the Calgary average, mixed-mode urbanites tend to travel further, closer to the full-sample average distances. Additionally, while committed cyclists are tightly clustered around central Calgary/downtown, mixed-mode urbanite home locations are predominantly in central Calgary, but have many cluster members living in areas more distant from downtown. These mixed-mode urbanite home locations further from central Calgary will be pulling down their measured liveability scores compared to committed cyclist home locations. However, with the larger gap in perceived liveability above the measured, it is expected that when mixed-mode urbanite home locations are in more peripheral areas, they are generally locating in relatively amenity rich environments within the lower Liveability Index scoring communities.

With both high measured and perceived liveability, committed cyclists and mixed-mode urbanites seem to be aware of concepts of liveability and accessibility. Though this could be at a more subconscious level, both groups report the presence of nearby amenities as their top consideration when choosing a home location, suggesting they are actively considering the implications of home location and the built environment on their transportation needs, lifestyle, and quality of life.

Transit Travelers: Choice and Captive Transit Riders

Both choice and captive transit riders tend to live along LRT and BRT routes and are not clustered in central Calgary's highest measured liveability neighbourhoods. Choice and captive transit riders have

very similar IQRs and mean Liveability Scores (hollow boxes) for their home locations (see Figure 14). However, their perceived liveability (filled boxes) differ greatly. Captive transit riders, despite living in similar areas of Calgary, rate their access to essential amenities much lower than choice transit riders. From the two groups' network distance to essential amenities radar charts, it can be seen that captive transit riders do travel further for their preferred groceries and preferred park. This suggests that within similarly scoring communities in the Liveability Index along major transit corridors, that captive riders are living in slightly more amenity scarce areas within these communities. Captive transit riders however, are the group whose perceived and measured liveability are most harmonized. With less affluence and transit dependent lifestyles, captive transit riders are more likely to be sensitive to the effects of the built environment on their transportation needs, lifestyle, and quality of life. Interestingly, the choice transit rider group is partially defined by their enjoyment of transit, while captive riders report disenchantment with their dominant mode choice. This dislike of transit in the captive transit group is likely contributing to their reduced perceived liveability.

Choice transit riders are younger than the captive transit rider group, and may be more content with their less car focused mobility. Choice transit riders seem satisfied with their relatively low accessibility/liveability around their home locations located around transit hubs. The group's atypical enjoyment of transit and transit focused lifestyles seem to be positively skewing their perceptions of liveability away from the measured.

Car Travelers: Car Dependent Suburbanites, Car Inclined Baby Boomers, and Food Unsupported drivers

Car dependent suburbanites, car inclined baby boomers, and food unsupported drivers all predominantly rely on cars as their main mobility option. Car dependent suburbanites and car inclined baby boomers have the largest gaps between their measured and perceived liveability. With cars often providing the fastest access to more distant destinations, it is expected that their car focused travel behaviour makes these two groups less sensitive to lower accessibility and liveability. Furthermore, car

dependent suburbanites, car inclined baby boomers, and food unsupported drivers all rate the quality of the property as their top consideration when choosing a home location. Additionally, these groups generally have higher incomes and previous research has shown that higher income households with more education prefer to live in relatively high quality dwelling units located further away from the CBD (Chau & Chin, 2002). The less amenity focused tendencies of these groups further help explain the gap between measured and perceived liveability.

The group with by far the largest difference between their measured and perceived liveability is the car-inclined baby boomers. With their average age at 50 years, this group most strongly represents retired travelers. Retirees, who have fewer travel needs and mostly travel by car, are likely to be the group most disconnected from the built environment's impact on their transportation needs, lifestyle, and quality of life. It is not surprising that food unsupported drivers have the most overlap between their measured and perceived liveability of the car focused groups, as they tend to live in more central, amenity rich environments. Food unsupported drivers are also more likely to not have children and will have fewer travel needs associated with childcare. With fewer travel needs and more central locations promoting higher liveability scores than other groups, food unsupported drivers' stronger overlap in perceived liveability among the car-focused travelers is somewhat expected.

Car and Transit Travelers: Car-Centric Students and Job Seekers

Next to captive transit riders, car-centric students and job seekers have the most overlap between the IQRs of measured and perceived liveability. Though this group predominantly travels by car, they have the second highest transit ridership rates next to the choice and captive transit rider groups. Car-centric students and job seeker home locations are predominantly found somewhat centrally, northwest of central Calgary, near many major schools. These areas of Calgary hold very high scores for transit and employment access from the Liveability Index. The presence of amenities relevant to this segment of the population may help explain the relatively strong correlation between measured and perceived liveability in this group. This group's younger age, likely best representing Calgary's millennial

populations, also suggests that Calgary's youth may be more perceptive to differences in accessibility and liveability than older generations.

Current Mode share in Calgary – Proportional Representation

To gain insights into how representative the Liveability survey respondents are of the general City of Calgary population, work/postsecondary commute mode choice of survey respondents was compared to the 2016 City Census and Central Business District Cordon Count data (see Table 3). The City Census data represents a more comprehensive view of mode choice in Calgary, while the CBD cordon count is an annual traffic count collected at major entry points into the CBD.

	Calgary CBD Cordon Count 16 Hour Inbound and Outbound (2016)	Calgary City Census Commute Mode Share (2016)	Survey: Work/Postsecondary Commute Mode Choice
Car	54.5	73.8	43.5
Transit	32.9	16.4	31.4
Walk	10.3	4.9	11.8
Bicycle	2.4	1.8	13.2

Table 3: Commute mode shares of City Census, CBD Cordon count, and Liveability Survey

Compared to the City Census data, the commute mode choices from survey respondents seem to underrepresent drivers (44% compared to 74%), while over representing cyclist, pedestrians, and transit riders. In the downtown CBD cordon counts, the proportion of car trips is 54%, with transit trips seeing the largest growth from the census mode share at 33%. Transit trips reported in the liveability survey are very similar to the cordon count transit ridership at 31%. Cycling is overrepresented in the survey results compared to both the census and cordon count data, while walking commutes are over represented compared to the census, but are comparable to the cordon count. With the survey mode share data showing a closer resemblance to the CDB Cordon Count, it is possible the liveability survey received responses from a disproportionate number of people employed in the CBD. Alternately, certain populations may be more eager to fill out online surveys about travel research, which could explain the

overrepresentation of more urban-minded groups such as the committed cyclists and mixed-mode urbanites.

For the citywide Liveability survey, the car-focused groups (car dependent suburbanites, car inclined baby boomers, food unsupported drivers, and car-centric student and job seekers) are underrepresented. The mixed-mode urbanites and their walking dominated mode share is likely the most overrepresented group. The committed cyclists are also expected to be overrepresented, representing 6% of the survey sample, while both the CBD and cordon count data report a 2% mode share of cyclists. The combined representation of transit riders from the choice and captive transit rider groups seems to be slightly underrepresented at a combined sample proportion of 9.6%.

CONCLUSIONS

Perceptions of liveability differ from this study's version of measured liveability most drastically in individuals who predominantly drive for their commutes and to reach essential amenities. Of the car dominant travel typologies, older car-focused travelers are the least sensitive to their lower liveability. The identified car-focused groups have less financial strain on their lifestyles and are freer to rely on auto-mobility to increase their accessibility. Commonly living in areas of poor land-use mix, these individuals are less perceptive to longer distances to reach essential destinations, the sacristy of amenities, and the built environment's effect on their travel needs and lifestyle. Conversely, individuals facing the greatest strain on their transportation needs are most acutely aware of their accessibility when they live in areas with low liveability. The travel typology found to have the most overlap between perceived and measured liveability were the captive transit riders, who are highly transit dependent, have lower incomes, and express the greatest frustration with their travel experiences. Active transportation users (pedestrians and cyclists) also report levels of access to essential amenities more in line with measured expectations. Their clear preference for living in more urban and amenity rich environments highlights these groups as representing individuals who are most consciously pursuing more sustainable and active lifestyles, fostered by more liveable environments.

The Calgary Liveability Index could easily be "tuned" to match the population's reported convenience to essential amenities/destinations with weighting coefficients for each of the nine input variables. However, this requires asking the question: who should the Liveability Index be tuned to? With some groups showing more overlap between the IQRs of measured and perceived liveability, careful consideration is needed when deciding how aspects of the index should be changed to reflect varying transportation needs in Calgary. Looking at the groups with smallest differences between mean measured and mean perceived liveability, captive transit riders, committed cyclists, car-centric students & job seekers, and mixed-mode urbanites take the top four ranks of most harmonized measured and perceived liveability (see Table 4). These groups strongly represent the most vulnerable segments of the populations, including those who depend on public transit and those who choose to walk and bicycle.

Conversely, the travel typologies with the four least harmonized differences between measured and perceived liveability are the car dependent suburbanites, food unsupported drivers, choice transit riders, and car inclined baby boomers (all car-focused travelers, except for choice transit riders). Table 4 shows the difference of means for each group, arranged in ascending order.

	Mean Perceived Liveability	Mean Measured Liveability	Difference
Captive Transit Riders	2.97	2.93	0.04
Committed Cyclists	4.25	3.68	0.57
Car-Centric Students & Job Seekers	3.71	2.84	0.87
Mixed-Mode Urbanites	4.28	3.26	1.02
Food Unsupported Drivers	4.09	3.05	1.04
Car Dependent Suburbanites	3.32	2.25	1.08
Choice Transit Riders	4.09	2.84	1.25
Car Inclined Baby Boomers	4.34	2.69	1.65

Table 4: Ascending differences between measured and perceived liveability means by travel behaviour typology

The Calgary Liveability Index, in its current form, is a strong indicator for spatially predicting the availability of sustainable transportation choices and identifying areas of high need and high demand for improved liveability. Though the urban metric nicely aligns with travel behaviour typologies who are most sensitive to changes to local accessibility, further refinement is possible through additional analysis of the Calgary Liveability Survey dataset. By examining the relationship between distances to specific essential amenities by mode choices in the survey, the index's pedestrian and cycling buffer radii based on previous research can be replaced by catchment areas defined by residents of Calgary. This analysis will be covered in a following report.

POLICY RECOMMENDATIONS

It is recommended that the City of Calgary Liveable Streets Division focus its Transportation Demand Management efforts where they are most needed spatially, and most likely to promote shifts towards more sustainable transportation choices culturally. For car travelers, it is recommended that transit

should be incentivized or driving should be disincentivized. This group, which likely represent a large portion of the car traffic entering the CBD at peak times could be excellent candidates for BRT and LRT alternatives to their car trips. However, with their generally higher incomes, fare reductions are unlikely to attract transit customers from car-focused travel typologies. CBD parking reductions for example, could be more effective at garnering shifts towards transit. For the current transit travelers, it is recommended that efforts are made to improve and promote the mixed mode experience of transit users. The captive transit group, which dislike their dependence on transit, could be candidates for improved accessibility/liveability having the greatest positive impact on their quality of life. Improved cycling infrastructure and pedestrian/cyclist specific links to shorten trip distances to key destinations by active transportation could help these individuals feel less reliant on the City's transit network and freer to make more trips on their own schedule. For active travelers, further cycling infrastructure and pedestrian oriented urban design should be prioritized to maintain individuals in these travel typologies and promote shifts towards greater cluster membership in more sustainable transport oriented groups. Finally, car/transit traveling students and youth should be supported with adequate transit service for current and future needs, to help maintain their high transit usage, while preventing this cohort from aging into further car reliance.

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APPENDIX A: Calgary Liveability Survey

Calgary Liveability & Travel Survey
Calgary Liveability Study

The interdisciplinary research group, Transportation Research at McGill (TRAM), in Montreal, Canada, in collaboration with the City of Calgary, is currently undertaking research aiming to update and enrich information from a 2016 project looking at the liveability of communities in Calgary AB. Additionally, this survey also aims to evaluate the travel habits of Calgarians, helping to inform future transportation planning in Calgary and produce academic, transportation research. Your participation is greatly appreciated and gives you the chance to win great prizes (approximately 1/500 odds), including:

- iPad (2 prizes, valued at $329 each)
- Calgary transit passes (2 prizes, valued at $101 each)

With a bit of your time, you can help guide further improvements to walkability, cycling infrastructure, and transit access in communities in Calgary AB. The project will be conducted by Mark Onderwater, a second year graduate student from the McGill School of Urban Planning and previous employee of the City of Calgary. The research is supervised by Ahmed El-Geneidy, Associate Professor with the School of Urban Planning, and the City of Calgary Liveable Streets Division. Funding is provided by the City of Calgary, Liveable Streets Division.

This survey will take approximately 10-15 minutes to complete. Participation is voluntary, and you may exit the survey at any time.

At the end of the survey, you may optionally provide your email address to be included in the prize draw. The data will be anonymized; email addresses will only be used for the prize draw and will never be downloaded with the survey data. Completing the survey indicates consent to participate in this study. While the survey does not ask for your name, we do ask for approximate home and work locations that might make it possible for someone to identify you. However, all survey responses will remain confidential, stored on password protected computers, and participants will not be identified in any publications or reports. The data may be kept for future related research purposes.

If you have any questions or concerns regarding this research project, please send an email to mark.onderwater@mail.mcgill.ca or ahmed.elgeneidy@mcgill.ca. If you need urgent assistance, you may call TRAM at 514-398-4058. If you have any questions or concerns regarding your rights or welfare as a participant in this research study, please contact the McGill Research Ethics Officer, Deanna Collin (deanna.collin@mcgill.ca).
Thank you for your participation!

There are 88 questions in this survey

(If desired, please print a copy of this page for your records)

General Happiness and Commute Satisfaction

1. Taking all things into account, please rate how satisfied you are with your life these days on a scale from 0 to 10, where 0 means least satisfied and 10 means most satisfied.
    (clickable radio buttons from 0 to 10)

2. On a scale from 0 to 10, please rate to what extent your commute impacts your quality of life, where 0 means your commute has no impact on your quality of life, and 10 means your commute highly impacts your quality of life.
    (clickable radio buttons from 0 to 10)

Occupations Status and Home/Work/School Map Locations

3. What describes you best? (Please choose the option applies to you the most)?

- Employed
- Unemployed
- Student
- Retired

4. On the following map, please adjust the zoom and drag the pin to the nearest intersection to your current home location:
    (Interactive map, pre-zoomed to Calgary)

*If Q4 = Employed
5.1. On the following map, please adjust the zoom and drag the pin to your work location:
    (Interactive map, pre-zoomed to Calgary)

*If Q4 = Student
5.2. On the following map, please adjust the zoom and drag the pin to your school location:
    (Interactive map, pre-zoomed to Calgary)

Home Choice Considerations

6. When choosing your current home location, please rank at least the top 3 factors in order of importance to you and others living in the home:

- The presence of nearby amenities
- The character of the neighbourhood
- The quality of the property
- The quality of the area's transportation network/systems

7. When choosing your current home location, please rank at least the top 3 considerations related to nearby amenities in order of importance to you and others living in the home:

- Proximity to my work/school
- Proximity to my partner’s or spouse's work/school Proximity to children’s school/preschool
- Proximity to grocery stores
  Proximity to public transit (bus, C Train stations, etc.)
- Proximity to retail (clothing stores, book stores, etc.)
- Proximity to recreational locations (gyms, community centre, trail centre)
- Proximity to parks and green spaces
- Proximity to cycling lanes and off-street pathways
- Proximity to freeways or arterial roads
- Proximity to cultural & entertainment attractions (theatres, restaurants, etc.)

8. When choosing your current home location, please rank the top 3 considerations related to neighbourhood characteristics in order of importance to you and others living in the home:

- The walkability of the neighbourhood
- The bikeability of the neighbourhood
- The sense of community in the neighbourhood
- Quietness of the neighbourhood
- The liveliness of the surrounding area
- The quality of the public transit systems in the area
- Uncongested traffic conditions
- The attractiveness of the housing in the neighbourhood

9. When choosing your current home location, please rank at least the top 3 considerations related to the quality of the property in order of importance to you and others living in the home:

- The affordability of the property
- The cost of transportation related to the home location Spacious lot, with a garage and yard
- Size of the house (living space)
- The age of the house

Mode Choice and Travel Perceptions

10. Please rate how easy it is for you to travel by the following modes of transportation in your neighbourhood.

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy	Not Applicable
• Walk	O	O	O	O	O	O
• Cycling	O	O	O	O	O	O
• Public Transit	O	O	O	O	O	O
• Driving as a driver or passenger	O	O	O	O	O	O

11. Which mode of transportation do you usually use to reach the following facilities in your neighbourhood in warm, dry weather?

	Drive	Bus	C Train	Bicycle	Walk	Other	Not Applicable
• Your Work	O	O	O	O	O	O	O
• Your School	O	O	O	O	O	O	O
• Grocery stores	O	O	O	O	O	O	O
• Your children's school or preschool	O	O	O	O	O	O	O
• Retail options (clothing stores, book stores, etc.)	O	O	O	O	O	O	O
• Cultural & entertainment attractions (theatres, restaurants, etc.)	O	O	O	O	O	O	O
• Recreational locations (gyms, community centre, trail centre)	O	O	O	O	O	O	O
• Parks and green spaces	O	O	O	O	O	O	O

12. How convenient is it for you to reach the following destinations in warm, dry weather?

	Extremely Inconvenient	Somewhat Inconvenient	Neutral	Somewhat Convenient	Extremely Convenient	Not Applicable
• Your Work	O	O	O	O	O	O
• Your School	O	O	O	O	O	O
• Grocery stores	O	O	O	O	O	O
• Your children's school or preschool	O	O	O	O	O	O
• Bus stops	O	O	O	O	O	O
• C Train stops	O	O	O	O	O	O
• Retail options (clothing stores, book stores, etc.)	O	O	O	O	O	O
• Cultural & entertainment attractions (theatres, restaurants, etc.)	O	O	O	O	O	O
• Recreational locations (gyms, community centre, trail centre)	O	O	O	O	O	O
• Parks and green spaces	O	O	O	O	O	O

13. Do you use the same mode of transportation in cold, wet weather to get to all of your destinations? (yes/no)

* If Q13 = no, cold, wet conditions questions asked

14. Which mode of transportation do you usually use to reach the following facilities in your neighbourhood in cold, wet weather?

	Drive	Bus	C Train	Bicycle	Walk	Other	Not Applicable
• Your Work	O	O	O	O	O	O	O
• Your School	O	O	O	O	O	O	O
• Grocery stores	O	O	O	O	O	O	O
• Your children's school or preschool	O	O	O	O	O	O	O
• Retail options (clothing stores, book stores, etc.)	O	O	O	O	O	O	O
• Cultural & entertainment attractions (theatres, restaurants, etc.)	O	O	O	O	O	O	O
• Recreational locations (gyms, community centre, trail centre)	O	O	O	O	O	O	O
• Parks and green spaces	O	O	O	O	O	O	O

15. How convenient is it for you to reach the following destinations in cold, wet weather?

	Extremely Inconvenient	Somewhat Inconvenient	Neutral	Somewhat Convenient	Extremely Convenient	Not Applicable
• Your Work	O	O	O	O	O	O
• Your School	O	O	O	O	O	O
• Grocery stores	O	O	O	O	O	O
• Your children's school or preschool	O	O	O	O	O	O
• Bus stops	O	O	O	O	O	O
• C Train stops	O	O	O	O	O	O
• Retail options (clothing stores, book stores, etc.)	O	O	O	O	O	O
• Cultural & entertainment attractions (theatres, restaurants, etc.)	O	O	O	O	O	O
• Recreational locations (gyms, community centre, trail centre)	O	O	O	O	O	O
• Parks and green spaces	O	O	O	O	O	O

16. Why do you change your mode of transportation between warm, dry conditions and cold, wet conditions?
Check all that apply

- Warm, dry mode choice not safe in cold, wet conditions
- Warm, dry mode choice takes too long in cold, wet conditions Warm, dry mode choice not comfortable in cold, wet conditions
- Other: (open text answer)

Work/School Trip Satisfaction

* If Q4 = Employed

17.1. Please rate your level of agreement with the following statements about your trip to work on a typical day with warm, dry weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

18.1. Please rate your level of agreement with the following statements about your trip to work on a typical day with cold, wet weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

* If Q4 = Student

17.2. Please rate your level of agreement with the following statements about your trip to school on a typical day with warm, dry weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

18.2. Please rate your level of agreement with the following statements about your trip to school on a typical day with cold, wet weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

Grocery Store Map Location and Trip Satisfaction

19. On the following map, please adjust the zoom and drag the pin to the location of the grocery store you shop at most often:

(Interactive map, pre-zoomed to Calgary)

20. Please rate your level of agreement with the following statements about your trip to your preferred grocery store on a typical day with warm, dry weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

21. Please rate your level of agreement with the following statements about your trip to your preferred grocery store on a typical day with cold, wet weather conditions using the primary mode you selected earlier

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I am satisfied with the travel time of my trip	O	O	O	O	O	O
• The travel time of my trip is consistent	O	O	O	O	O	O
• The cost of my trip is reasonable	O	O	O	O	O	O
• Overall, I am satisfied with my trip	O	O	O	O	O	O

Trip Chaining

* If Q4 = Employed
22.1 On a typical day with warm, dry weather conditions, do you regularly stop on your way to or from work for any of the following purposes?
Check all that apply

- Drop off children at school/daycare/etc. Grocery shopping
- Buy coffee/meal
- Stop at the gym
- Stop at the bank/post office/etc.
- Stop for social gatherings
- I don't stop on my way to work for any purpose
- Other: (open text answer)

23.1 On a typical day with cold, wet weather conditions, do you regularly stop on your way to or from work for any of the following purposes?
Check all that apply

- Drop off children at school/daycare/etc. Grocery shopping
- Buy coffee/meal
- Stop at the gym
- Stop at the bank/post office/etc.
- Stop for social gatherings
- I don't stop on my way to work for any purpose
- Other: (open text answer)

* If Q4 = Student
22.2 On a typical day with warm, dry weather conditions, do you regularly stop on your way to or from work for any of the following purposes?
Check all that apply

- Drop off children at school/daycare/etc. Grocery shopping
- Buy coffee/meal
- Stop at the gym
- Stop at the bank/post office/etc.
- Stop for social gatherings
- I don't stop on my way to work for any purpose
- Other: (open text answer)

23.2 On a typical day with cold, wet weather conditions, do you regularly stop on your way to or from work for any of the following purposes?
Check all that apply

- Drop off children at school/daycare/etc. Grocery shopping
- Buy coffee/meal
- Stop at the gym
- Stop at the bank/post office/etc.
- Stop for social gatherings
- I don't stop on my way to work for any purpose
- Other: (open text answer)

Travel Considerations

24. How important are the following statements when planning any trip?

	Extremely Unimportant	Somewhat Unimportant	Neutral	Somewhat Important	Extremely Important	Not Applicable
• The travel habits of my friends and family	O	O	O	O	O	O
• The travel habits of my colleagues consistent	O	O	O	O	O	O
• The opportunity to multi- task (eg. reading, email, etc.)	O	O	O	O	O	O
• The price of fuel	O	O	O	O	O	O
• The environmental impact of my chosen mode	O	O	O	O	O	O
• The overall enjoyment of the trip	O	O	O	O	O	O
• The long-term effect on my health	O	O	O	O	O	O
• The cost of the trip	O	O	O	O	O	O
• The length of time of the trip	O	O	O	O	O	O

25. How much do you agree with the following statements?

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I enjoy driving	O	O	O	O	O	O
• I enjoy walking	O	O	O	O	O	O
• I enjoy cycling	O	O	O	O	O	O
• I enjoy riding the bus	O	O	O	O	O	O
• I enjoy riding the C Train	O	O	O	O	O	O

26. How do you feel you are (or would be) viewed by your peers as a:

	Very Negatively	Somewhat Negatively	Neutrally	Somewhat Positively	Very Positively
• Pedestrian?	O	O	O	O	O
• Cyclist?	O	O	O	O	O
• Bus Passenger?	O	O	O	O	O
• C Train Passenger?	O	O	O	O	O
• Driver?	O	O	O	O	O

Number of Children and Active Transportation Encouragement in the Household

27. How many children under the age of 15 are in your household?
(drop down menu, with numeric options from 0 to "20 or more")

*If Q27 >= to 1, then child travel questions asked

28. What mode(s) of transportation do the school aged children in your household use to get to their school in warm, dry weather?
Check all that apply

- School Bus
- Walk
- Bicycle
- Public Transit
- Drive (either as passenger or driver)

29. What mode(s) of transportation do the school aged children in your household use to get to their school in cold, wet weather?
Check all that apply

- School Bus
- Walk
- Bicycle
- Public Transit
- Drive (either as passenger or driver)

30. To what extent are you actively encouraging or discouraging the school aged children in your household to use active modes of transportation (walking, cycling, taking public transit) to get to their:

	Actively Discourage	Somewhat Discourage	Neither Encourage or Discourage	Somewhat Encourage	Actively Encourage
• School	O	O	O	O	O
• Friends' houses	O	O	O	O	O

Preferred Park Map Location

31. In warmer seasons, do you go to parks at least once every month?
    (yes/no)

*If Q31 = yes, ask park location map question
32. On the following map, please adjust the zoom and drag the pin to the location of the park you visit most often:
    (Interactive map, pre-zoomed to Calgary)

Desire for Change and Neighbourhood Liveability

33. How much do you agree with the following statements?

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
• I would like to walk more than I currently do	O	O	O	O	O	O
• I would like to cycle more than I currently do	O	O	O	O	O	O
• I would like to take transit more than I currently do	O	O	O	O	O	O
• I would like to drive more than I currently do	O	O	O	O	O	O
• I would like to use shared vehicles more (eg. Uber)	O	O	O	O	O	O

34. How would you rate the overall liveability of your neighbourhood (ability to access your essential amenities) during warmer and dryer seasons?

- Very high liveability
- Somewhat high liveability
- Neutral
- Somewhat low liveability
- Very low liveability

35. How would you rate the overall liveability of your neighbourhood (ability to access your essential amenities) during colder and wetter seasons?

- Very high liveability
- Somewhat high liveability
- Neutral
- Somewhat low liveability
- Very low liveability

Household Structure, Sociodemographic, and General Questions

36. Select all the following that apply to you:
Check all that apply

- I have a driver's license
- I have a monthly/seasonal/annual transit pass
- I have a carshare membership (eg. Car2Go)
- I have a bicycle
- I have access to a privately owned car (not car-share)

37. How many days a week do you on average do you travel to work or your school?
(drop down menu, from 1 to 7)

38. What best describes your primary home that you are currently living in?
Choose one of the following answers

- Apartment or condo
- Row-house or town-house
- Semi-detached house
- Detached, self-standing house
- Other

39. In what year did you start living in your current residence?
(drop down menu, from 1925 to 2017)

40. How many people are in your household, including yourself?
(drop down menu, from 0 to "more than 20")

41. How many cars are owned by the members of your household?
(drop down menu, from 0 to "10 or more")

42. What is the highest level of education that you have completed?
Choose one of the following answers

- No formal education
- High school
- College
- Diploma (technical)
- Undergraduate degree
- Graduate degree or higher
- Other

43. What is your annual gross household income (before taxes)?
Choose one of the following answers

- Less than $20,000
- Between $20,001 - $40,000
- Between $40,001 - $60,000
- Between $60,001 - $80,000
- Between $80,001 - $100,000
- Between $100,001 - $120,000
- Between $120,000 - $140,000
- Between $140,001 - $200,000
- Between $200,001 - $300,000
- Over $300,000
- Prefer not to say

44. You are:

- Female
- Male
- Prefer not to say
- Other

45. What year were you born?
(drop down menu, from 1920 to 2002)

Final Comments and Map Locations of Areas of Concern

46. Do you have any further comments on the quality of life in your neighbourhood or feel there is anything missing from your community?
(open text answer)

47. Would you like to place a pin on a map to specify a location related to your above comments about your neighbourhood (e.g. a problem intersection or a specific street)?
(yes/no)

*If Q47 = yes, ask map question
48. On the following map, please adjust the zoom and drag the pin to the location related to your comments about neighbourhood/community improvements:
(Interactive map, pre-zoomed to Calgary)

Draw Prize Participation

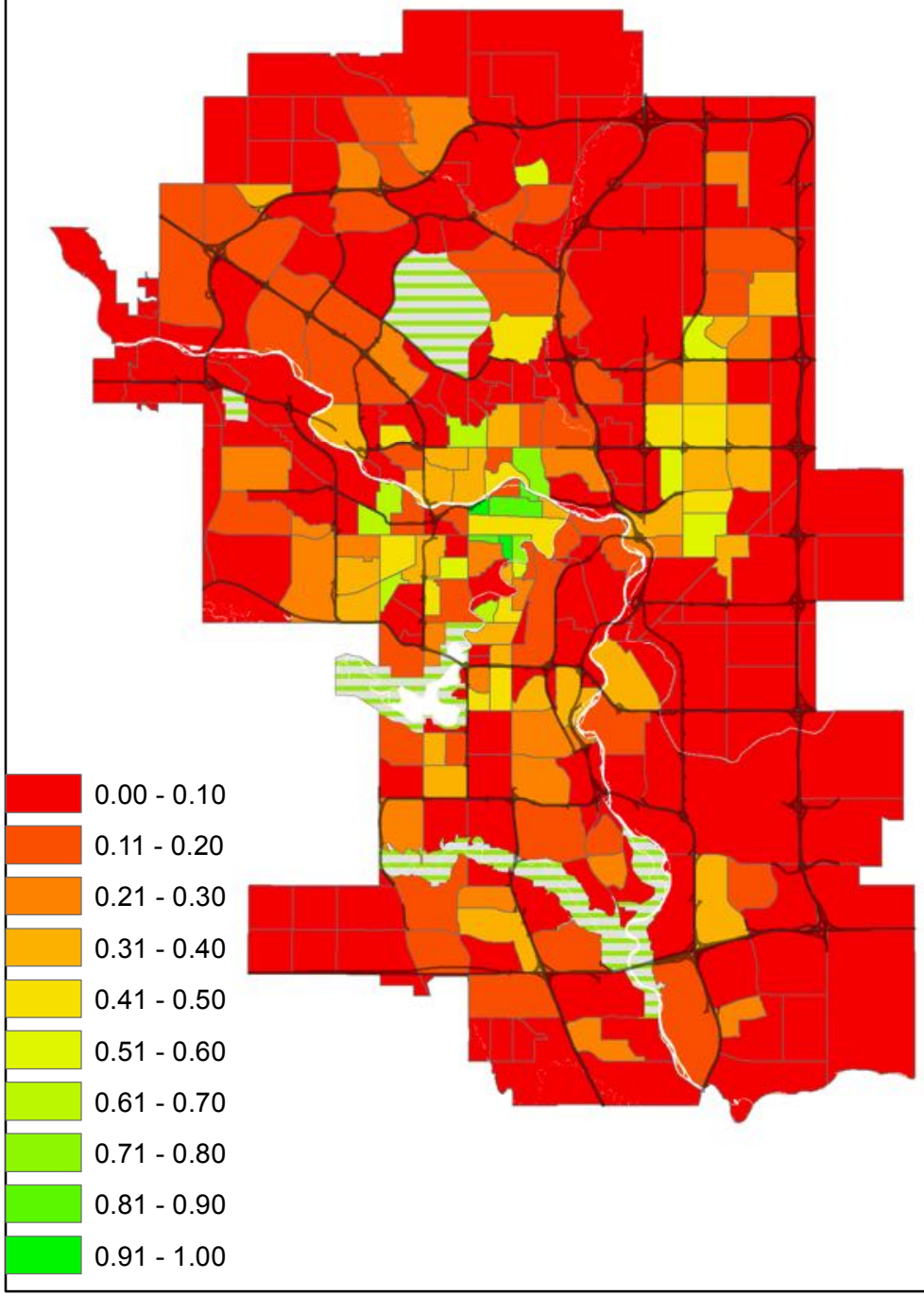
48. Would you like to provide your email address to be included in the random draw prize for this survey?
(your email address will be anonymized and never connected to your responses to this survey)
(yes/no)

*If Q48 = yes, provide email text box
Please type your preferred email address below.
Winners will be contacted in April 2017.

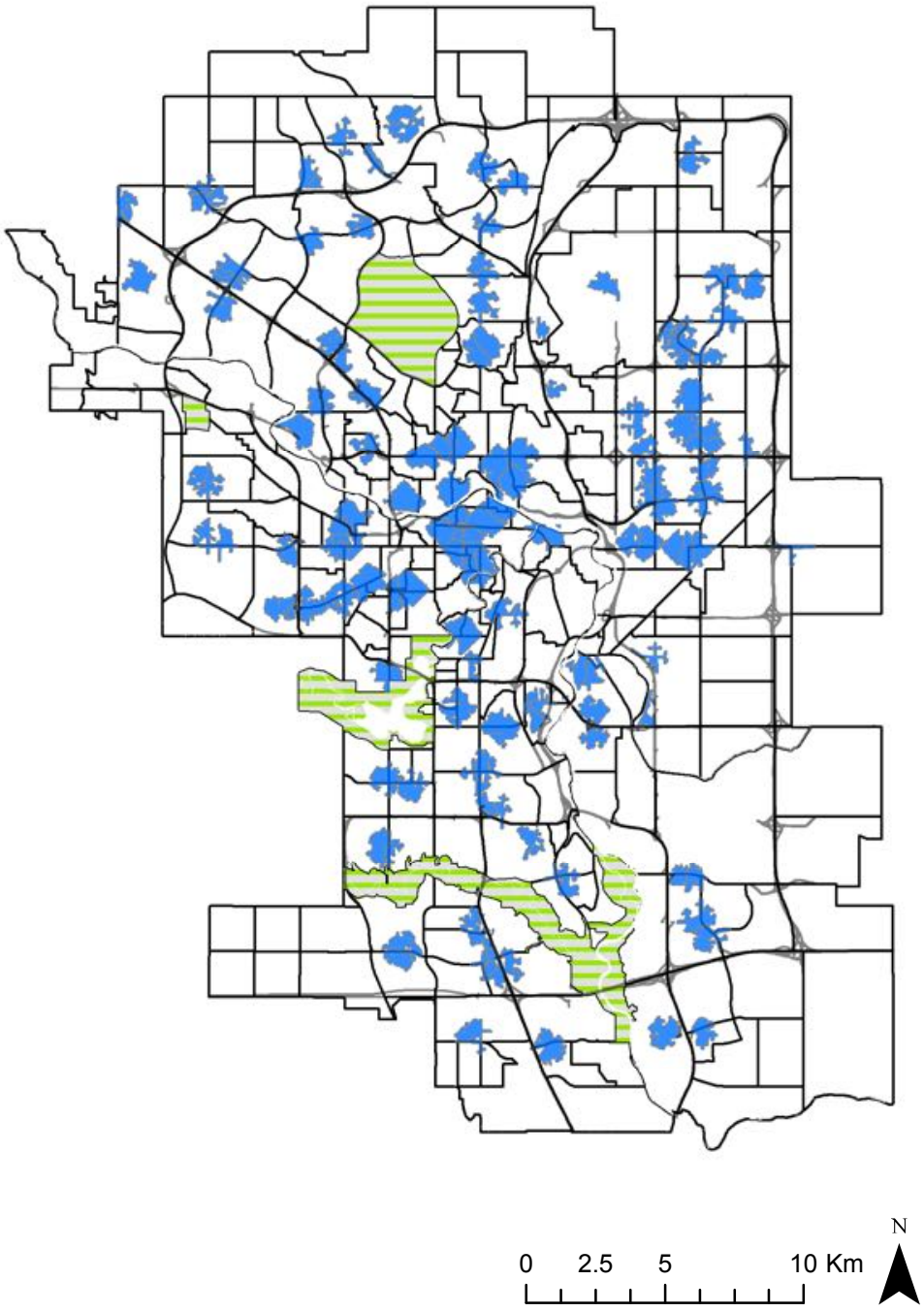
APPENDIX B: Calgary Liveability Index Layers

i) Community Retail Food Access (Walk)
ii) Community Retail Food Access (Bicycle)
iii) Community School Access (Walk)
iv) Community School Access (Bicycle)
v) Community Employment Access (Walk)
vi) Community Employment Access (Bicycle)
vii) Community Park Access (Walk)
viii) Community Park Access (Bicycle)
ix) Community Transit Utility Score
x) Cumulative, Community Liveability Score

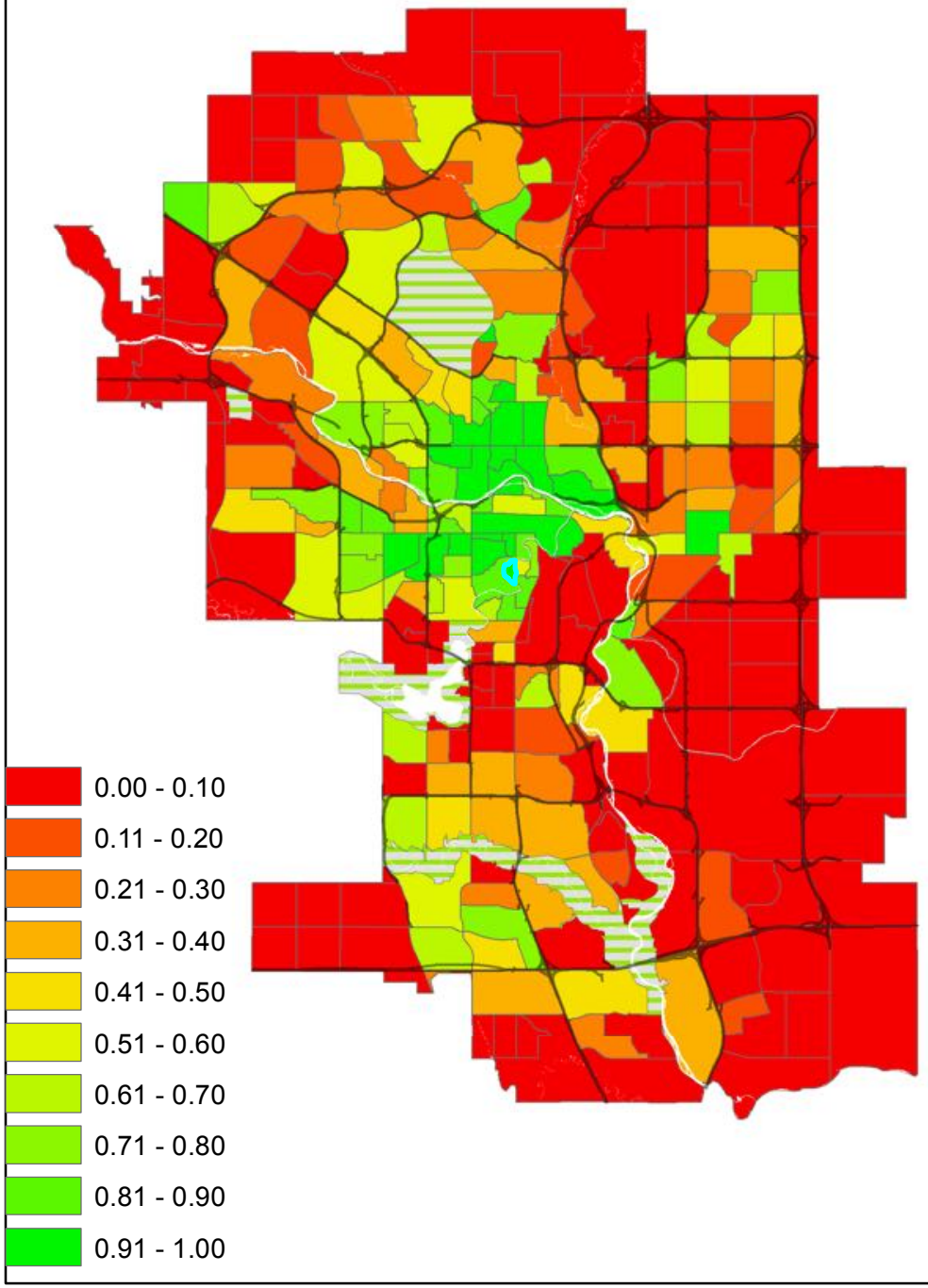
Retail Food Scores



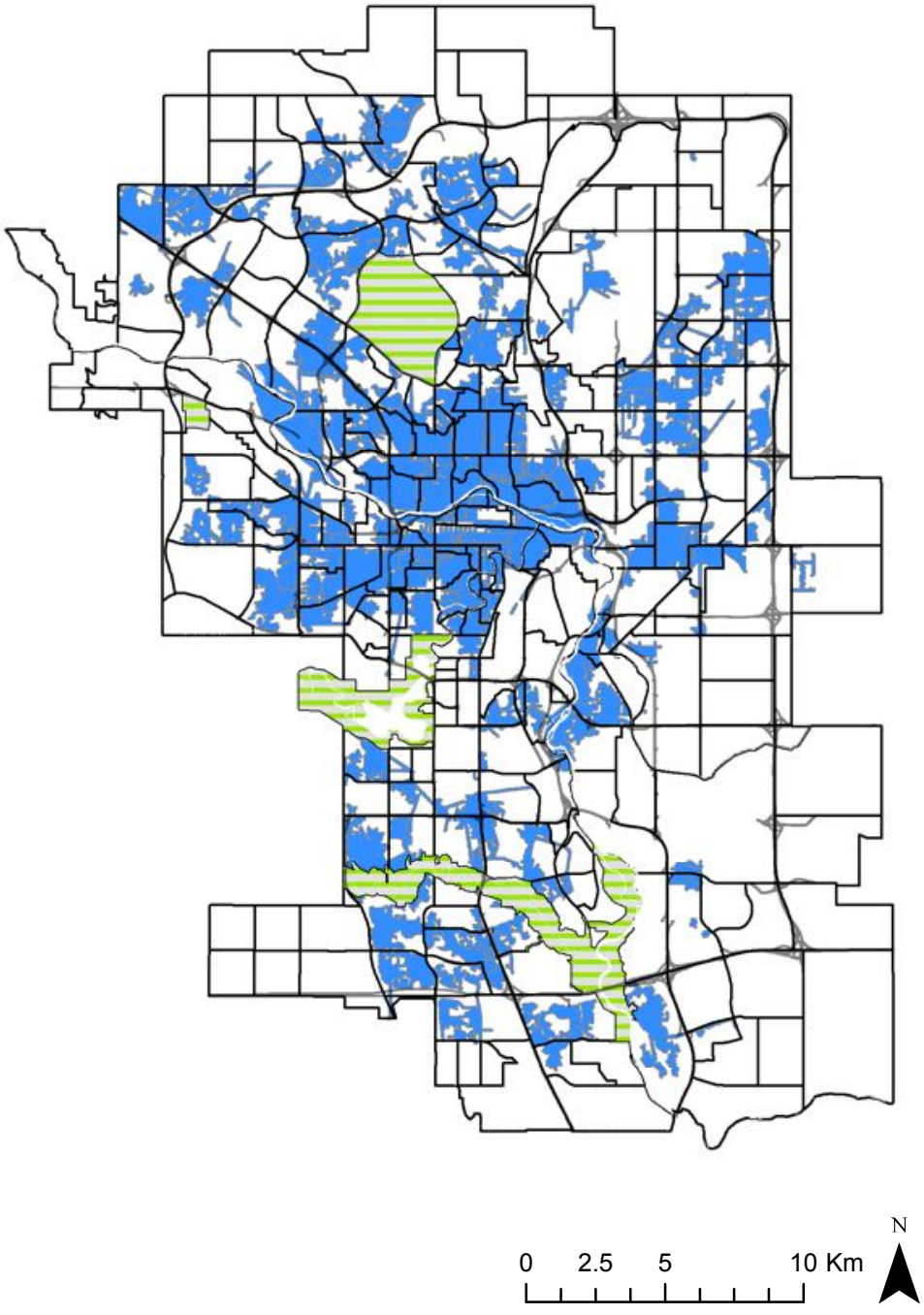
Retail Food Network Buffers 800 meters



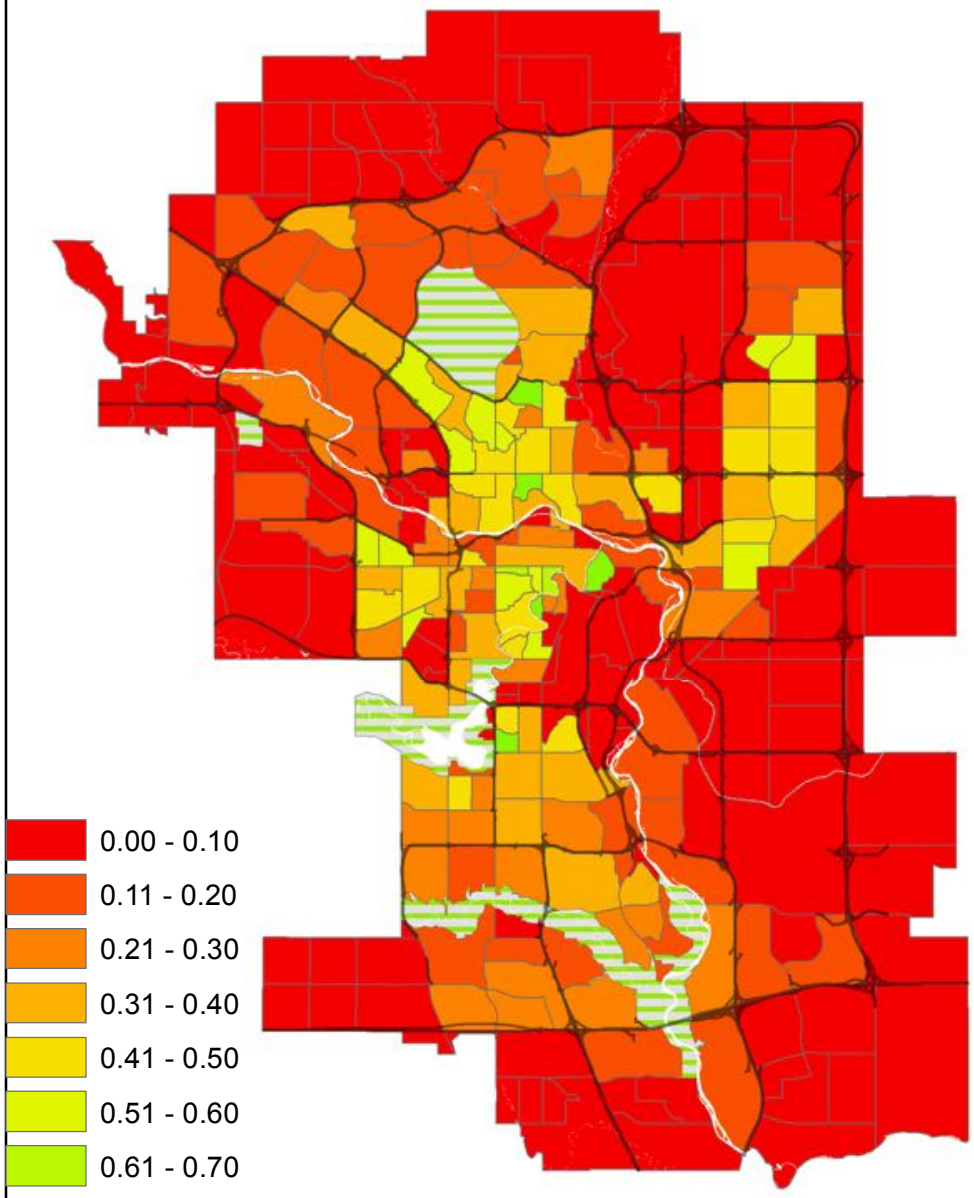
Retail Food Scores
Cycling Accessibility



Retail Food Network Buffers
3500 meters

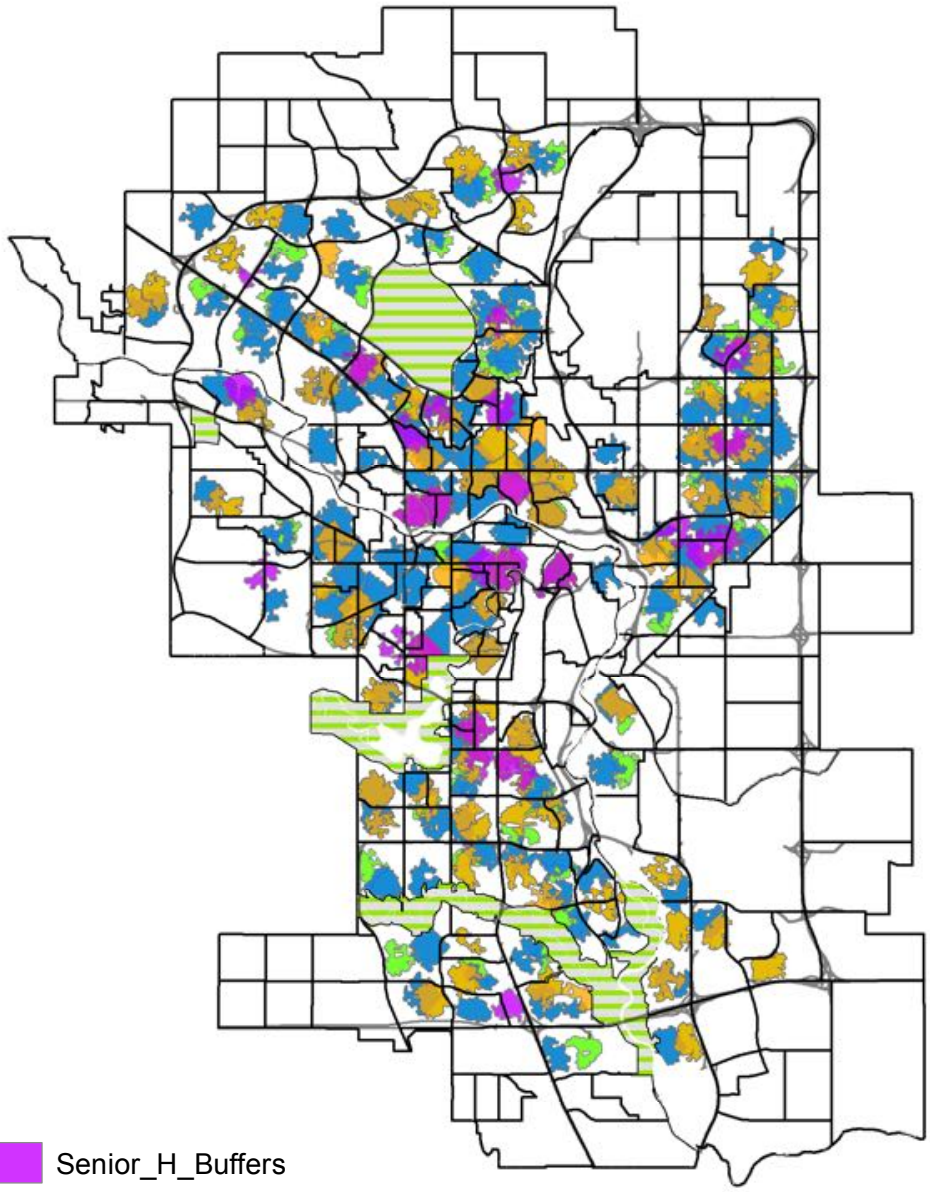


School Scores



0.00 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00

School Network Buffers
800 meters

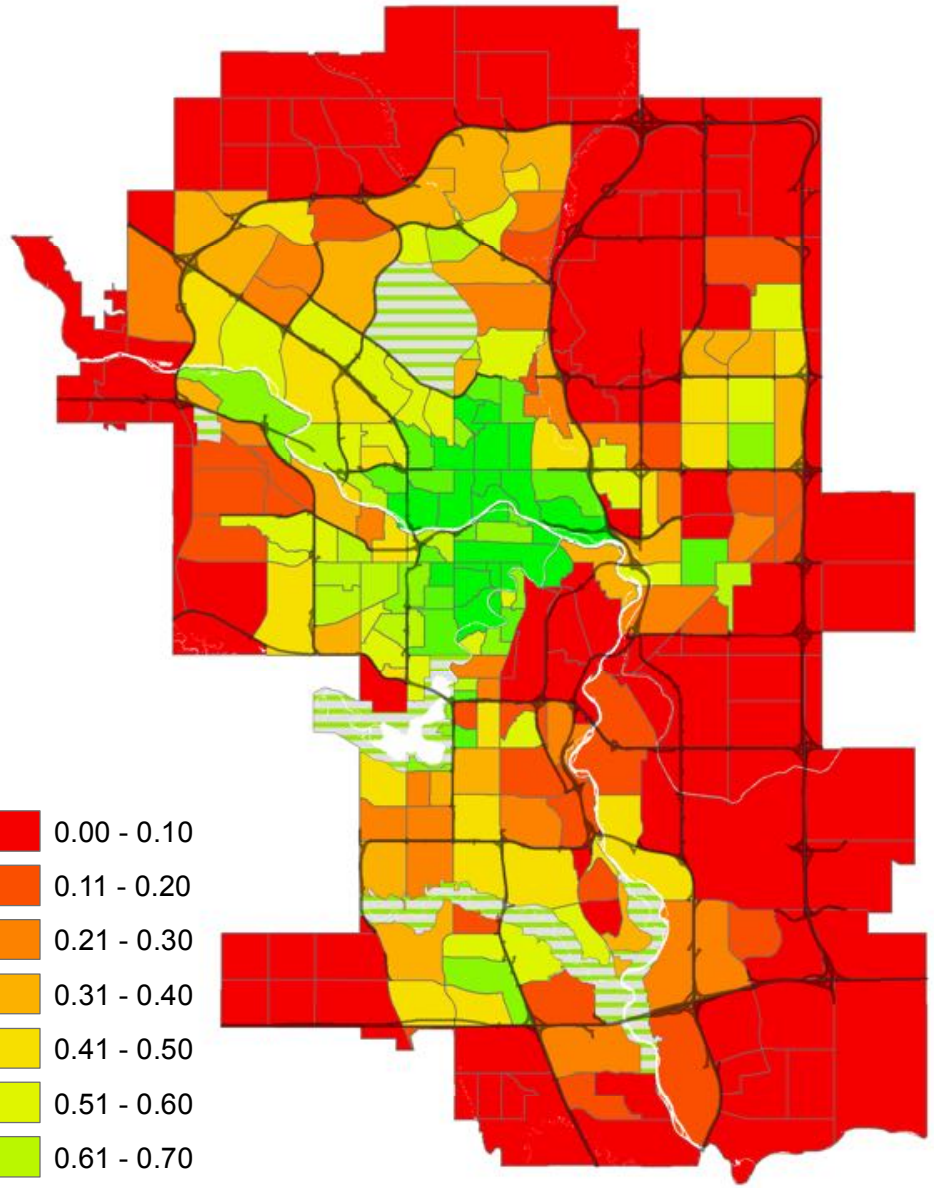


Senior_H_Buffers
Junior_H_Buffers
ECS_Buffers
Elem_Buffers

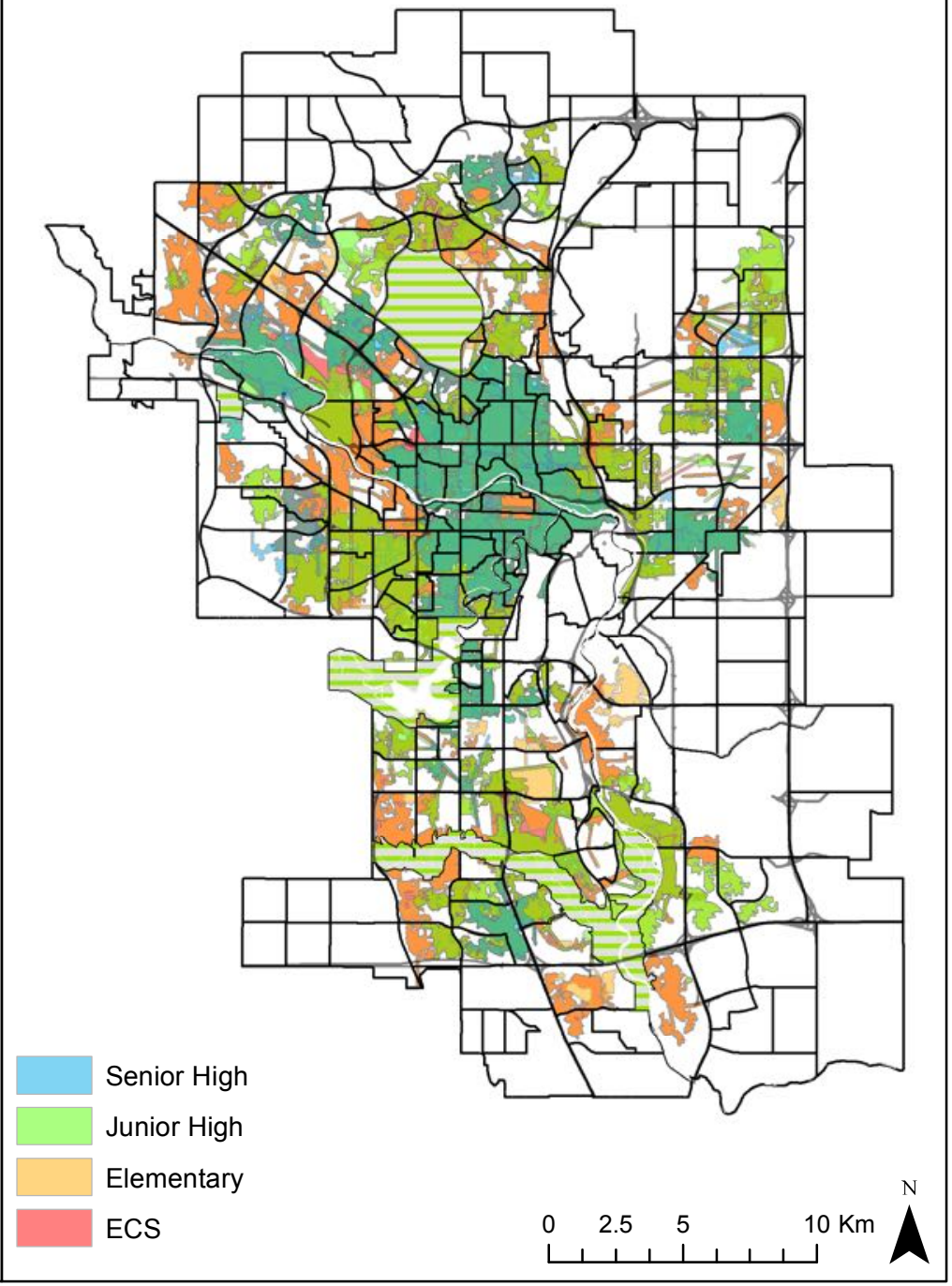
0 2.5 5 10 Km

N

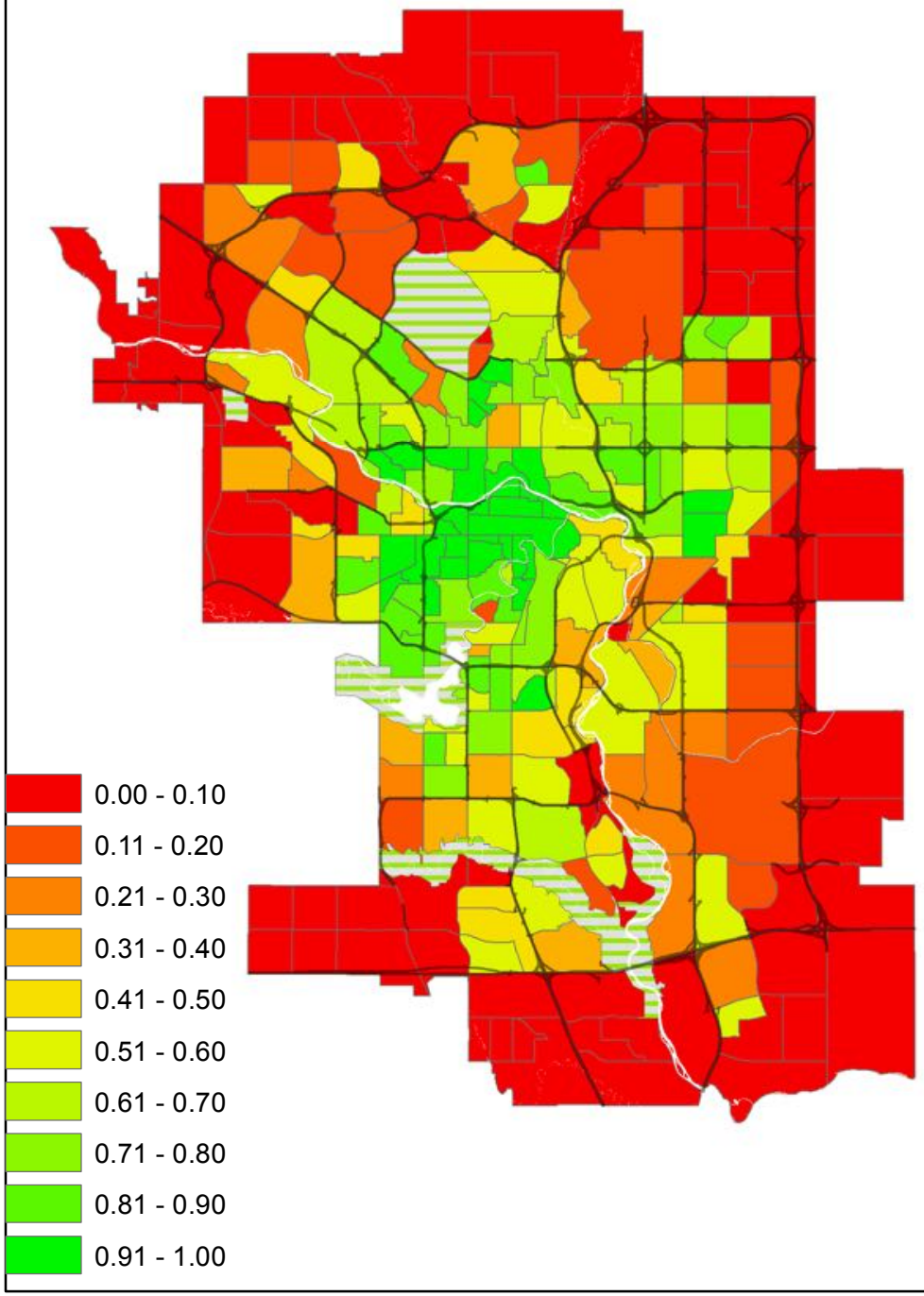
Schools
Cycling Accessibility



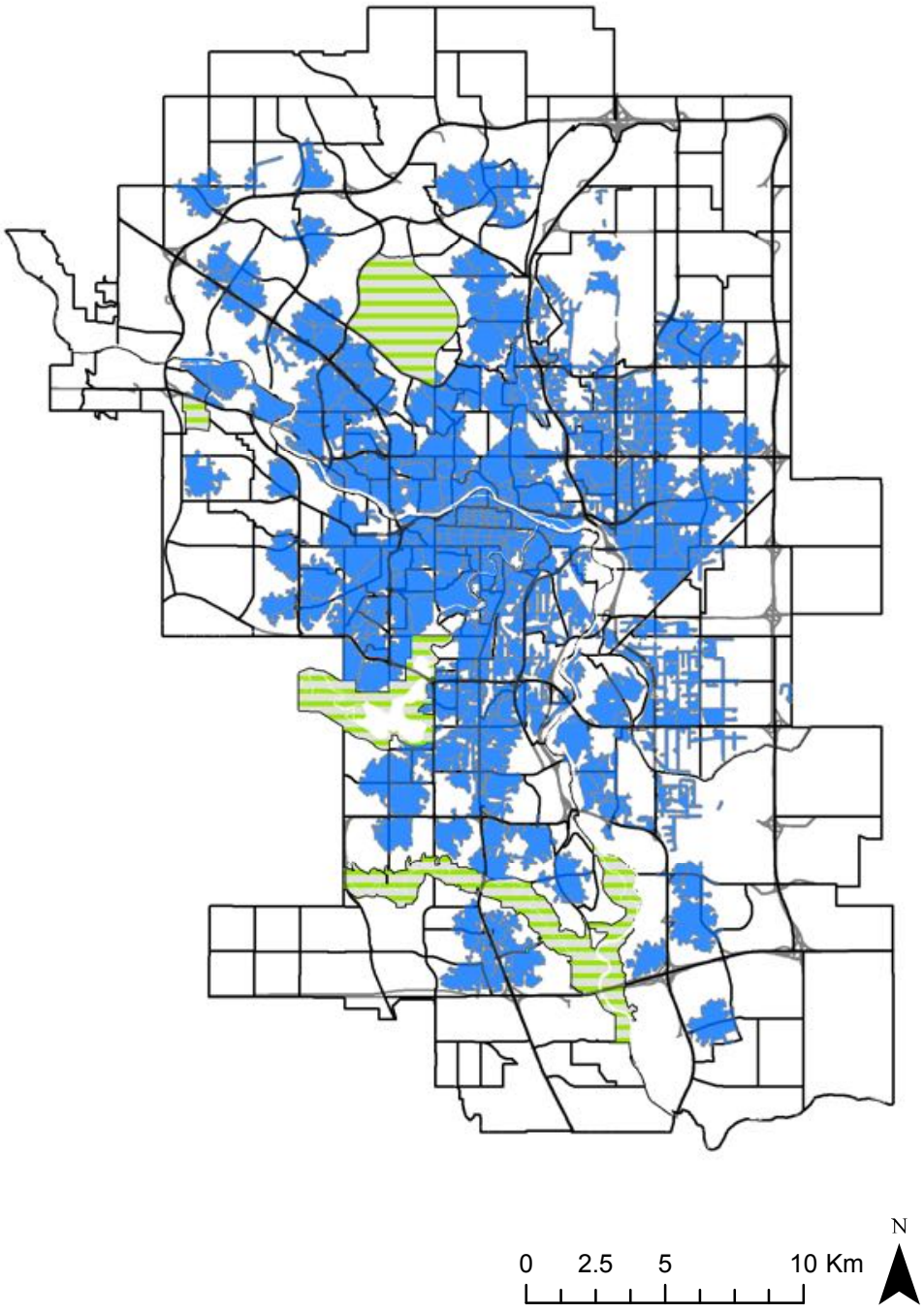
School Buffers
3500 meters



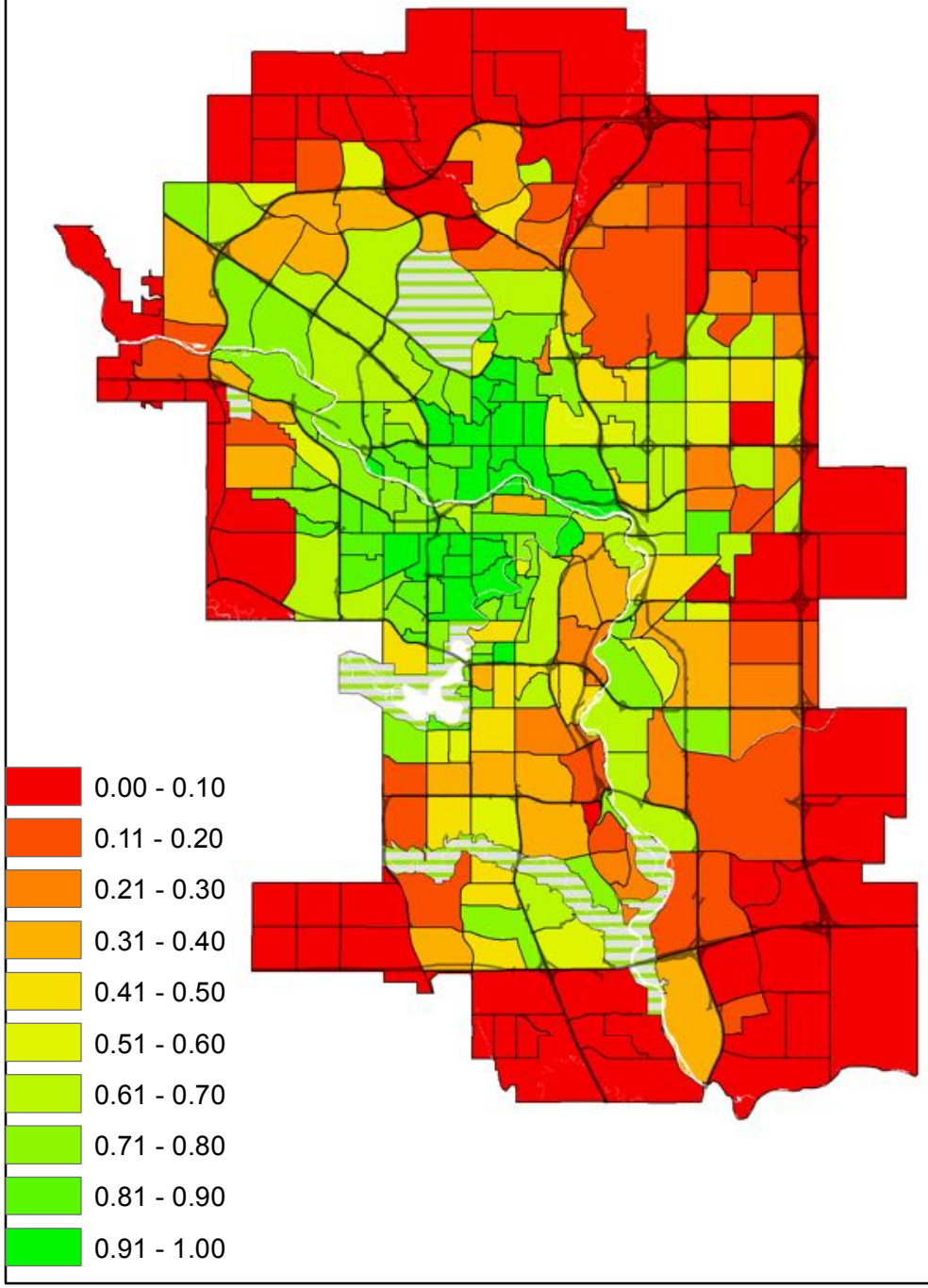
Employment Scores



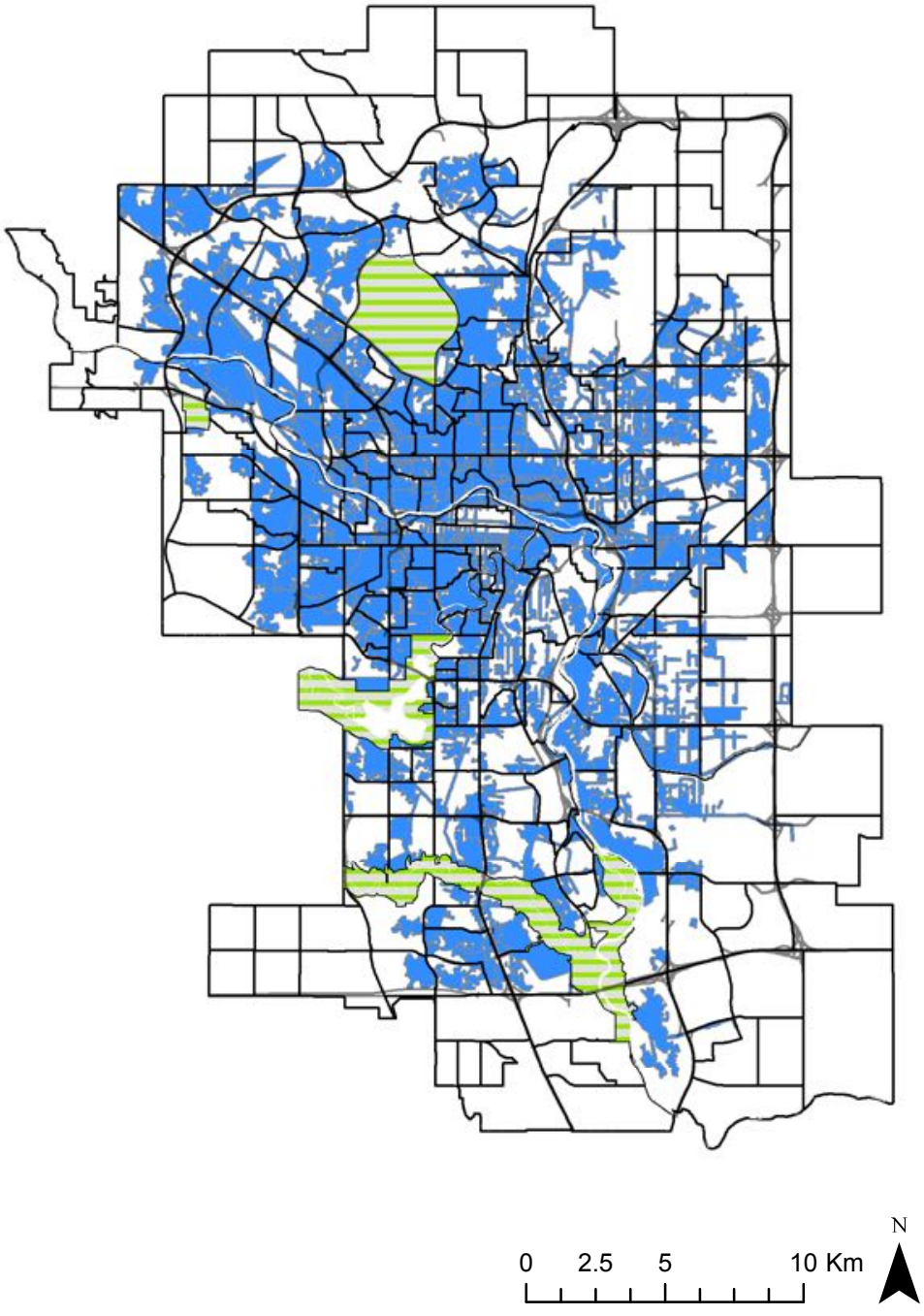
Employment Network Buffers 1200 meters



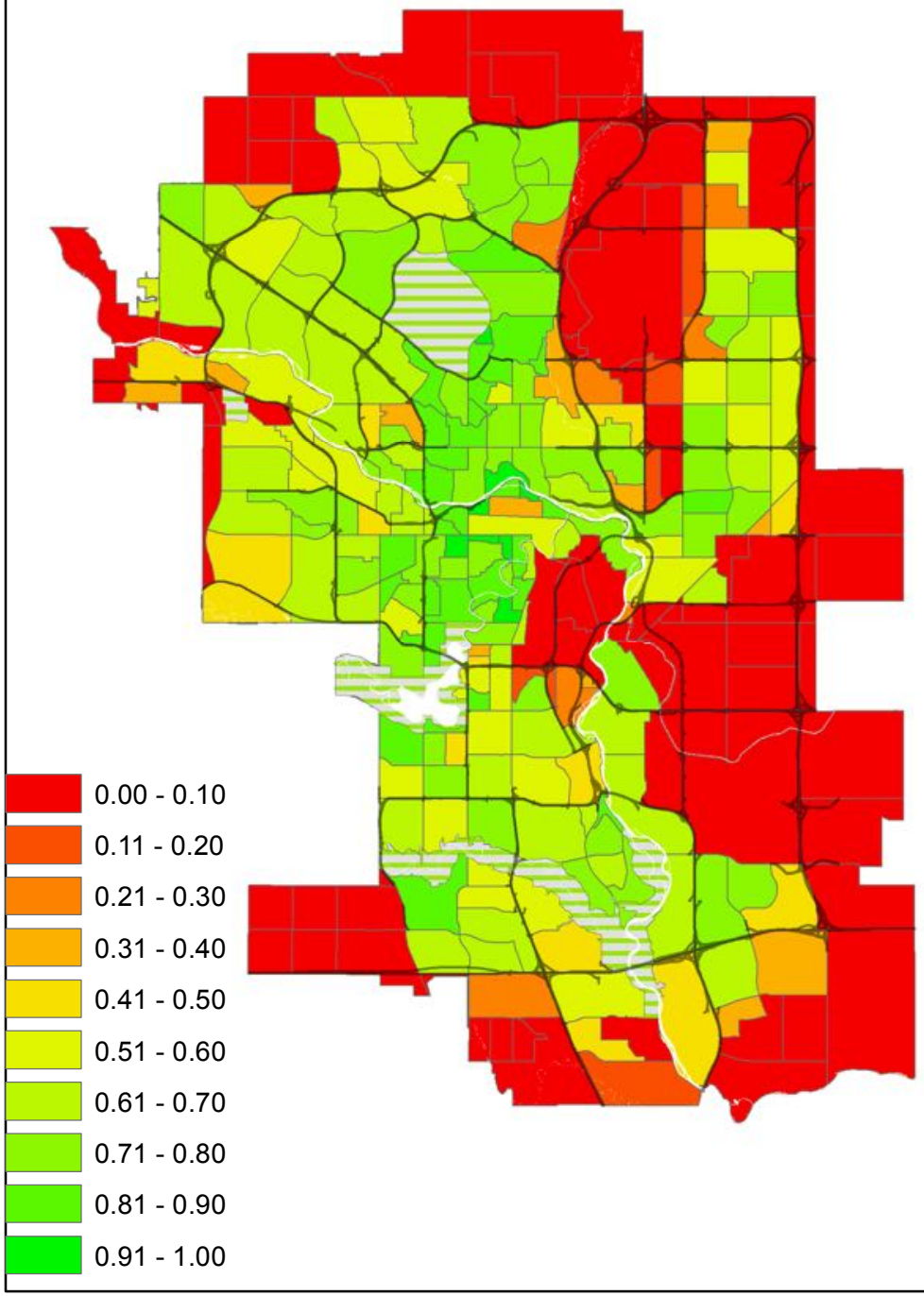
Major Employment Centres Cycling Accessibility



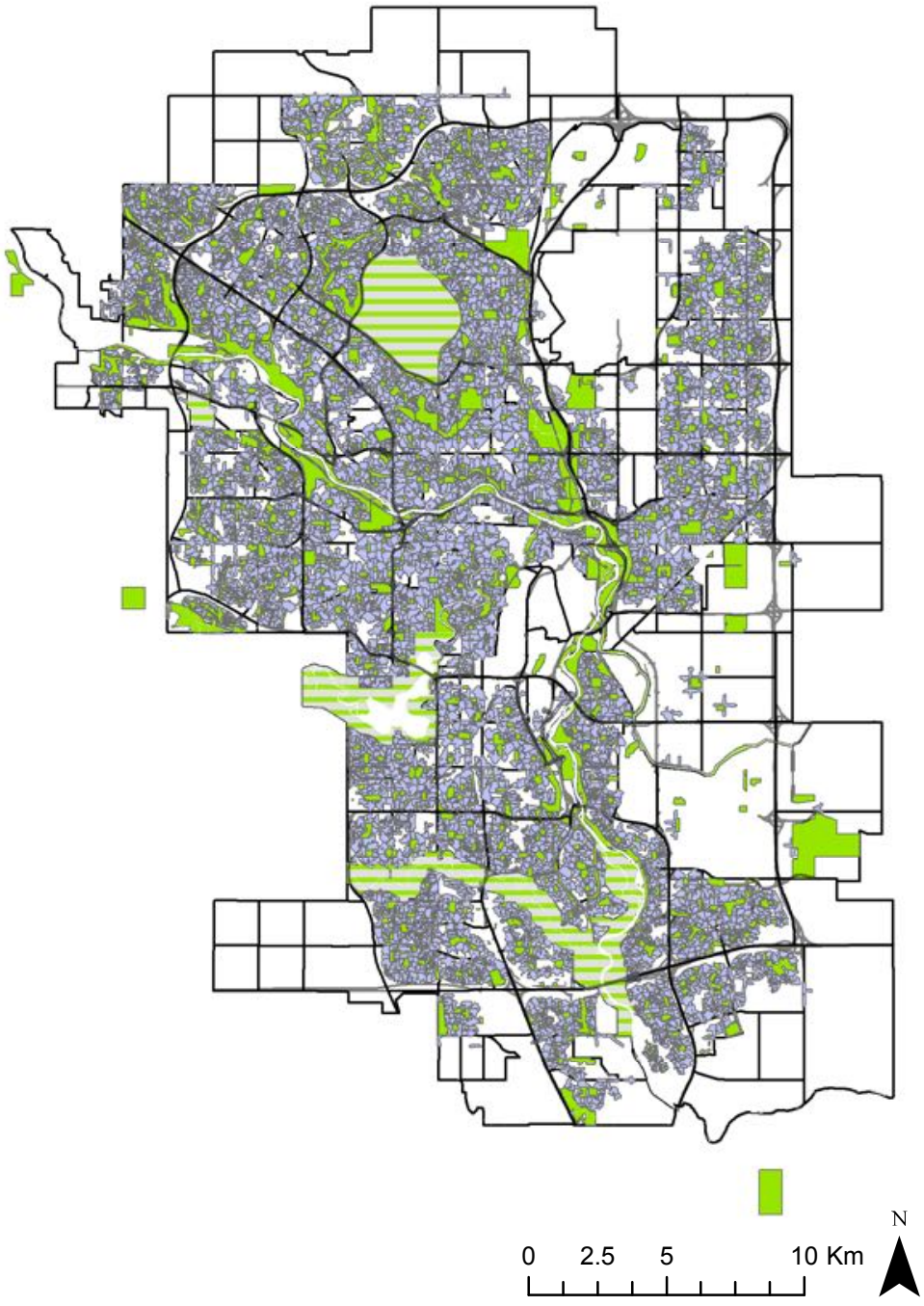
Major Employment Centre Buffers 5000 meters



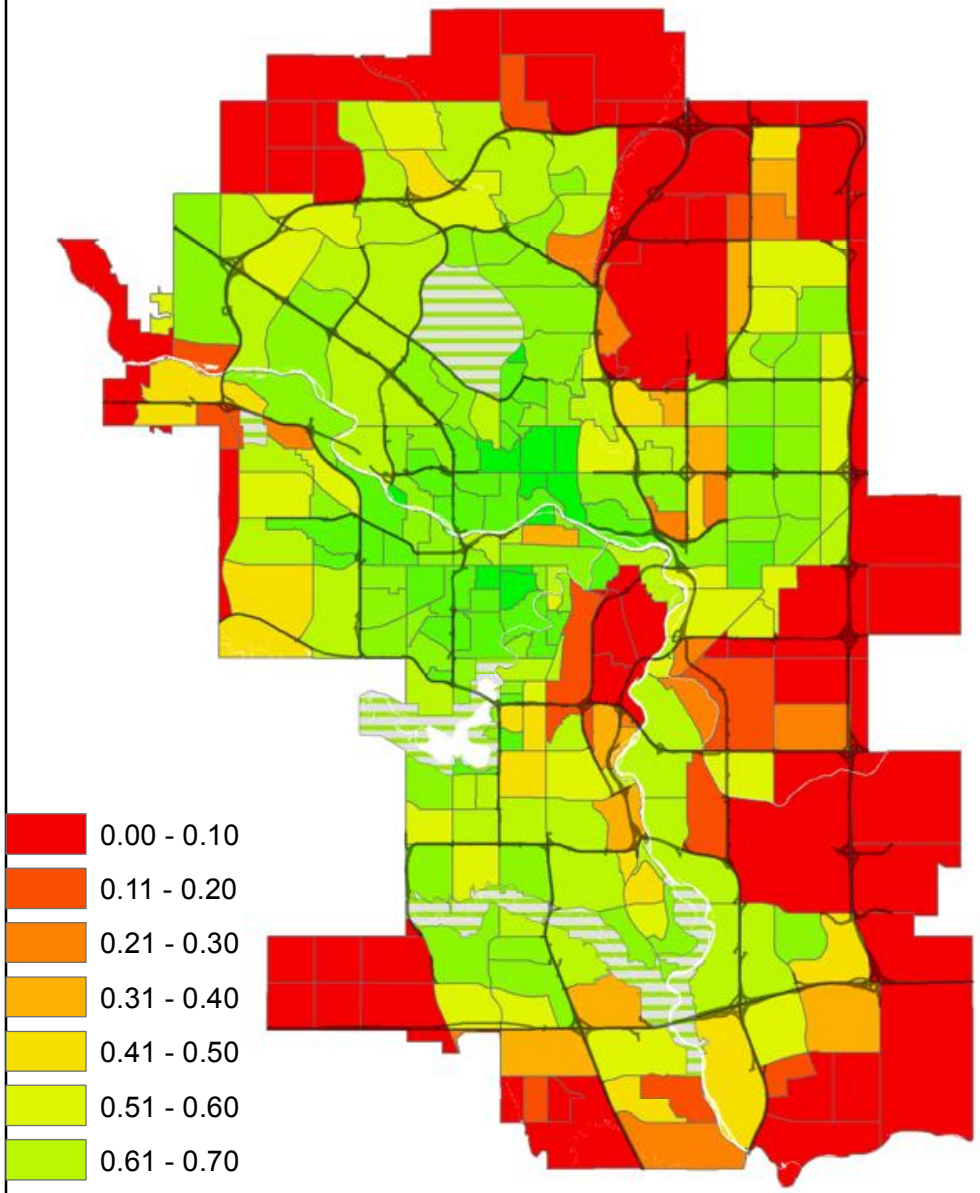
Park Scores



Park Network Buffers
400 meters

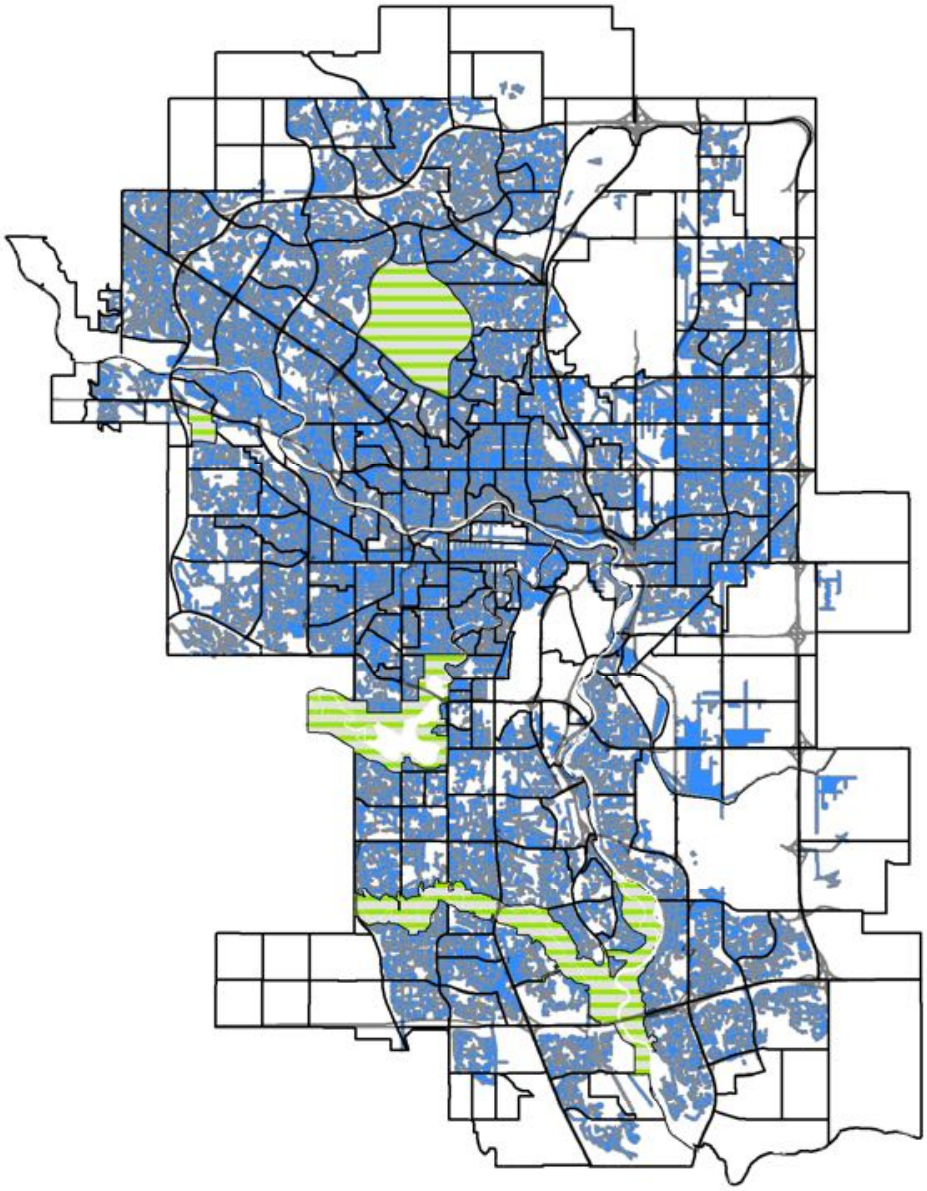


Park Entrances
Cycling Accessibility



0.00 - 0.10
0.11 - 0.20
0.21 - 0.30
0.31 - 0.40
0.41 - 0.50
0.51 - 0.60
0.61 - 0.70
0.71 - 0.80
0.81 - 0.90
0.91 - 1.00

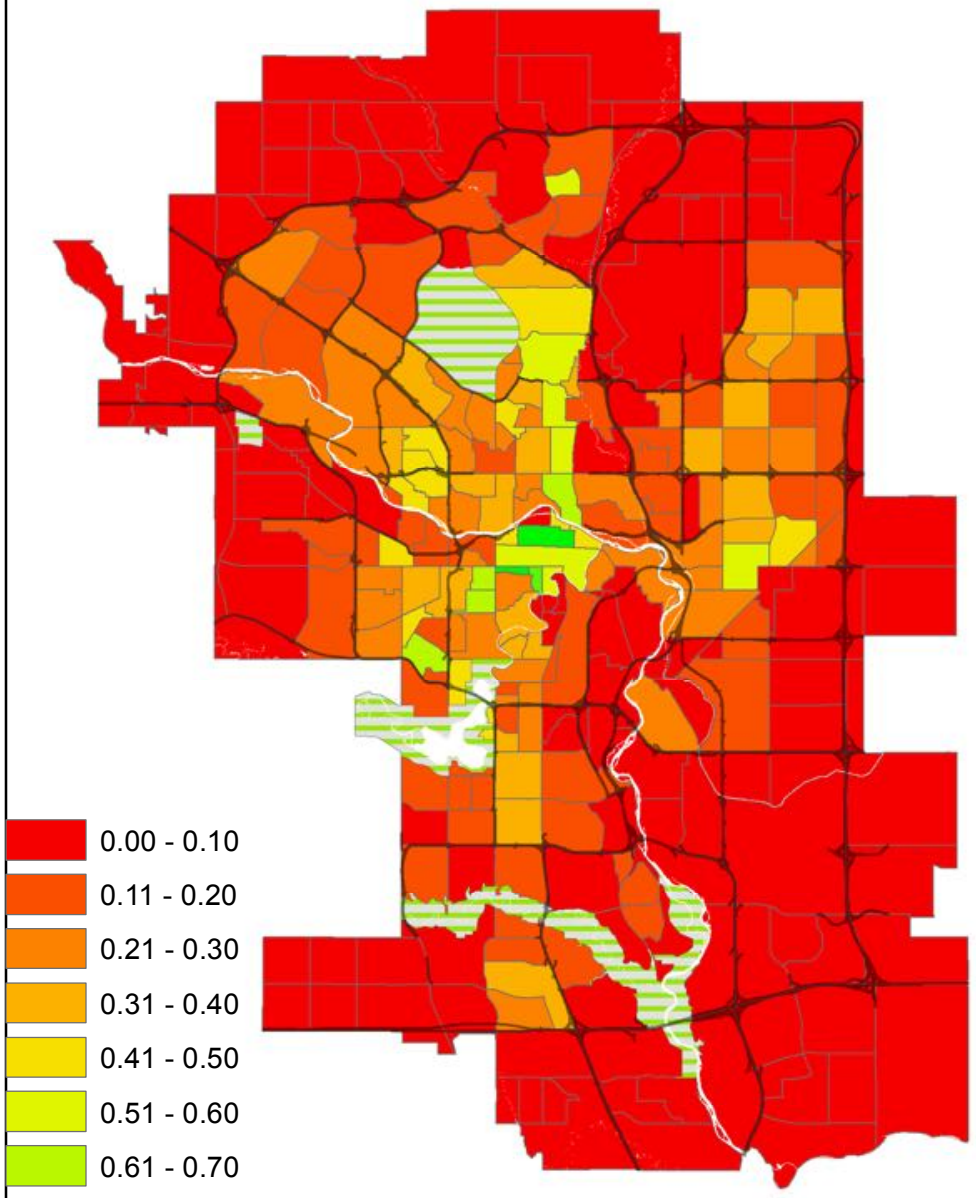
Park Entrance Buffers
1750 meters



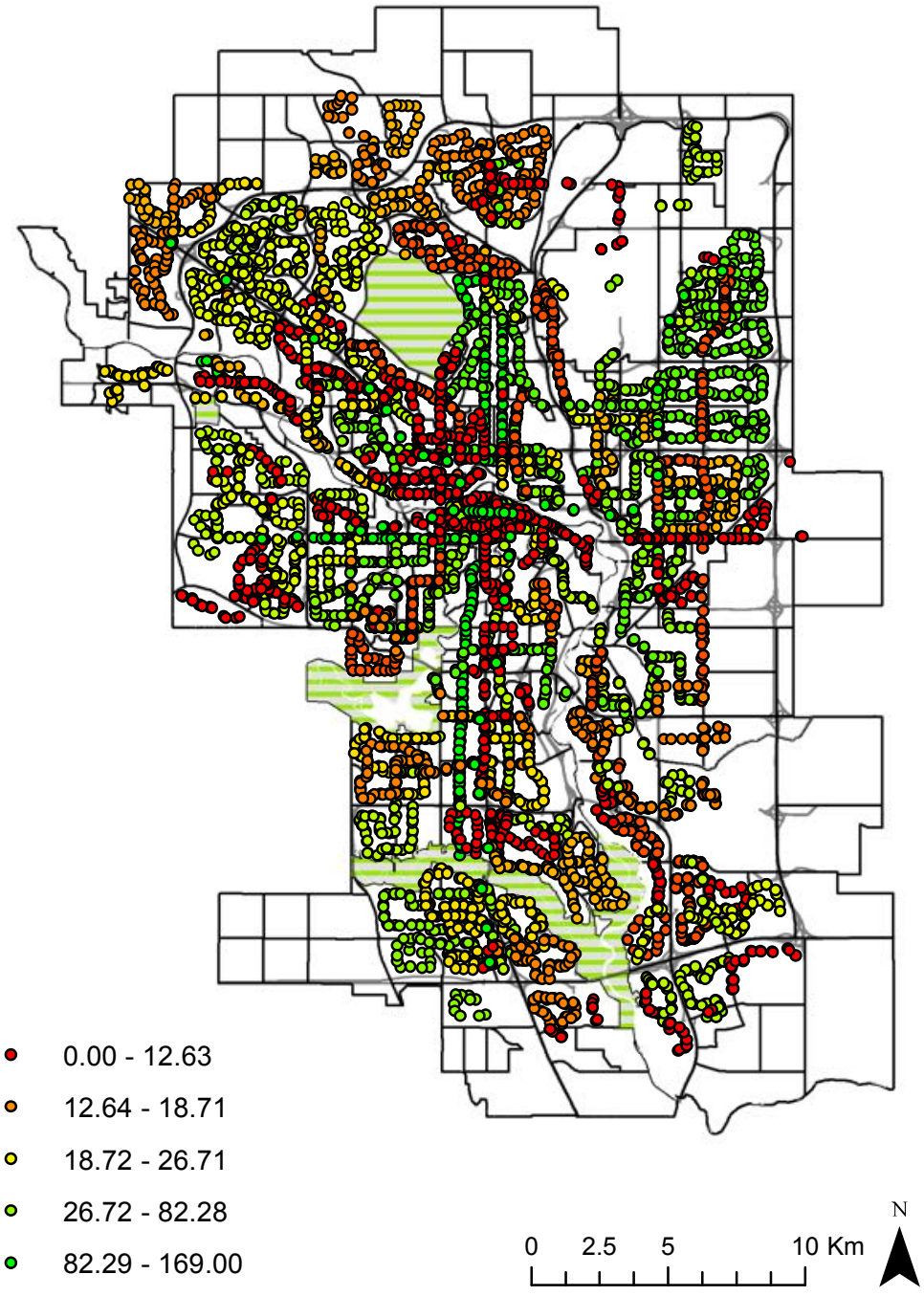
0 2.5 5 10 Km

N

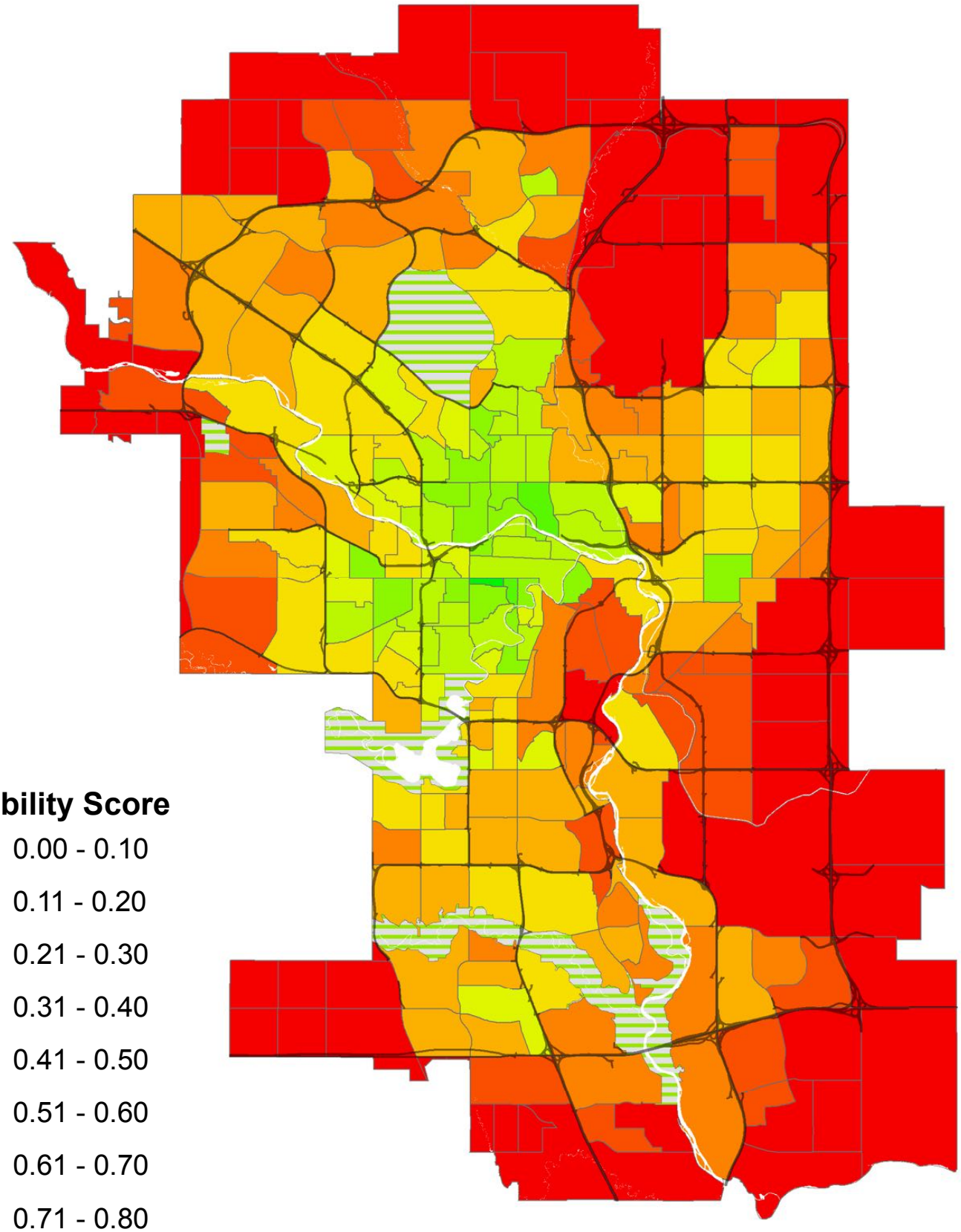
Community Transit Utility Index



Bus and LRT Stop Locations with Visualized ROH Values



Liveability Index
Calgary AB



Liveability Score

- 0.00 - 0.10
- 0.11 - 0.20
- 0.21 - 0.30
- 0.31 - 0.40
- 0.41 - 0.50
- 0.51 - 0.60
- 0.61 - 0.70
- 0.71 - 0.80
- 0.81 - 0.90
- 0.91 - 1.00

0 2.5 5 10 Km

N