Canadian Active Living Environments Database (Can-ALE)

User Manual & Technical Document

Project prepared for and funded by the Public Health Agency of Canada.

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1: Background and Dataset Summary

1.1: Background

Over the past few decades, there has been a significant rise in physical inactivity-related health conditions (e.g., diabetes, cardiovascular disease) among Canadians [1-5]. This trend has prompted interest in promoting built environments that facilitate physical activity during activities of daily life (e.g., walking for transportation) as a population-level health intervention [6-9]. This dataset provides public health researchers with a Canada-wide set of Geographic Information Systems (GIS) measures that indicate the active living friendliness, sometimes referred to as the "walkability", of neighbourhoods.

This document is intended for researchers who have a basic understanding of GIS and those with a research interest in active living environments (ALEs) across Canada. Communities with favourable ALEs are those whose built environments are conducive to physical activity resulting from walking, cycling, and the use of public transportation. These built environments tend to be densely populated, have very connected street patterns and have a variety of walking destinations.

1.2: About Can-ALE

The Canadian Active Living Environments (Can-ALE) database is a geographic-based set of measures that represents the active living friendliness of Canadian communities. The primary envisioned use for Can-ALE is research and analysis of the relationship between the way communities are built and the physical activity levels of Canadians. By using geography conversion tools such as the Postal Code Conversion File (PCCF+) [10] (see Table A3, page 19 for URL), it is possible to link Can-ALE measures to individual-level health data from national-level survey platforms (e.g., National Population Health Survey, Canadian Community Health Survey) or to local-level data, such as travel surveys (e.g., Transportation Tomorrow Survey, Montreal Origin-Destination Survey).

Each of the measures was selected from fourteen potential measures identified by a literature review. Several considerations were weighed in deriving the Canada-wide set of measures, including: (1) the suitability of each measure across different Canadian regions and built areas (e.g., urban, suburban, rural areas); (2) the incorporation of high-quality, open and free-to-use data sources; and (3) the strength of the association between the derived measures with walking rates and active transportation (i.e., walking, cycling, and public transit use). Public transit use is included in our definition of active transportation, as public transit is shown to generate physical activity via walking to and from transit stops [11-13].

1.2.1: Reference years

There are two Can-ALE datasets: the 2006 Can-ALE Dataset includes two measures derived from 2006 data for geographic units corresponding to 2006 geographies, whereas the 2016 Can-ALE dataset includes four measures derived from 2016 or 2017 data for geographic units corresponding to 2016 geographies. Census years were selected for the dataset to facilitate the use of census data by users. Users are discouraged from performing longitudinal analyses using data from both the 2006 and 2016 datasets, as the derivation methodologies and census geographies changed between the reference years.

1.2.2: Geographic unit of analysis

Can-ALE measures are based on one-kilometre, circular (Euclidean) buffers drawn from the centre points (centroids) of Dissemination Areas (DAs). DAs are small geographic units defined by Statistics Canada, with a population of between 400 to 700 persons. All of Canada is divided into DAs. This is the smallest geographic unit for which complete census data is released across all of Canada [14]. DA boundaries are created by and can be downloaded online from Statistics Canada [15, 16] (see Table A3, page 19 for URL).

1.2.3: File format and naming convention

Both Can-ALE datasets are provided in the Comma Separated Values (.csv) format. This file format may be opened easily in spreadsheet programs (e.g., Microsoft Excel, Google Sheets) and statistical software (e.g., STATA, SPSS, R).

The datasets are named using the following naming convention: six-character file name (i.e., “CanALE”), underscore (“_”), reference year for the geographic units (e.g., “2016”). The two files, therefore, are:

Dataset	***2006 Can-ALE Dataset***	***2016 Can-ALE Dataset***
File Name	CanALE_2006.csv	CanALE_2016.csv

1.2.4: Dataset completeness

For the 2006 dataset, two measures were produced for all dissemination areas (DAs) in Canada (intersection density and dwelling density). For the 2016 dataset, three measures were produced for all DAs in Canada (intersection density, dwelling density, and points of interest), and one measure was produced for all DAs within Census Metropolitan Areas (CMAs) in Canada (transit stops).

Intersection density was derived successfully for all DAs for both 2006 and 2016, and points of interest was derived successfully for all DAs for 2016.

Dwelling density values are not present for 410 DAs in 2006 and 500 DAs in 2016 (see Table A2, pages 17-18). All DAs with no values (null) are assigned a period (“.”). In all instances of null dissemination area values, the DA buffer was located entirely within a DA where Statistics Canada does not disseminate data on dwelling counts (e.g., First Nations reserves).

The transit measure (unique to the 2016 dataset) covers DAs in Canada’s largest cities, known as Census Metropolitan Areas (CMAs). The transit measure was derived for 35,338 DAs (97.1% of the DAs within CMAs). Spatial data on transit stop locations was unavailable for a few smaller CMAs: Belleville, ON; Peterborough, ON; Saguenay, QC; and Trois-Rivières, QC.

1.3: Field Directories and Measure Definitions

The active living environment measures included in Can-ALE are calculated from circular buffers based on centroids of dissemination areas (DAs), rather than the boundaries themselves (see Section 1.2.2, page 5). For instance, if the number of points of interest is indicated as "60", there are 60 points of interest within one kilometre of the centre point of that dissemination area.

For the 2006 dataset, intersection density and dwelling density measures were derived across Canada. No open-use historical datasets were available to derive the points of interest or transit measures in 2006.

For the 2016 dataset, three ALE measures are included for all of Canada (intersection density, dwelling density, and points of interest) and one measure is provided for DAs within CMAs (transit stops). A detailed protocol of how each measure was derived is provided in Section 2 (page 9). There are a few null values for the dwelling density and transits stop measures (see Section 1.2.4, page 5).

Summary statistics for each of the ALE measures is provided in the appendix (Table A1, page 16). Each of the datasets also includes z-scores for each measure, a summarized index measure (ALE Index), and a categorical measure of the favourability of the active living environment (see Sections 1.5 and 1.6, page 8).

Table 1: Field Directory for 2006 Can-ALE Dataset (54,624 Dissemination Areas)

Field name	*Full name*	*Definition*	*Derivation sources*
DAUID	Dissemination area – unique ID	Unique identifier of the dissemination area (eight digits)	Statistics Canada (Boundary Files, 2006)
INT_D	Intersection density	The number of ≥3-way intersections per square kilometre in the buffer around a dissemination area centroid	Statistics Canada (Road Network File, 2006)
DWL_D	Dwelling density	The number of dwellings per square kilometre in the buffer around a dissemination area centroid	Statistics Canada (Census 2006)
Z_INT_D	Intersection density (z-score)	Z-score of the intersection density measure	Statistics Canada (Road Network File, 2006)
Z_DWL_D	Dwelling density (z-score)	Z-score of the dwelling density measure	Statistics Canada (Census 2006)
ALE_INDEX	Active Living Environment Index	Sum of the z-score of the intersection density, dwelling density, and points of interest measures	-
ALE_CLASS	Active Living Environment class	Categorical value characterizing the favourability of the ALE on a scale from 1 (very low) to 5 (very high)	-

Table 2: Field Directory for 2016 Dataset (56,589 Dissemination Areas)

Field name	*Full name*	*Definition*	*Derivation sources*
DAUID	Dissemination area – unique ID	Unique identifier of the dissemination area (eight digits)	Statistics Canada (Boundary Files, 2016)
INT_D	Intersection density	The number of ≥3-way intersections per square kilometre in the buffer around a dissemination area centroid	OpenStreetMap road and footpath features (downloaded 2017)
DWL_D	Dwelling density	The number of dwellings per square kilometre in the buffer around a dissemination area centroid	Statistics Canada (Census 2016)
POI	Points of interest	The number of points of interest in the buffer around a dissemination area centroid	OpenStreetMap amenity features (downloaded 2017)
Z_INT_D	Intersection density (z-score)	Z-score of the intersection density measure	OpenStreetMap road and footpath features (downloaded 2017)
Z_DWL_D	Dwelling density (z-score)	Z-score of the dwelling density measure	Statistics Canada (Census 2016)
Z_POI	Points of interest (z-score)	Z-score of the points of interest measure	OpenStreetMap amenity features (downloaded 2017)
ALE_INDEX	Active Living Environment Index	Sum of the z-score of the intersection density, dwelling density, and points of interest measure	-
ALE_CLASS	Active Living Environment class	Categorical value characterizing the favourability of the ALE on a scale from 1 (very low) to 5 (very high)	-
TRANSIT	Transit stops	The number of public transit stops or stations in the buffer around a dissemination area centroid	Canadian municipalities and transit agencies
Z_TRANSIT	Transit stops (z-score)	Z-score of the transit measure	Canadian municipalities and transit agencies
ALE_TRANSIT	Transit stops (z-score)	Sum of the z-score of the intersection density, dwelling density, points of interest, and transit measures	-
ALE_TRANSIT_CLASS	Active Living Environment + Transit class	Categorical value characterizing the favourability of the ALE in CMAs on a scale from 1 (very low) to 5 (very high)	-

1.4: Guidelines for Use

1.4.1: Caution for Analysis of Certain DAs in Rural Areas

Although Can-ALE measures are valid for most rural areas, there are certain DAs with uncommon built or economic environments that may affect statistical analysis (e.g., isolated resort areas, remote communities not connected by road, fishing or hunting camps).

1.4.2: Caution Against Comparing 2006 and 2016 Datasets

The field names in both the 2006 and 2016 datasets are similar, but the ALE measures are not directly comparable between years. First, there were some boundary changes in the dissemination areas (DAs) between 2006 and 2016. Second, due to limited historical data availability, intersection density was derived using different road files between years: the Statistics Canada Road Network File was used for the 2006 dataset and OpenStreetMap road and footpath features were used for the 2016 dataset. Accordingly, the 2006 and 2016 datasets are best suited to cross-sectional analyses. Only the dwelling density measures from 2006 and 2016 can be compared directly, and only for DAs where boundaries did not change between the two census years.

1.5: Explanation of the ALE Index & the ALE/Transit Index

A summarized, single measure of active living environments (ALE Index) is provided for both the 2006 and 2016 datasets. The ALE Index is the sum of the z-scores for each ALE measure available throughout Canada for that census year (i.e., intersection density and dwelling density for 2006 and intersection density, dwelling density, and points of interest for 2016). The summed z-scores, or ALE Index, therefore, indicate the distribution of the ALE measure values for each DA relative to all DAs in Canada: negative ALE index scores indicate below average ALE measures and positive ALE index scores indicate above average ALE measures. A z-score near zero indicates that the DA is near the Canadian average for the quality of the active living environment. The ALE Index was not calculated for DAs with missing data (see Section 1.2.4, page 5).

The ALE/Transit Index is an additional index provided for the 2016 dataset and includes the z-score of the transit measure as a fourth, summed indicator. The ALE/Transit Index, therefore, indicates the distribution of the DA relative to DAs within included Canadian CMAs: values near zero indicate an ALE near the average for the included CMAs.

1.6: Explanation of the ALE Class Variable

The ALE Class variable is a categorical measure of the active living environment. Each DA is assigned a value from 1 (very low) to 5 (very high) which characterizes the favourability of the active living environment. A cluster analysis (k-medians approach) was performed to assign each DA to one of the five groups. In 2006, the k-medians cluster was based on two measures at the DA: intersection density and dwelling density. In 2016, the k-medians cluster was based on three measures at the DA: intersection density, dwelling density, and points of interest.

A similar measure, ALE/Transit Class, is provided for DAs in CMAs). Similar to the ALE class measure, the ALE/Transit Class measure categorizes CMA DAs into five categories according to their active living friendliness based on four measures at the DA: intersection density, dwelling density, points of interest, and transit stops. The mean value of each of the ALE measures for each cluster group is reported in the Appendix (Table A4, page 20), as well as reference maps that visualize the distribution of the cluster groups in four Canadian urban areas (Figure A1, page 22).

2: Protocol for Deriving the ALE Measures

2.1: Data Preparation

2.1.1: Software

Three Geographic Information System (GIS) software packages were used to derive the Active Living Environment (ALE) measures: ArcMap v10.5.1, QGIS v2.18.13, and PostGIS v2.3.3. ArcMap and QGIS were used for most data preparation, while all final measures were derived using PostGIS. PostGIS is a GIS extension for the PostgreSQL object-relational database management system. While ArcMap is proprietary software, the other two programs are free and open source, and can be downloaded and installed easily. This protocol describes deriving the ALE measures in QGIS and PostGIS. Links for all necessary software are provided in the appendix (Table A3, page 19).

2.1.2: Acquiring Data

Data is taken entirely from free, open-use sources. Statistics Canada data was obtained to derive dissemination areas buffers and dwelling densities for both datasets, and intersection density for the 2006 dataset. Road and footpath features from OpenStreetMap were used for 2016 intersection density, as the added detail of off-road footpaths was found to strengthen the intersection density measure's association with walking rates. The data sources are summarized and download URLs are provided in the appendix (Table A3, page 19).

Data from online portals of municipal governments and transit authorities that operate in Census Metropolitan Areas (CMAs) was used to calculate the transit stop measure. This data was located using TransitFeeds, an online portal which provides links to datasets from various authoritative sources which use the Google Transit Feed Specification (GTFS) data standard. If data was not found via TransitFeeds, searches of municipal and transit agency websites for each CMA were conducted. Although spatial data was found for most transit agencies within CMAs, no spatial transit data was found for four smaller CMAs (see Section 1.2.4, page 5).

2.1.3: Spatial Reference

All geometric and spatial analysis functions were performed in PostGIS, in order to balance the need to derive measures using a Canada-wide projection with the need for spatial and statistical accuracy. The North American Datum 1983 (a.k.a., NAD 83, SRID: 4269) projection was used to calculate areas and distances and the spatial information was stored in the "geometry" column. The World Geodetic System 1984 (a.k.a., WGS 84, SRID: 4326) projection was stored in the "geography" column and was used for topological functions, such as polygon intersection.

2.2: Intersection Density Measure

The intersection density measure captures the directness and connectedness of streets and/or paths through a community. This is done by counting the number of three or more way intersections within a one kilometre buffer of the dissemination area (DA) centroid. Intersection density is derived using the Statistics Canada Road Network File for the 2006 dataset and OpenStreetMap road and footpath features in the 2016 dataset. In the both datasets, limited-access highways (e.g., freeways, 400-Series Ontario Highways, Quebec Autoroutes) and highway entrances and exits are removed from the files before calculating intersection density, as these roads typically restrict active transport. The classification of highways varies slightly, however, between the data sources, so both procedures for removing highway features are described below. For the 2016 measure, off-road footpaths and recreational trails were added to the files. While the process of creating the two measures is similar, there are important methodological and dataset differences, thus the measures are not directly comparable. The differences in methodology are noted in the steps below.

Step 1: Acquiring and preparing the data

1.1: Construct the Dissemination Area buffers.

Download the Dissemination Areas (DAs) from Statistics Canada, choosing the cartographic boundaries and shapefile extension options. Ensure that the DA boundary file year corresponds to the data and/or dataset you wish to use. Open in QGIS.

Use Vector > Geometry Tools > Polygon Centroids to produce polygon centroids for each DA. This may take a few minutes. Save centroid file.

Use Vector > Geoprocessing tools > Fixed Distance Buffers to produce one kilometre buffers of the DA centroids. This also may take a few minutes. Save the buffer file(s).

1.2: Prepare road network file

Download the OpenStreetMap road features or Statistics Canada Road Network File.

If using OpenStreetMap, download OSM “extracts” for each province and territory. Open each zipped folder in QGIS. Save zipped folders.

Open the **gis.osm_roads_free_1.shp** file from each zipped province folder. Merge all the roads into one file using Vector > Data Management Tools > Merge Vector Layers. Save merged file.

Step 2: Clean Road Features

2.1a Remove non-pedestrian road features: ***(Follow if using OpenStreetMap data, consistent with 2016 methodology)***

Filter the merged roads using the filter menu that appears when right clicking on the layer in the layers panel.

The following Query will select the desired road segments. This query retains footpaths and excludes limited-access highways and their entrances and exits. Save filtered layer as new shapefile.

"fclass" = 'trunk' OR "fclass" = 'primary' OR "fclass" = 'primary' OR "fclass" = 'secondary' OR "fclass" = 'tertiary' OR "fclass" = 'unclassified' OR "fclass" = 'residential' OR "fclass" = 'pedestrian' OR "fclass" = 'living_street' OR "fclass" = 'footway' OR "fclass" = 'steps' OR "fclass" = 'path'

2.1b: Remove non-pedestrian road features: ***(Follow using Statistics Canada data, consistent with 2006 methodology)***

Due to inconsistent road classifications in the 2006 Statistics Canada Road Network File, we used a buffer around OSM 'motorway' classified roads to identify limited-access highways.

Obtain the OSM road and footpath using the methodology from the previous step. Filter the OSM street file to select limited-access highway features, using the query: **"fclass"='motorway'**. Save selected features as a separate layer. Create a 10 metre buffer around the motorway features. Save. Open the Statistics Canada Road Network File. Use the erase tool to remove features overlapping with the buffer file from the Road Network File. Save output. The output now contains all of the road features in Canada, with limited-access highways removed.

Step 3: PostGIS Processing

3.1: Import Layers into PostGIS

Open PgAdmin4 (automatically installs when PostgreSQL and the PostGIS extension are downloaded).

Import DA Buffers and streets file(s) (cleaned in step 2) into PostGIS using the Database > Database Manager > PostGIS import tool. Select the "Create spatial index" and the "Convert field names to lowercase" options. Specify the target geometry field SRID as '4269' (NAD 83).

3.2: Preparing PostGIS Data

Create geography column for streets and buffers tables using the ST_Transform function. Specify the geography field SRID as '4326' (WGS 84).

3.3: Intersection counting function.

Create ≥3-way intersections table using the streets table and ST_Intersection function.

Count intersections in buffers using the ST_Intersects function and create a new table

Save the output using COPY. This is your raw intersection measure. Calculate z-scores for each observation for final measure.

2.3: Dwelling Density Measure

This measure captures the average dwelling density of the DAs in the buffer area. This is a common measure of active living environments and strongly correlates with active transportation rates. Note that DAs with null values are removed before running the script to avoid calculation errors.

Step 1: Acquire and prepare data

1.1: Join Dwelling Counts to DAs

Download dwelling counts for DAs from CHASS (see Table 4 for link).

Open dwelling counts in QGIS as table with no geometry. Open DA boundaries *(not buffers)* from previous measure.

Join dwelling count to DA Boundaries by right clicking on DA boundaries layer, selecting properties and then joins. Join based on DA and DAUID. Save new joined layer as separate file. Next remove all DAs that have null values (not zero values!) for dwelling density from the shapefile by using the filter tool to select non-null values. Save the output. This will be the file imported into PostGIS.

1.2: Create DA Buffers

Use DA buffers that have already been created for Intersection Density Measure and are in PostGIS environment already. If you have not done this measure yet, see Section 2.2, Step 1.

Step 2: PostGIS Processing

2.1: Import Layers into PostGIS

Open PgAdmin4 that has been installed with PostGIS extension.

Import DA Buffers (if this has not already been done) and DA boundaries with Dwelling Counts and No Null value DAs into PostGIS using Database > Database Manager > PostGIS. Check the create spatial index box and the convert field names to lowercase box. Make sure to specify the Geom SRID as 4269.

2.2: Prepare PostGIS Data

Create geography column for DA boundries using the ST_Transform function. Specify the geography field SRID as ‘4326’ (WGS 84).

` 2.3: PostGIS Processing

Calculate average dwelling density using ST_Intersection, ST_Intersects, and ST_Area.

Save the output using COPY. This is your raw dwelling density measure. Calculate z-scores for each observation for final measure.

2.4: Points of Interest Measure

This measure captures the number of points of interest (POIs) in a one kilometre buffer around the DA centroids. These points include a wide range of potential walking destinations (e.g., parks, schools, shops, places of business, landmarks, etc.). Almost all OSM POIs (a.k.a., "amenities") are included in our measure; the POIs excluded are alpine huts, caravan sites, wayside crosses and a few other features that likely have no relationship with walking. This specific subset of OSM POIs was chosen after a number of POI subsets were tested. The presence of points of interest is strongly associated with active transportation rates.

Step 1: Acquire and prepare the data

1.1: Acquire POIs from OpenStreetMap

Inside the zipped Canadian Provincial Extracts folders there are two POI shapefiles: "POI" and "POI_a". POI has POIs stored as points. POI a has POIs stored as polygons. Open these files in QGIS.

Merge all the POI points into one file using Vector > Data Management Tools > Merge Vector Layers. Save merged file.

Merge all the POI_a polygons into one file using Vector > Data Management Tools > Merge Vector Layers. Save merged file.

To make the geometry of these files comparable the polygons must be converted to points. Use the Vector > Geometry Tools > Polygon Centroids to produce polygon centroids for each "POI_a" polygon from the merged file. Save centroid file.

Now merge the two Canada wide POIs as points files to form a single file. Save.

1.2: Remove undesired POIs

To remove POIs that are not relevant to active living environments (e.g., utility lines), select features from the merged Canada wide POI layer. Open the filter window by right clicking on the layer. Use the query below. Note the code corresponds to the standard OSM classification.

"code" NOT IN (2423, 2725, 2424, 2951, 2961, 2734, 2422)

1.3: Create DA Buffers

Use DA buffers that have already been created for Intersection Density Measure and are in PostGIS environment already. If you have not done this measure yet, see Section 2.2, Step 1.

Step 2: PostGIS Processing

2.1: Load the data into PostGIS

Open PgAdmin4 that has been installed with PostGIS extension.

Import DA Buffers (if this has not already been done) and POIs into PostGIS using Database > Database Manager > PostGIS. Check the create spatial index box and the convert field names to lowercase box. Make sure to specify the Geom SRID as 4269.

2.2: Prepare PostGIS Data

Create geography column for tables using the ST_Transform function. Specify the geography field SRID as '4326' (WGS 84).

2.3: Count the POIs in the buffers

Count POIs and place output in table. Use ST_Intersects.

Save the output using COPY. This is your POI count.

2.5: Transit Measure

The transit measure is meant to capture the presence of public transit stops in the community. The process involved in creating it is almost identical to the creation of the POI measure. Note that this measure only covers DAs within Census Metropolitan Areas (CMAs). The websites of transit agencies and/or municipalities from which the data was obtained is listed in the appendix (Table A5, page 21).

Step 1: Acquire and prepare the data.

1.1: Collect and prepare GTFS static data.

Collect GTFS static data from all Canadian CMAs. This will take a few hours. See Table 2 for links to sources. Then open the GTFS files named "stops" in QGIS.

Merge all the GTFS stops files into one file using Vector > Data Management Tools > Merge Vector Layers. Save merged file.

1.2: Create DA Buffers

Use DA buffers that have already been created for Intersection Density Measure and are in PostGIS environment already. If you have not done this measure yet, see Section 2.2, Step 1.

1.3 Refining the calculation area to include only CMAs with transit data

Download 2016 Canadian CMA (Census Metropolitan Area) Boundary file from Statistics Canada. Open in QGIS. Filter file to select only type B CMAs (classification for all CMAs not including CAs). Save filtered group as Canadian CMAs. Edit this file to remove any CMAs with no transit available data. Save as Transit CMAs. These are the areas where the transit measure will be calculated.

Use Vector > Research Tools > Select by location for DA buffers when the buffer centroid falls within the area of Transit CMAs. Save. This is the DA buffer file that will be imported into postGIS along with the transit stops data.

Step 2: PostGIS Processing

2.1: Load the data into PostGIS

Open PgAdmin4 that has been installed with PostGIS extension.

Import DA Buffers (if this has not already been done) and Transit Stops into PostGIS using Database > Database Manager > PostGIS. Check the create spatial index box and the convert field names to lowercase box. Make sure to specify the Geom SRID as 4269.

2.2: Prepare PostGIS Data

Create geography column for table(s) without one.

2.3: Count the transit stops and stations in the buffers.

Count transit stops using the ST_Intersects function.

Save the output using COPY. This is your Transit Stop count. Calculate z-scores for final measure.

3: Appendix

Table A1: Summary Statistics of Derived ALE Measures

Variable	Source	N	Mean value	Standard deviation	Minimum value	Maximum value
2006 Dataset						
ID	Statistics Canada (2006 Road Network File)	54,624	26.2	20.8	0	164.7
DD	Statistics Canada (Census 2006)	54,214	868.2	1,129.6	0	11,506.4
2016 Dataset						
ID	OpenStreetMap road and footpath features	56,589	48.8	54.6	0	1081.8
DD	Statistics Canada (2016 Census)	56,089	941.7	1,256.6	0	14,747.6
POI	OpenStreetMap amenity features	56,589	55.4	114.8	0	2,119
TRANSIT	Multiple sources	35,338	46.8	32.72	0	252

Table A2: Dissemination areas with null dwelling density

DAs with dwelling density values in 2006 (n=410)

10010687	24140094	24870086	24830055	24990182	35540073	47170163	59331545	61060078
10010693	24160035	24880047	24830056	24990183	35540142	47170188	59331547	61070025
10010732	24210038	24880096	24840037	24990186	35560186	47170206	59331548	62040033
10020080	24210040	24890074	24840056	24990187	35560189	47170208	59331572	62040035
10020121	24220036	24890075	24850081	24990188	35560202	47170257	59331575	62040040
10030056	24340074	24890143	24850082	24990189	35560278	47180156	59331576	62040043
10030061	24340075	24890145	24850091	24990191	35560280	47180158	59331577	62040044
10030065	24340163	24140094	24870086	24990194	35560337	47180159	59331578	62050013
10050091	24340165	24160035	24880047	24990196	35570307	47180161	59331580	62080015
10060074	24350026	24210038	24880096	24990200	35580363	47180173	59331581	62080020
10070491	24350055	24210040	24890074	24990201	35580365	47180181	59331584	62080021
10070500	24350056	24220036	24890075	24990204	35580366	47180211	59331585	
10070501	24350057	24340074	24890143	24990207	35580369	47180225	59331586	
10070564	24410067	24340075	24890145	24990233	35580371	48030115	59331589	
10080185	24620101	24340163	24890146	24990235	35580396	48030171	59331590	
10090078	24620102	24340165	24910096	35010176	35590070	48050162	59331601	
10090100	24620103	24350026	24910103	35010177	35590102	48050221	59331602	
10100061	24620104	24350055	24920051	35010379	35600206	48050222	59331603	
10100063	24620108	24350056	24930150	35010385	35600227	48061856	59331604	
10110001	24620109	24350057	24930151	35010386	35600241	48061900	59331605	
10110005	24620110	24410067	24930152	35010388	35600244	48061901	59331606	
12020086	24620189	24620101	24930154	35010389	35600254	48100200	59331607	
12030054	24620190	24620102	24940313	35010395	35600266	48111161	59331612	
12090845	24620191	24620103	24940333	35010396	35600295	48111989	59331613	
12120122	24620192	24620104	24940335	35010397	35600301	48112107	59331621	
12130034	24670285	24620108	24950049	35010398	35600304	48120241	59331624	
13060066	24690080	24620109	24960045	35061391	35600305	48120250	59331625	
13080107	24690081	24620110	24970068	35120375	35600307	48130200	59390128	
13090106	24690083	24620189	24970070	35120388	35600309	48130201	59390140	
13090170	24690085	24620190	24970074	35190001	35600311	48140055	59390198	
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24030039	24790082	24690090	24990140	35380197	46180092	48170240	59490101	
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24060068	24790088	24790081	24990156	35440255	46220090	48170349	59490108	
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24070074	24790137	24790084	24990159	35480201	46220153	59010134	59550129	
24070083	24830051	24790085	24990160	35480228	47030110	59153616	59550231	
24070088	24830052	24790086	24990161	35490212	47050217	59190154	60010122	
24070089	24830053	24790087	24990162	35490214	47100164	59190305	60010123	
24070092	24830054	24790088	24990163	35510069	47100223	59190306	60010125	
24080080	24830055	24790103	24990164	35510078	47110581	59190308	60010127	
24090071	24830056	24790136	24990166	35510097	47150391	59210291	60010131	
24090072	24840037	24790137	24990167	35510101	47160253	59230148	60010132	
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24110023	24850081	24830052	24990177	35510104	47160285	59310127	60010191	
24140065	24850082	24830053	24990178	35520089	47160287	59331493	60010193	
24140093	24850091	24830054	24990180	35530347	47170152	59331519	61060075	

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DAs with dwelling density values in 2016 (n=500)

10010693	24220036	24910103	24990253	35600265	48170328	59550121	60010124	62040032
10010732	24340074	24920051	35010379	35600304	48170350	59550122	60010125	62040035
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12120122	24620192	24990140	35290332	47060694	59390191	59550214	61010034	62040069
12130034	24670285	24990141	35290333	47100164	59390192	59550215	61010035	62040070
13060066	24690081	24990143	35360458	47100223	59390193	59550217	61010037	62040071
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13080093	24690085	24990149	35390749	47160253	59410371	59550219	61010046	62050012
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13090170	24780137	24990156	35390754	47160285	59470062	59550221	61010048	62050014
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13140184	24790086	24990162	35490212	47170208	59510222	59550227	61030116	62080023
13150209	24790087	24990163	35490214	47170257	59530200	59570209	61030140	62080024
24010018	24790088	24990164	35510097	47180159	59530201	59570210	61040070	62080025
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24020068	24790137	24990167	35510103	47180181	59530203	59570218	61040073	62080027
24030039	24790160	24990172	35510104	47180211	59530204	59570219	61040081	
24030042	24790162	24990177	35520082	47180225	59530205	59590013	61040082	
24040057	24830051	24990178	35520089	47180252	59530206	59590014	61040084	
24050035	24830052	24990180	35530347	48030171	59530224	59590015	61040124	
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24060068	24830054	24990183	35560186	48080365	59530228	59590017	61040128	
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24090071	24850082	24990194	35570373	48150088	59530237	59590023	61050078	
24090072	24870043	24990196	35580366	48150089	59530238	59590024	61050080	
24100153	24870086	24990198	35580369	48150090	59530239	59590025	61050118	
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24140065	24890074	24990204	35590102	48160102	59550115	60010118	61050130	
24140093	24890075	24990207	35590124	48160109	59550116	60010119	61050131	
24140094	24890145	24990233	35600221	48160188	59550117	60010120	61050142	
24160035	24890146	24990235	35600241	48170229	59550118	60010121	61060141	
24210038	24890170	24990248	35600244	48170252	59550119	60010122	61060163	
24210040	24910096	24990252	35600254	48170307	59550120	60010123	61060164	

Table A3: Dataset and software download links

Dataset or software	*Source*	*Link*	*File format*	*Used to derive:*
Datasets used for the creation of measures				
Census housing data	Statistics Canada	http://dc1.chass.utoronto.ca/census/	Comma separated values (.csv)	Dwelling density
Census Metropolitan Areas	Statistics Canada	http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm	Shapefile (.shp)	CMAs used for transit measure
Dissemination area (DA) boundary files	Statistics Canada	**2006**: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2006-eng.cfm **2016**: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm	Shapefile (.shp)	DA circular buffers
OSM Provincial Extracts	OpenStreetMap	http://download.geofabrik.de/north-america/canada.html	Shapefile (.shp)	Intersection density (2016), POI measure
Road Network File	Statistics Canada	http://www12.statcan.gc.ca/census-recensement/2011/geo/rnf-frr/index-eng.cfm	Shapefile (.shp)	Intersection density (2006)
Transit Stops	Municipal or transit agency websites	https://transitfeeds.com/l/32-canada	Comma separated values (.csv)	Transit measure
Software download links				
QGIS	QGIS	http://www.qgis.org/en/site/forusers/download.html	-	Several measures
PostgreSQL & PostGIS	PostgreSQL	https://www.PostgreSQL.org/download/	-	Several measures
Other useful datasets				
PCCF+	Statistics Canada	http://www5.statcan.gc.ca/olc-cel/olc.action?ObjId=82F0086X&ObjType=2&lang=en&limit=0	SAS control program and datasets	For linkage to Postal Codes

Table A4: Mean Values of Each ALE Measure for by Class Group

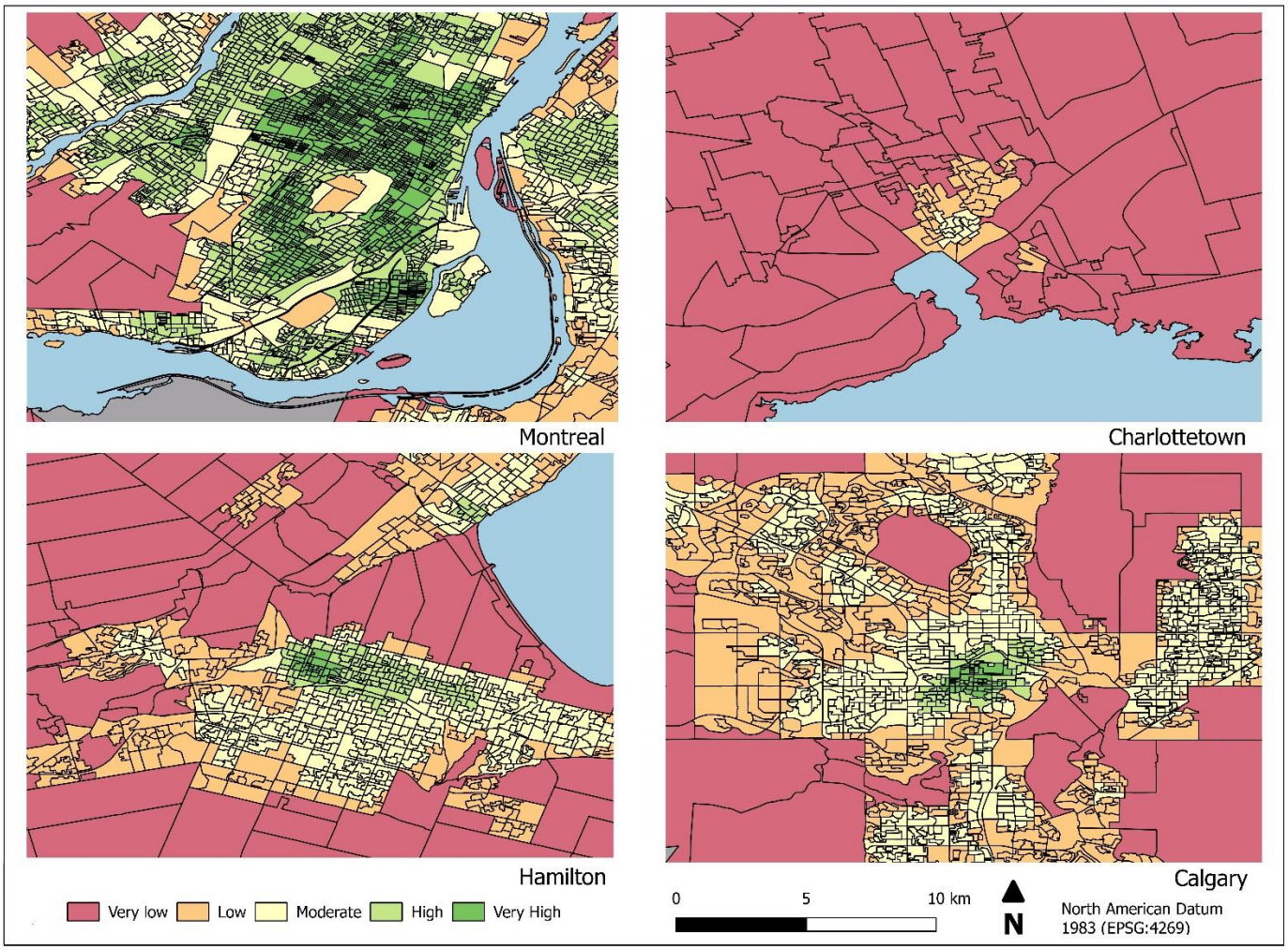
Group	*Intersection density*	*Dwelling density*	*Points of interest*	*Transit stops*	*ALE-Index*
2006 ALE Class					
1 (very low)	5.6	61.7	-	-	-1.7
2 (low)	29.5	581.5	-	-	-0.1
3 (moderate)	40.0	1,114.1	-	-	0.9
4 (high)	47.9	2,060.5	-	-	2.1
5 (very high)	60.4	4,352.4	-	-	4.7
2016 ALE Class					
1 (very low)	7.4	71.1	5.2	-	-1.9
2 (low)	49.0	661.4	38.4	-	-0.4
3 (moderate)	75.1	1,272.3	67.0	-	0.8
4 (high)	100.1	2,548.5	125.8	-	2.8
5 (very high)	173.5	5,366.5	408.1	-	8.9
2016 ALE/Transit Class					
1 (very low)	15.2	170.6	11.6	8.2	-1.6
2 (low)	57.0	789.1	46.3	37.9	-0.1
3 (moderate)	78.9	1,399.2	73.3	57.5	1.1
4 (high)	103.9	2,718.6	135.1	77.2	3.1
5 (very high)	178.4	5,534.1	429.1	103.4	9.3

Table A5: Sources and download dates for transit measure stops data

Census Metropolitan Area (CMA)	Download source	Download date
Abbotsford - Mission	BC Transit*	November 1, 2017
Barrie	Barrie Transit*	November 1, 2017
Belleville	No Data Available	N/A
Brantford	Brantford Open Data Portal	December 19, 2017
Calgary	Calgary Transit*	November 1, 2017
Edmonton	Edmonton Transit System*, Strathcona County Transit*, St Albert Transit*	November 1, 2017
Greater Sudbury	Greater Sudbury Transit*	November 1, 2017
Guelph	Guelph Transit*	November 1, 2017
Halifax	MetroTransit*	November 1, 2017
Hamilton	Hamilton Street Railway, BurlingtonTransit*	November 1, 2017
Kelowna	BC Transit*	November 1, 2017
Kingston	City of Kingston*	November 1, 2017
Kitchener–Cambridge–Waterloo	Grand River Transit*	November 1, 2017
Lethbridge	Lethbridge Open Data Portal	December 11, 2017
London	London Transit Commision*	November 1, 2017
Moncton	Codiac Transpo*	November 1, 2017
Montreal	AMT*, STM*, STL*	November 1, 2017
Oshawa	Durham Region Transit*	November 1, 2017
Ottawa–Gatineau	OC Transpo*, STO*	November 1, 2017
Peterborough	No Data Available	N/A
Quebec City	RTC*, STLévis Données Ouverts	November 1, 2017
Regina	The City of Regina*	November 1, 2017
Saguenay	No Data Available	N/A
Saint John	The City of Saint John Open Data Catalogue	November 21, 2017
Saskatoon	City of Saskatoon*	November 1, 2017
Sherbrooke	STS*	November 1, 2017
St. Catharines–Niagara	Regional Municipality of Niagara*	November 1, 2017
St. John's	MetroBus Transit*	November 1, 2017
Thunder Bay	Thunder Bay Transit*	November 1, 2017
Toronto	TTC*, GoTransit*, MiWay*, Brampton Transit*, York Region*, Oakville Transit*	November 1, 2017
Trois-Rivières	No Data Available	N/A
Vancouver	TransLink*	November 1, 2017
Victoria	BC Transit*	November 1, 2017
Windsor	City of Windsor*	November 1, 2017
Winnipeg	Winnipeg Transit*	November 1, 2017

Asterisk (*) indicates that data source was located via the TransitFeeds portal. All other data was obtained from the official websites of the listed agencies

Figure A1: Reference Maps of Four Canadian Urban Areas by their 2016 ALE Class Value



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