
Contiguously Settled Areas: Boundaries and User Documentation

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1 Summary

This product contains contiguously settled area (CSA) boundaries for a subset of Canadian population centres¹ for 2010 and 2020.

The CSA boundaries are derived from land cover data and represent the geographic extent of settled areas based on their physical footprint on the landscape. The boundaries can be used for reference, mapping and spatial analysis of settled areas and urban ecosystems.

The CSA boundaries are created and maintained under the umbrella of the Census of Environment,² and will support Statistics Canada's ecosystem accounting efforts following the System of Environmental-Economic Accounting — Ecosystem Accounting (SEEA EA) framework.³ The primary purpose of the CSA boundaries is to represent the extent of the contiguous urban footprint and allow for the measurement of settled area expansion over time. They will also contribute to the urban and industrial ecosystem class⁴ in Statistics Canada's ecosystem accounting efforts. The boundaries will be used for other types of urban ecosystem analyses, including measures of urban ecosystem condition and services. The CSA boundaries may also be used for urban thematic accounts or to inform where users of ecosystem services are located.

Moving forward, CSA boundaries will be updated on an ongoing basis.

2 User documentation

2.1 Background

Settled areas represent the areas where people live and work and are part of the intensive land-use biome class of the International Union for the Conservation of Nature's Global Ecosystem Typology, which is the proposed reference classification for classifying ecosystems following the SEEA EA. While they account for a small percentage of the overall land area in Canada, settled areas represent the places where natural ecosystems are the most modified and where the demand for ecosystem services is most concentrated.

The expansion of settled areas has implications for the surrounding environment and ecosystems. While the permanent conversion of land to settled areas provides benefits to humans in terms of providing places to live and work, there are environmental trade-offs, including the loss or fragmentation of forests and the loss of high-quality agricultural land. Habitat loss, often caused by urbanization, is the most common threat facing species-at-risk (Ventor et al., 2006; McCune et al., 2013).

To measure urban expansion and understand how the physical form of the settled area is changing, it is first necessary to delineate the footprint of settled areas. Because administrative and statistical boundaries representing settled areas do not necessarily represent urban morphology or change in morphology over time (European Environment Agency, 2011), they are inappropriate for some types of analysis such as measuring settled area expansion.

Census metropolitan areas, census subdivisions and population centres are some examples of statistical geographies representing metropolitan areas, cities, towns, or densely populated areas in Canada. These boundaries, while valuable for many purposes, often overbound the physically settled area; that is, they include other land covers and uses, such as forest and agriculture, that occur on the periphery of the main settled area. Conversely, administrative and statistical boundaries may also underbound the settled area, by not capturing

1. A population centre has a population of at least 1,000 people and a population density of 400 people or more per square kilometre, based on population counts from the current Census of Population [Dictionary, Census of Population, 2021 – Population centre \(POPCTR\)](#).

2. [Census of Environment: A roadmap to environmental and economic sustainability](#)

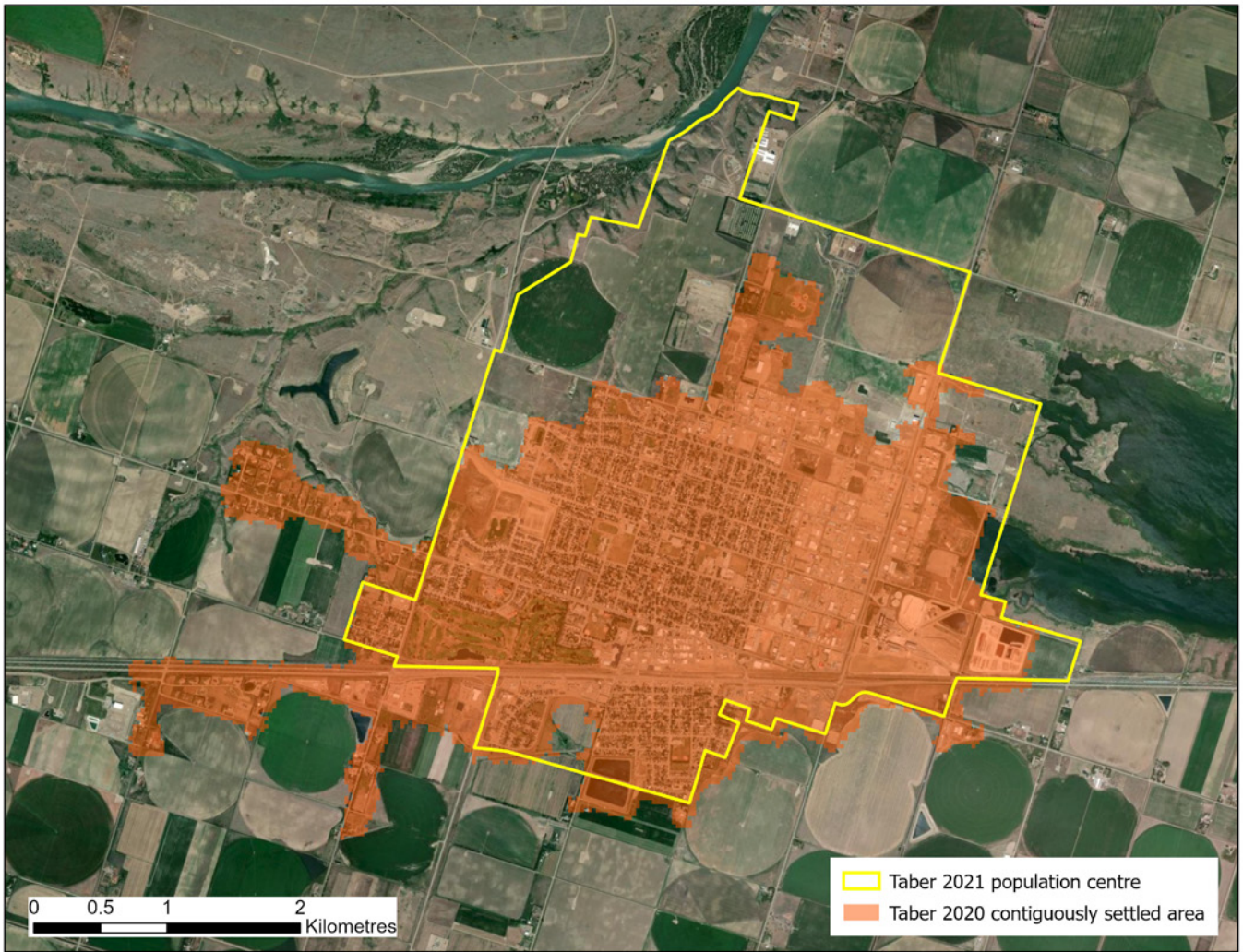
3. [Ecosystem Accounting | System of Environmental Economic Accounting](#)

4. The urban and industrial ecosystem class is an ecosystem functional group under the intensive land-use biome of the International Union for the Conservation of Nature's Global Ecosystem Typology. Currently, CSA boundaries have not been created for population centres with fewer than 5,000 people unless they fall within a census metropolitan area or census agglomeration. Over time, CSA boundaries may be created for all population centres.

settled areas that are contiguous with the core urban area. Further, their relative size and the proportion of settled area within these boundaries can vary from region to region, making comparisons complicated and possibly misleading.

An example of overbounding and underbounding of a population centre is shown in Figure 1, while a comparison of the proportion of settled and non-settled areas in a selection of census metropolitan areas or census agglomerations is shown in Table 1. These issues make it problematic to use administrative and statistical boundaries to measure settlement form and to conduct some types of analysis on urban ecosystems.

Figure 1
Population centre and contiguously settled area of Taber, Alberta



Note: In the population centre boundaries, overbounding is present in the north, where agricultural fields are included within the boundaries, and underbounding is present in the southwest, where contiguous settled development is not included. Contiguously settled area boundaries more accurately reflect the morphological form of the settled area.

Sources: Statistics Canada. (2022). 2021 Census Boundary files, Catalogue no. 92-166-X.
Retrieved June 6, 2023 from <https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-limit/limites/index2021-eng.cfm?year=21>; Esri World Imagery, Maxar (June 22, 2021).

Table 1**Area and percentage of settled versus non-settled land in selected census metropolitan areas or census agglomerations**

Census metropolitan area / census agglomeration name	Total area	2020 Settled area	2020 Non-settled area	2020 Settled area	2020 Non-settled area
		km ²		percent	
Halifax	7,774	557	7,217	7	93
Trois-Rivières	1,052	171	881	16	84
Toronto	6,273	2,466	3,807	39	61
Winnipeg	5,418	832	4,586	15	85
Okotoks	39	20	19	52	48
Wood Buffalo	66,534	965	65,569	1	99
Terrace	9,923	57	9,867	1	99

Source: Statistics Canada, 2022, [2021 Census – Boundary Files](https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-limit/limit2021-eng.cfm?year=21), Catalogue no. 98-26-0002. Retrieved June 1, 2023 from <https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-limit/limit2021-eng.cfm?year=21>

The contiguously settled area boundaries aim to represent the morphology of settled areas as their physical footprint on the landscape. Data derived from Earth observation (EO) are useful for delineating settled area footprints because they are detailed, comprehensive, up-to-date, and not subject to the limitations associated with administrative or statistical boundaries (Wang et al., 2017; Neptis Foundation, 2010). CSA boundaries use EO-derived land cover data to delineate settled areas morphologically, including contiguous development outside the urban core while excluding natural and semi-natural land covers on the periphery of the main settled area. An example of a CSA is shown in Figure 1.

Since the CSA approach creates representations of settled areas that are based on morphology rather than on administrative or statistical spatial definitions, it is relatively consistent over space and allows for comparisons across regions. Similar approaches for measuring growth in settled areas have been used by others including national statistical offices, the European Environment Agency and non-governmental organizations. The United Kingdom's Office for National Statistics, for example, uses "Built Up Areas" created by the Ordnance Survey as a geographical area for which census data are tabulated and to define the urban extent for natural capital accounts of urban areas (Ordnance Survey, 2023; Office for National Statistics, 2019). The European Environment Agency has defined "Urban Morphological Zones" based on built-up land cover, from which urban growth is measured over time (European Environment Agency, 2011), and the Neptis Foundation has used land cover to create an urban land base to assess urban growth patterns in Toronto, Calgary and Vancouver (Neptis Foundation, 2010).

2.2 Data sources and methodology

Contiguously settled area boundaries were produced for population centres with a 2021 population greater than 5,000 people or for those that fell within a census metropolitan area or census agglomeration (Statistics Canada, 2022a).

The CSA boundaries are derived from Agriculture and Agri-Food Canada's (AAFC) 2010 and 2020 *Semi-decadal Land Use Time Series* data products (AAFC, 2021). These data have a spatial resolution of 30 metres and are based on high quality spatial datasets, many of which are derived from Earth observation. For each CSA year, the land use product for the corresponding year was used as the base data (i.e., the 2010 *Semi-decadal Land Use* 2010 product was used as the base data for the 2010 CSA boundaries). Because the *Semi-decadal Land Use Time Series* does not have coverage for areas north of 60° North latitude, CSA boundaries were not created for the population centres of Iqaluit, Whitehorse and Yellowknife although they met the criteria of having a population greater than 5,000 people.

Settled areas were identified by extracting pixels from the *Semi-decadal Land Use Time Series* that were classified as one of the following classes: settlement, high reflectance settlement, settlement forest, roads, vegetated settlement or very high reflectance settlement. Examples of land covers and uses included in these classes include residential, commercial, industrial or transportation areas; bare pavement; vegetated areas associated with settlements, including parks, lawns, and golf courses; and settlement areas mostly covered by tree canopy. A more detailed description of the settlement classes is provided in Appendix 1.

The extracted settlement pixels were collapsed into a single settlement class, which was then converted to vector format. Shared boundaries were dissolved and polygons less than 3,600 square metres (four pixels) were removed from further analysis.⁵

The 2021 population centre (Statistics Canada, 2022b) served as the starting point for identifying the core area of the CSA. For each population centre, the settled area intersecting that population centre was selected and edited to create a CSA boundary according to a set of delineation guidelines, explained below. Visuals supporting the guidelines are provided in the appendices.

Delineation guidelines for contiguously settled area boundaries

1. Settled areas that are not contiguous with the core settled area are generally removed. However, in the following situations, non-contiguous areas are included in the CSA:
 - a. A settled area that is separated into multiple parts because of the physical geography of the area, such as a settled area that is divided by a river (see Appendix 2) or located along the shores of a body of water.
 - b. Settled areas that are non-contiguous but that are located within the population centre boundaries and have a population of at least 1,000 people.⁶
 - c. If a population centre has a compound name, which occurs when a population centre is made up of two or more principal census subdivisions (e.g., St. Catharines–Niagara Falls), the non-contiguous settled areas of each principal census subdivision are retained.
 - d. Other exceptions, such as relatively large settled area polygons that are separated from the core settled area by a very short distance (e.g., a width of one or two pixels), are made on a case-by-case basis. Ancillary datasets (including population centre boundaries, population counts, roads, water bodies and Google Earth imagery) are used to support these decisions.
2. The CSA boundaries are truncated when the settled area is reduced to a width of three or fewer pixels (see Appendix 3). Areas narrower than this width are considered as transportation connectors between settled areas and are excluded from the CSA.
 - a. Before applying the three-pixel rule, natural and semi-natural land covers that are less than 10 hectares and surrounded by settled areas are filled in.⁷ This is to account for small fragments of natural and semi-natural land such as those formed by highway interchanges. These areas are retained in the CSA even if the settled area that encloses them is narrower than three pixels in width (see guideline 3).
 - b. Some exceptions to this guideline, such as when a relatively large area would have been included in the 2020 CSA but not the 2010 CSA because of a difference in classification of a small number of pixels, are made on a case-by-case basis. Supplementary datasets, such as census population counts and high-resolution imagery, are used to support these decisions.
3. Natural and semi-natural land covers enclosed by settled areas are included within the CSA boundary. As a result, the CSA includes land covers other than built-up areas, such as forest, water, cropland and grassland, when these areas are predominantly surrounded by settled areas at least three pixels in width (see Appendix 4).
4. If the CSAs of two or more population centres are attached (i.e., the settlement corridor linking them is wider than three pixels), one CSA is created for the entire area (Appendix 5). These areas are called “agglomerated CSAs” and are flagged in the attribute table.

5. When using raster data sources, a minimum mapping unit is often applied to identify the smallest feature that can be mapped. Below this size, features will not be considered in the analysis, as they cannot be reliably identified. This practice helps reduce data variability from uncertainty, improve accuracy and reflect the limitations of the EO-derived data. See Knight, J.F. & Lunetta, R.S. (2003). An experimental assessment of minimum mapping unit size. *IEEE Transactions on Geoscience and Remote Sensing*, 41(9), 2132–2134. Retrieved June 6, 2023 from <https://doi.org/10.1109/TGRS.2003.816587>.

6. This rule is to account for settled areas that meet the criteria of a population centre, but do not form a separate population centre due to their proximity to an existing one. See <https://www12.statcan.gc.ca/census-recensement/2021/ref/dict/az/Definition-eng.cfm?ID=geo049a> for further details on [population centre delineation rules](#).

7. A threshold of 10 hectares was selected based on research on minimum patch sizes required to support biodiversity in urban areas. See Joscha, B., Veith, M. & Hochkirch, A. (2010). Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation. *Ecology Letters*, 13(6). Retrieved March 2, 2022 from <https://doi.org/10.1111/ele.12427>; The Environmental Law Institute. (2003). *Conservation thresholds for land use planners*. Retrieved March 2, 2022 from <https://www.eli.org/sites/default/files/eli-pubs/d13-04.pdf>; Drinnan, I. N. (2005). The search for fragmentation thresholds in a Southern Sydney Suburb. *Biological Conservation*, 124(3). Retrieved March 2, 2022 from <https://doi.org/10.1016/j.biocon.2005.01.040>.

2.3 Using the contiguously settled area boundaries to measure the expansion of settled areas

Urban growth can occur primarily in two ways: densification and expansion (Mohajeri et al., 2015). Densification can refer to new built-up areas within the existing boundaries of a settlement or the increasing density of population or buildings within a settlement, while expansion refers to the addition of new settled areas at the margins of the present boundaries of a settlement (Mohajeri et al., 2015). Using the CSAs as the boundaries of a settlement at one time point, it is possible to measure urban expansion beyond the boundaries over time.

CSA boundaries can be used to measure settled area expansion in two ways: growth of the CSA area over time, which is indicative of the growth of the settled area as an ecosystem, and growth in land cover converted to built-up in the area surrounding the CSA.

- Growth in the CSA can be measured by subtracting the area of the CSA at an initial time point from the area of the corresponding CSA at a later point. It is important to note that increases in the area of a CSA for a given settled area over time do not necessarily imply a change in land cover for the entire area of change. They may also be because of natural and semi-natural land cover classes becoming enclosed by settled area growth or areas meeting the CSA delineation guidelines that did not meet the rules at an earlier time point (e.g., a settled area becoming contiguous with the core settled area that was previously non-contiguous).
- The CSA can also be used as the boundary from which to measure land cover conversions to built-up (defined as one of the following classes: settlement, high reflectance settlement, settlement forest, roads, vegetated settlement or very high reflectance settlement from the AAFC's *Semi-decadal Land Use Time Series*). Buffers can be created around each CSA and growth areas calculated within these buffers by identifying new areas classified as built-up.

The two measures of settled area expansion—growth in the CSA and growth in the built-up area within a buffer around the CSA—are available from Table 38-10-0163-01.⁸

2.4 Attribute descriptions

A list of attributes of the CSA boundary files and their descriptions is shown in Table 2.

CSA unique identifiers (CSAUID) are unique four-digit codes that are assigned sequentially based on alphabetical order of the associated population centre name upon creation of a CSA. These codes remain consistent between years. If a CSA becomes agglomerated with another CSA over time, the CSAUID of the population centre with the larger population is retained, while that of the other is retired.

Table 2
Contiguously settled area dataset attributes

Attribute name	Data type	Description
C_CSAUID	Character (6)	Uniquely identifies a contiguously settled area in the current time period.
CSA_agglom	Character (1)	Identifies whether the contiguously settled area is agglomerated.
PCUID	Character (4)	2021 population centre ID associated with the contiguously settled area. If a CSA is agglomerated, the PCUID is that of the associated population centre with the largest population.
PCNAME	Character (100)	2021 population centre name associated with the contiguously settled area. If a CSA is agglomerated, the PCNAME is that of the associated population centre with the largest population.
PRUID	Character (2)	Uniquely identifies a province or territory that the contiguously settled area is in.
PRNAME	Character (100)	Name of the province or territory that the contiguously settled area is in.
XPRCODE	Character (2)	Uniquely identifies a province or territory. Used when a CSA has parts in two provinces.
P_CSAUID	Character (6)	Uniquely identifies a contiguously settled area in the previous time period.
DGUID	Character (15)	Dissemination geography unique identifier for a contiguously settled area.

8. [Extent and growth of contiguously settled areas](https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810016301) (Table 38-10-0163-01), Statistics Canada. <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810016301>

2.5 Notes to users

1. The CSA boundaries identified in this product do not reflect all settled areas in Canada. CSAs were created for 540 of 1,026 population centres, and do not include settled areas that are non-contiguous with these areas.
2. Increases in the area of a CSA for a given settled area over time do not necessarily imply a change in land cover for the entire area of change. Increases to the CSA area over time involve the conversion of land cover to built-up area at the periphery of a CSA but may also result from two other factors. First, natural and semi-natural land cover classes (such as forest, water, cropland or grassland) that were on the periphery of the CSA can become enclosed by settled area growth over time. Second, an existing built-up area that was not initially contiguous may meet the CSA delineation guidelines at a later time point. For example, a settled area connected to the core CSA by a narrow transportation corridor at an earlier time point may become connected by a wider corridor of more than three pixels at a later point, becoming part of the CSA.
3. Over time, non-agglomerated CSAs may become agglomerated CSAs as settled areas increase and become merged with adjacent settled areas.

2.6 Maintenance

Moving forward, CSA boundaries will be maintained on an ongoing basis.

2.7 Spatial reference system

The projection information is as follows:

Projected Coordinate System: NAD 1983 Albers

Projection: Albers

False Easting: 6200000.00000000

False Northing: 3000000.00000000

Central Meridian: -91.86666667

Standard Parallel 1: 49.00000000

Standard Parallel 2: 77.00000000

Latitude of Origin: 63.39067500

Linear Unit: Meter

Geographic Coordinate System: GCS North American 1983

Datum: D North American 1983

Prime Meridian: Greenwich

Angular Unit: Degree

2.8 Limitations

The CSA boundaries are based on AAFC's *Semi-decadal Land Use Time Series*, which is derived from EO data. Uncertainty is inherent in EO-derived data and some level of misclassification of data is expected although new technologies and methods have resulted in improved data quality over time. Uncertainty in EO-derived data arises from a variety of factors, including scale dependency, classification errors and limitations, and positional and temporal accuracy. Because of these limitations, caution should be used when considering change of CSA boundaries over time, as change in land cover datasets at different time points can result from both real change and classification errors. Users are encouraged to examine the data for their area of interest to better understand its fitness for purpose. Because the *Semi-decadal Land Use Time Series* data on which the CSA boundaries are based are created from the integration of multiple spatial datasets representing different temporal periods, the CSA boundary files should be considered as circa the year they are named.

3 References

- Agriculture and Agri-Food Canada (AAFC). (2021). [AAFC Semi-decadal land use time series](https://open.canada.ca/data/dataset/fa84a70f-03ad-4946-b0f8-a3b481dd5248). [Data set]. Retrieved October 1, 2021 from <https://open.canada.ca/data/dataset/fa84a70f-03ad-4946-b0f8-a3b481dd5248>
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4 Appendices

Appendix 1

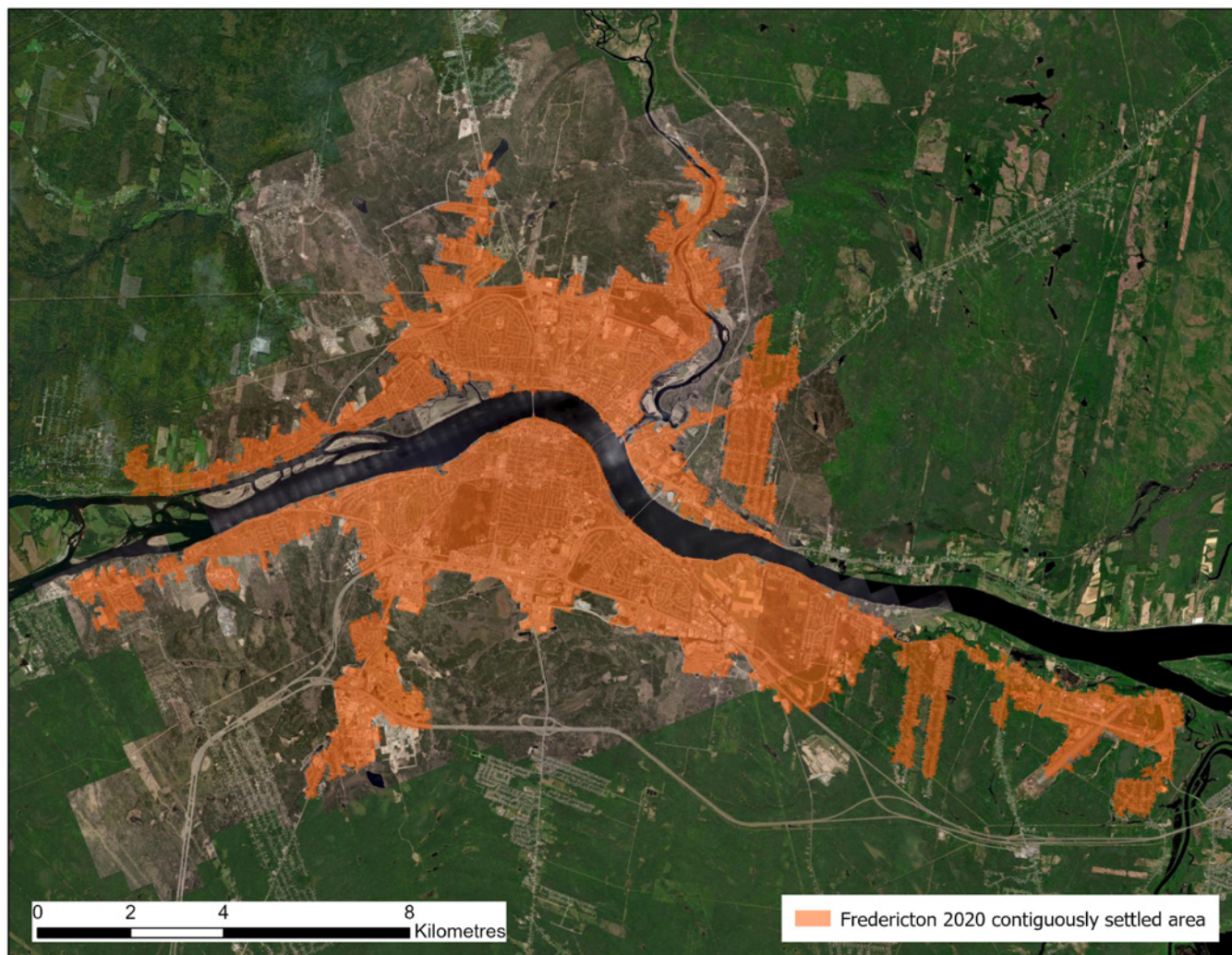
Descriptions of the settlement and road classes from the Semi-decadal Land Use product

Class code	Class name	Class description
21	Settlement	Urban and rural residential, commercial, industrial, transportation or other built infrastructure use
22	High reflectance settlement	Settlement areas with high spectral reflectance such as pavement, buildings, or other surfaces with little to no observable vegetation
24	Settlement forest	Settlement areas mostly or entirely covered by tree canopy
25	Roads	Primary, secondary and tertiary roads
28	Vegetated settlement	Settlement areas with observable vegetation such as lawns, golf courses, and settlement areas with 30-50% tree canopy
29	Very high reflectance settlement	Settlement areas with very high spectral reflectance such as pavement, buildings, or other surfaces with no observable vegetation
81	Newly-detected settlement	Settlement (21) that was first identified as a Settlement land use less than 10 years prior
82	Newly-detected high reflectance settlement	High Reflectance Settlement (22) that was first identified as a Settlement land use less than 10 years prior
84	Newly-detected settlement forest	Settlement Forest (24) that was first identified as a Settlement land use less than 10 years prior
88	Newly-detected vegetated settlement	Vegetated Settlement (28) that was first identified as a Settlement land use less than 10 years prior
89	Newly-detected very high reflectance settlement	Very High Reflectance Settlement (29) that was first identified as a Settlement land use less than 10 years prior

Source: Agriculture and Agri-Food Canada (AAFC). (2023). [ISO 19131 AAFC Land Use Time Series – Data Product Specifications](https://agriculture.canada.ca/atlas/data_donnees/landuse/supportdocument_documentdesupport/en/ISO_19131_AAFC_Semi_Decadal_Land_Use_Time_Series_Data_Product_Specification.pdf). Retrieved July 24, 2023 from https://agriculture.canada.ca/atlas/data_donnees/landuse/supportdocument_documentdesupport/en/ISO_19131_AAFC_Semi_Decadal_Land_Use_Time_Series_Data_Product_Specification.pdf

Appendix 2

Example of a settled area divided by a river

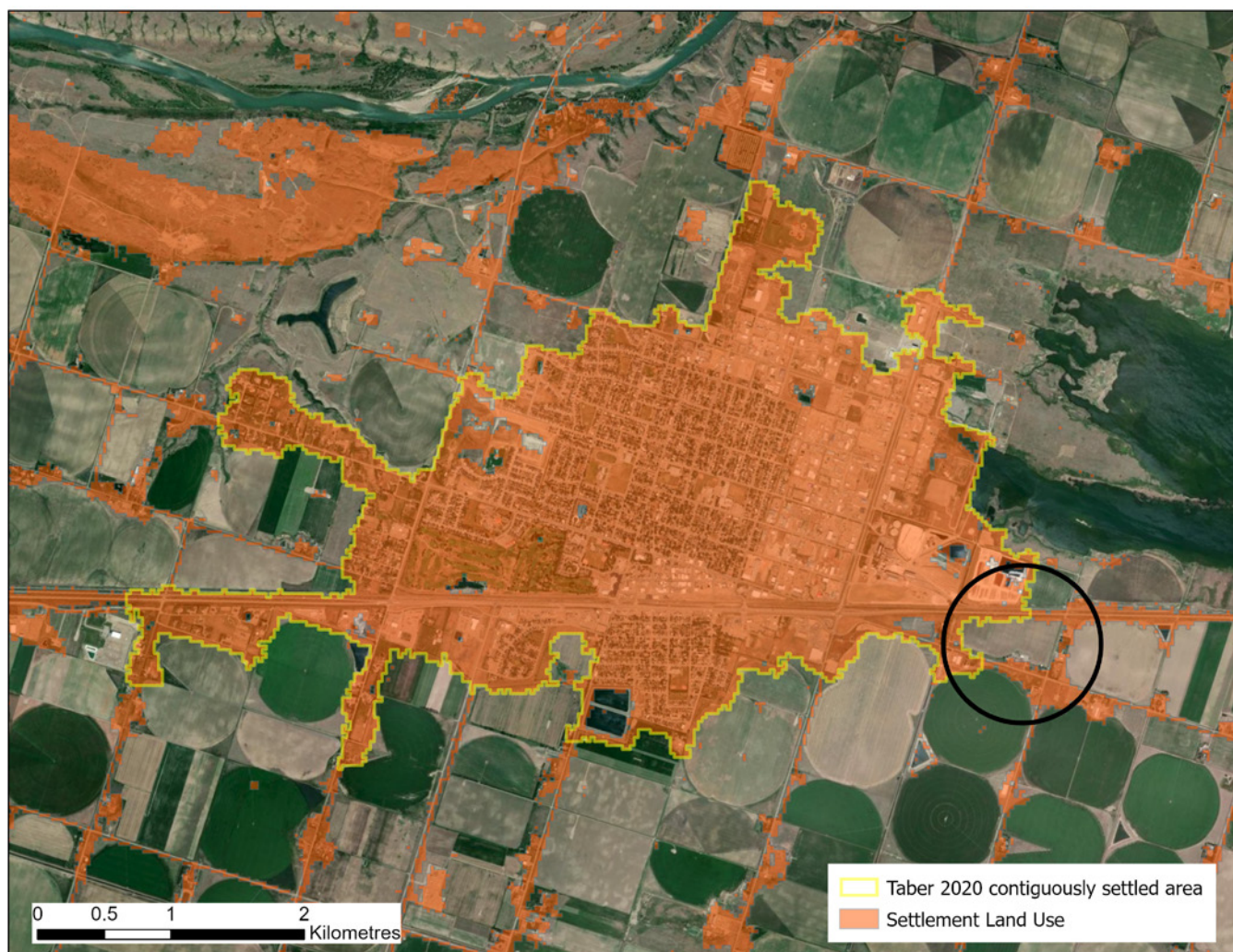


Note: When a settled area is separated into multiple parts because of the physical geography of the area, such as a settled area divided by a river as demonstrated in the example of Fredericton, New Brunswick, non-contiguous areas are retained in the contiguously settled area.

Source: Esri World Imagery, City of Fredericton (May 1, 2020).

Appendix 3

Example of where the contiguously settled area boundaries are truncated



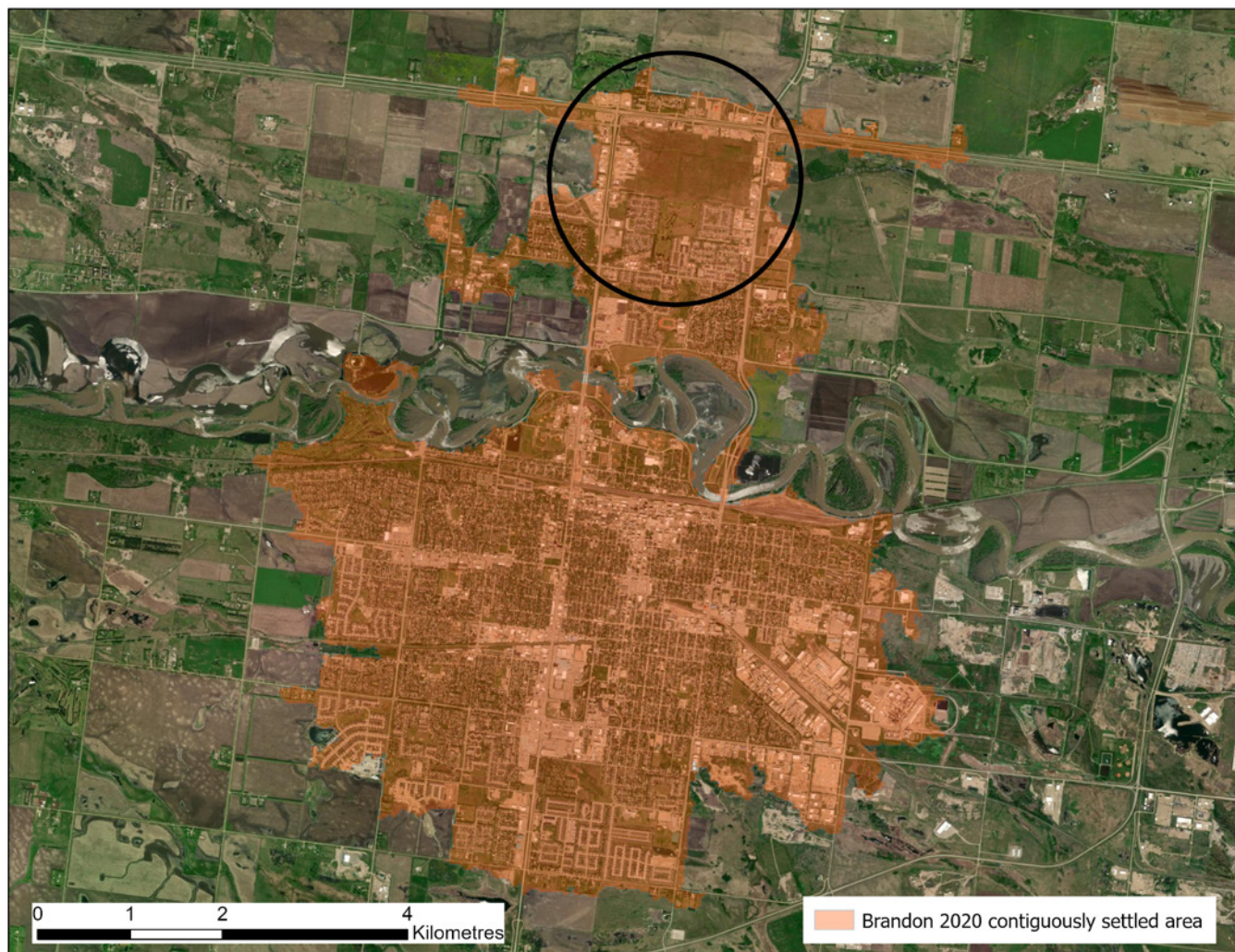
Note: When the area classified as settlement is reduced to a width of three pixels or less (e.g., the roads emerging from the core settled area within the black circle), the contiguously settled area (CSA) is trimmed. Areas narrower than this width were considered transportation connectors between settled areas and not included in the CSA.

Sources: Agriculture and Agri-Food Canada (AAFC). (2021). *AAFC Semi-decadal land use time series*. [Data set].

Retrieved October 1, 2021 from <https://open.canada.ca/data/dataset/fa84a70f-03ad-4946-b0f8-a3b481dd5248>; Esri World Imagery, Maxar (June 22, 2021).

Appendix 4

Example of natural or semi-natural land covers included within the contiguously settled area boundary

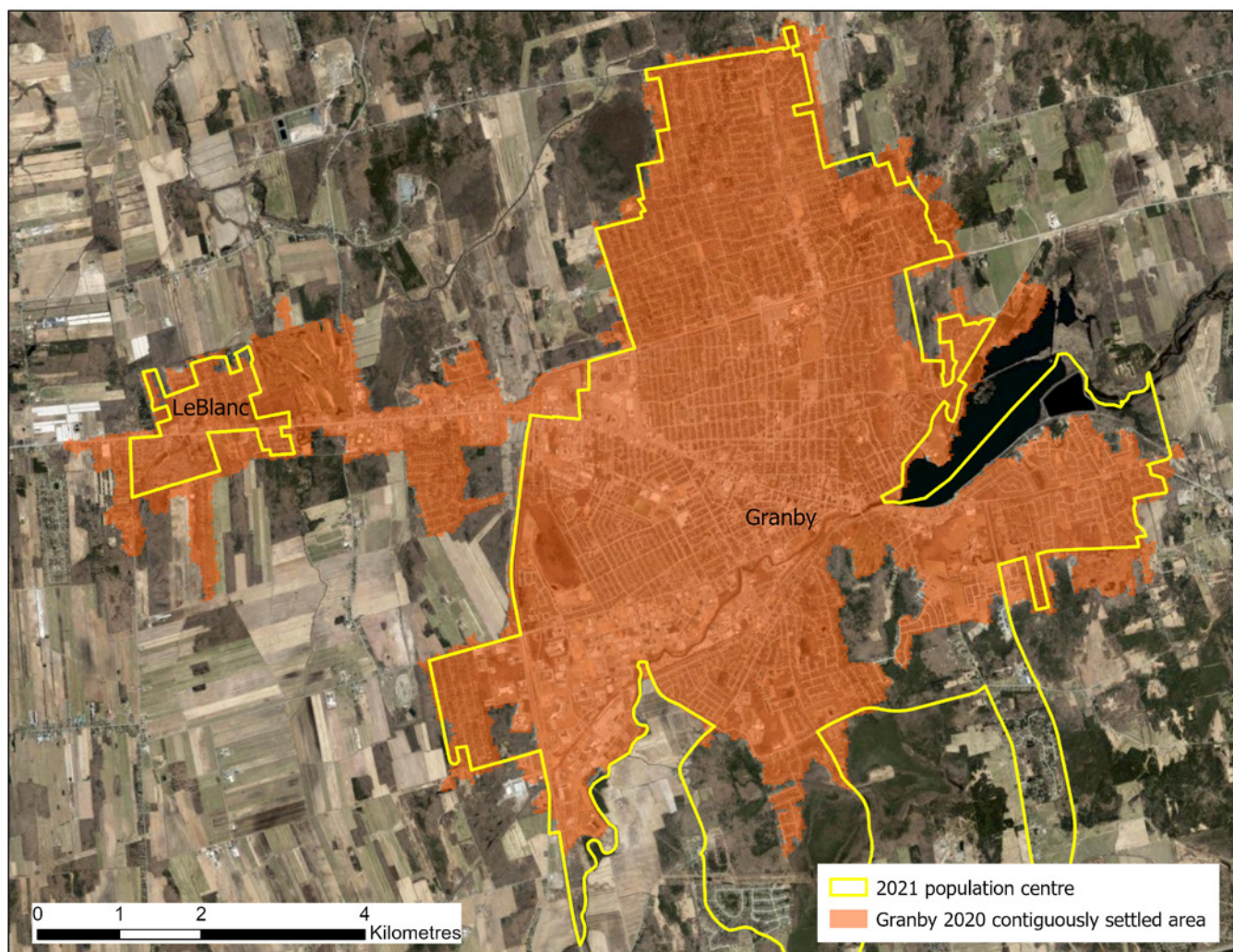


Note: Natural and semi-natural land covers enclosed by settled areas are included within the contiguously settled area (CSA) boundary by filling interior holes. As a result, land covers other than built-up areas, such as forest, water, cropland and grassland, are included within CSA boundaries when surrounded by settled areas at least three pixels in width. In the example of Brandon, Manitoba, the natural area indicated within the black circle is part of the CSA, as it is enclosed by settled area.

Source: Esri World Imagery, Maxar (June 4, 2022).

Appendix 5

Example of an agglomerated contiguously settled area



Note: If the contiguously settled areas (CSAs) of two or more population centres are attached (i.e., the settlement corridor linking them is wider than three pixels), as shown in the example of Granby, Quebec and LeBlanc, Quebec, one CSA is created for the entire area and is called an “agglomerated CSA.” Agglomerated CSAs are flagged in the attribute table and are assigned the name of the population centre with the larger population.

Sources: Statistics Canada. (2022). *2021 Census Boundary files*, Catalogue no. 92-166-X.

Retrieved June 6, 2023 from <https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-limit/2021-eng.cfm?year=21>; Esri World Imagery, GéoMont (May 1, 2020).