Catalogue no. 16-510-X
ISBN 978-0-660-74054-6

Census of Environment: Spatial information products

Urban greenness: Data product specifications

by Nicholas Lantz

Release date: November 21, 2024

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Urban greenness: Data product specifications

by **Nicholas Lantz**

1 Overview

1.1 Title

Urban greenness: Data product specifications

1.2 Reference date

2024-11-21

1.3 Responsible party

Census of Environment

Environment Accounts and Statistics Division, Statistics Canada

150 Tunney's Pasture Driveway
Ottawa, Ontario
K1A 0T6

Email: statcan.environ-environ.statcan@statcan.gc.ca

1.4 Language

eng – English

fra – French

1.5 Terms and definitions

Average NDVI: average of weekly Normalized Difference Vegetation Index (NDVI) imagery from the *Corrected representation of the NDVI using historical MODIS satellite images (250m resolution) from 2000 to 2024*, during peak summer conditions (Julian weeks 26 to 34, approximately late-June to late-August)

Green/grey classification: binary classification based on a NDVI threshold value. If the average NDVI value was greater than or equal to 0.5, it was classed as green, else it was classed as grey.

Population centres: statistical boundary that represent urban areas. A population centre (POPCTR) has a population of at least 1,000 and a population density of 400 persons or more per square kilometre, based on population counts from the current Census of Population. All areas outside population centres are classified as rural areas.

1.6 Abbreviations and acronyms

AAFC	Agriculture and Agri-Food Canada
CALMS	Canadian Ag-Land Monitoring System
CCAP	Crop Condition Assessment Program
CoE	Census of Environment
EA	Ecosystem Accounting
GCS	Geographic Coordinate System
GeoTIFF	Geographic Tagged Image File Format
ISIN	Integrated Sinusoidal projection
ISO	International Organization for Standardization
IUCN GET	International Union for Conservation of Nature Global Ecosystem Typology
MODIS	Moderate Resolution Imaging Spectroradiometer
NAD	North American Datum
NDVI	Normalized Difference Vegetation Index
POPCTR	Population centre
SEEA	System of Environmental Economic Accounting

1.7 Informal description of the data product

This product contains gridded datasets of average Normalized Difference Vegetation Index (NDVI) and green/grey classification. Both datasets were derived from satellite imagery from MODIS collected during a nine-week period in the summer when vegetation is at its peak. Annual datasets are available from 2000 to 2024. The datasets cover most of Canada south of 60°N latitude. Pixels have been masked if water covers, at minimum, half of a pixel's area.

This product supplements Statistics Canada's tabular estimates of urban greenness by providing users with spatial data for visualization and spatial analytical uses. These raster datasets provide information to help assess the condition of urban and industrial ecosystems.

The datasets are released as part of a suite of products associated with the Census of Environment (CoE). The CoE organizes data about Canada's natural environment based on the System of Environmental-Economic Accounting (SEEA) international statistical standard including the SEEA Central Framework and the SEEA Ecosystem Accounting (EA), which takes a spatial approach to accounting for ecosystems and natural capital. Urban greenness is a variable that is relevant under the urban condition accounts of the SEEA EA.

The datasets will be updated on an annual basis.

2 Specification scope

In these specifications, only one scope is used.

2.1 Scope identification

Main

2.2 Level

Series

2.3 Level name

Main scope of the Urban Greenness series

2.4 Level description

Gridded datasets of average NDVI and green/grey classification for Canada south of 60°N latitude.

2.5 Extent

2.5.1 Description

This product is a series of two-dimensional datasets (no elevation):

- Both datasets are available on an annual basis from 2000 to 2024.
- Pixels have been masked if water covers at minimum half of the pixel's area.
- For all years, the datasets cover Canada south of 60°N latitude, except for the following:
    - For all years, northwestern British Columbia.
    - For 2000 to 2016, northeastern Quebec and eastern Labrador.
    - For 2015, an area 660km by 12km, centered at 51.55°N latitude and 91.0°W longitude, covering a part of Manitoba and Ontario.

2.5.2 Vertical extent

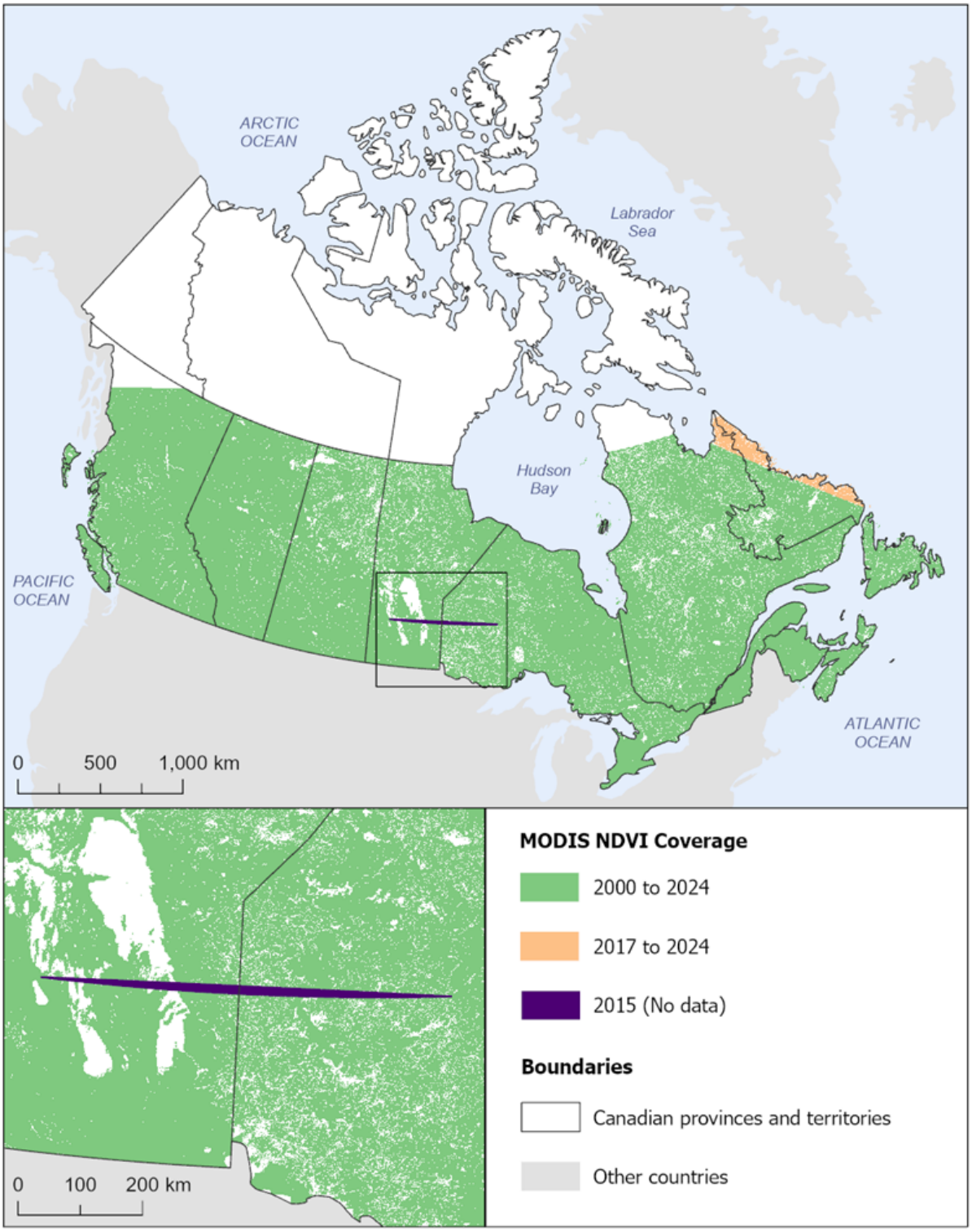
The data are two-dimensional. There is no elevation (z) associated with the data.

2.5.3 Horizontal extent

For all years, the datasets cover Canada south of 60°N latitude, except for the following:

- For all years, northwestern British Columbia.
- For 2000 to 2016, northeastern Quebec and eastern Labrador.
- For 2015, an area 660km by 12km, centered at 51.55°N latitude and 91.0°W longitude, covering a part of Manitoba and Ontario.

Map 1
MODIS Normalized Difference Vegetation Index (NDVI) coverage



Sources: Statistics Canada, 2024, Corrected representation of the NDVI using historical MODIS satellite images (250 m resolution) from 2000 to 2024, (https://open.canada.ca/data/en/dataset/dc700f75-19d8-4913-9846-78615ca93784 (accessed September 5, 2024); Bédard, F., 2010, "Satellite image data processing at Statistics Canada for the Crop Condition Assessment Program (CCAP)," https://www.statcan.gc.ca/eng/statistical-programs/document/5177_D1_T9_V1 (accessed September 5, 2024); Davidson, A., 2018, *An Operational Canadian Ag-Land Monitoring System (CALMS): Near-real-time agricultural assessment from space*, Agriculture and Agri-Food Canada, 100 pp.

Table 1
Longitude and latitude boundaries

	degrees
West bounding longitude	-134
East bounding longitude	-52
South bounding latitude	+41
North bounding latitude	+60

2.5.4 Temporal extent

The temporal extent covers a nine-week period in the summer when vegetation is at its peak. Weekly MODIS NDVI data from Julian weeks 26-34 were averaged. The first Julian week of a given year is the one that contains the first Thursday of January, and its start date is the preceding Monday. As a result, Julian weeks 26-34 represent slightly different periods, depending on the specific year. In general, the period covered is approximately late-June to late-August (Table 2).

Table 2
Start and end dates for the nine-week analysis period by year

Year	Julian week 26 start date	Julian week 34 end date
2000	June 26, 2000	August 27, 2000
2001	June 25, 2001	August 26, 2001
2002	July 1, 2002	September 1, 2002
2003	June 30, 2003	August 31, 2003
2004	June 28, 2004	August 29, 2004
2005	June 27, 2005	August 28, 2005
2006	June 26, 2006	August 27, 2006
2007	June 25, 2007	August 26, 2007
2008	June 30, 2008	August 31, 2008
2009	June 29, 2009	August 30, 2009
2010	June 28, 2010	August 29, 2010
2011	June 27, 2011	August 28, 2011
2012	June 25, 2012	August 26, 2012
2013	July 1, 2013	September 1, 2013
2014	June 30, 2014	August 31, 2014
2015	June 29, 2015	August 30, 2015
2016	June 27, 2016	August 28, 2016
2017	June 26, 2017	August 27, 2017
2018	June 25, 2018	August 26, 2018
2019	July 1, 2019	September 1, 2019
2020	June 29, 2020	August 30, 2020
2021	June 28, 2021	August 29, 2021
2022	June 27, 2022	August 28, 2022
2023	June 26, 2023	August 27, 2023
2024	June 24, 2024	August 25, 2024

2.5.4.1 Beginning date

2000

2.5.4.2 Ending date

2024

2.6 Coverage

The information applies to all coverages.

3 Data product identification

Table 3
Data product identification for the average NDVI series

Title	Average NDVI
Alternate title	andvi_mivdn_YYYY
Abstract	The average NDVI averaged from nine-week (Julian week 26-34) MODIS NDVI imagery. Values are calculated across southern Canada by 230 x 230 m cells.
Purpose	This product provides users with geographic data on annual average NDVI values for a nine-week period during the summer. It was produced by averaging MODIS NDVI imagery for Julian weeks 26 to 34 for each year. The average NDVI dataset was used to estimate average NDVI for 2021 population centres. These data are produced in the context of developing ecosystem condition data for urban ecosystems accounts following the SEEA EA.
Topic category	Environment, imageryBaseMapsEarthCover
Spatial representation type	Grid
Spatial resolution	230 m
Geographic description	Authority: International Organization for Standardization (ISO) ISO 3166-1:1997 Codes for the representation of names of countries and their subdivisions – Part 1: Country codes. Reference date of the ISO 3166-1 standard: 1997-10-01 Data type: Publication Code: CA – Canada Extent type code: inclusion
Specification scope	Main

Table 4
Data product identification for the green/grey classification series

Title	Green/grey classification
Alternate title	ggc_cvg_YYYY
Abstract	The green/grey classification used for estimating greenness statistics for 2021 population centres. Values are calculated across southern Canada by 230 x 230 m cells.
Purpose	This product provides users with a binary classification produced by applying a threshold to the average NDVI product. If the average NDVI value was greater than or equal to 0.5, it was classed as green, else it was classed as grey. The green/grey classification dataset was used to estimate average greenness for 2021 population centres. These data are produced in the context of developing ecosystem condition data for urban ecosystems accounts following the SEEA EA.
Topic category	Environment, imageryBaseMapsEarthCover
Spatial representation type	Grid
Spatial resolution	230 m
Geographic description	Authority: International Organization for Standardization (ISO) ISO 3166-1:1997 Codes for the representation of names of countries and their subdivisions – Part 1: Country codes. Reference date of the ISO 3166-1 standard: 1997-10-01 Data type: Publication Code: CA – Canada Extent type code: inclusion
Specification scope	Main

4 Data content and structure

4.1 Description

This product is composed of two raster products that characterize the quantity and health of vegetation in urban areas: average NDVI and green/grey classification. Each year and product are individually stored as a single file resulting in 25 annual files for each product and 50 files in total. This enables users to choose the data and time period they require for their analytical purposes.

4.2 Feature information

Not applicable

4.3 Coverage information

4.3.1 Description

Name: Average NDVI

Technical description: NDVI is an indicator of vegetation presence and quantity. It is an index with values ranging from -1 to +1, where high values (close to +1) correspond to healthier vegetation (dense green leaves) whereas low NDVI values (0.1 and below) indicate less or no vegetation (barren rock, sand, snow, water or impervious surfaces such as roads and buildings). The NDVI image source was the Corrected representation of the NDVI using historical MODIS satellite images (250m resolution) from 2000 to 2024. Weekly NDVI images during peak summer conditions (Julian weeks 26 to 34, approximately late-June to late-August) were averaged to provide a measure of vegetation condition for each year. “NoData” values represent areas that are not considered Canadian land area (e.g., water or international land area). Pixels have been masked if water covers at minimum half of the pixel’s area.

Type of coverage content: image

Name: Green/grey classification

Technical description: The green/grey classification is a binary classification produced by applying a threshold to the annual average NDVI product. If the average NDVI value was greater than or equal to 0.5, it was classed as green, else it was classed as grey. “NoData” values represent areas that are not considered Canadian land area (e.g., water or international land area). Pixels have been masked if water covers at minimum half of a pixel’s area.

Type of coverage content: thematicClassification

4.3.2 Coverage type

Continuous quadrilateral grid coverage

4.3.3 Specification

4.3.3.1 Domain extent

Refer to section 2.5 of this document.

4.3.3.2 Range type

Name: Average NDVI

Value data type: Float (0-20000)

Name: Green/grey classification

Value data type: Integer (0-255)

Table 5
Green/grey classification class

Label	Value	Definition
Grey	1	Average NDVI < 15000
Green	2	Average NDVI ≥ 15000

4.3.3.3 Common point rule

Not applicable

4.4 Reference to the specification scope

Main

5 Reference systems

5.1 Spatial reference system

Table 6
Spatial reference system

Projected Coordinate System	NAD_1983_Albers
Geographic Coordinate System	GCS_North_American_1983
Datum	D_North_American_1983
Spheroid	GRS_1980
Semimajor Axis	6378137.0
Inverse Flattening	298.257222101
Prime Meridian	Greenwich (0,0)
Angular Unit	Degree (0.0174532925199433)
Projection	Albers
False Easting	6200000.0
False Northing	3000000.0
Central Meridian	-91.8666666666667
Standard Parallel 1	49.0
Standard Parallel 2	77.0
Latitude of Origin	63.390675
Linear Unit	Metres (1.0)

5.2 Linear reference system

Not applicable

5.3 Temporal reference system

Gregorian calendar

5.4 Reference to specification scope

Main

6 Data quality

6.1 Completeness

Average NDVI and green/grey classification grids cover all of Canada's land area at 230m resolution south of 60°N latitude, with a few exceptions (see section 2.5 of this document). Water was masked using the 1:50,000 scale CanVec Hydrography layer acquired in 2019 and used by Statistics Canada's Statistical Geomatics Centre for 2021 Census boundary file layer and attribute creation purposes. This file is available upon request. Pixels have been masked if the pixel area was covered by 50% or more by water.

6.1.1 Commission

Pixels have been masked if the pixel area was covered by 50% or more by water. NDVI values may be affected for unmasked pixels that overlap with water and contain algae, emergent or aquatic plants near the surface. A single water layer was used to mask water for the entire time series and therefore does not account for water features that may have been removed or changed through time. Pixels not representing Canadian land were removed.

6.1.2 Omission

Average NDVI and green/grey classification grids cover all of Canada's land area at 230m resolution south of 60°N latitude, with a few exceptions (see section 2.5 of this document).

Pixels have been masked if the pixel area was covered by 50% or more by water. NDVI values may be affected for unmasked pixels that overlap with water and contain algae, emergent or aquatic plants near the surface. A single water layer was used to mask water for the entire time series and therefore does not account for water features that may have been created or changed through time.

6.2 Logical consistency

6.2.1 Conceptual Consistency

Annual average NDVI layers are generated for each year, however, only nine weeks of imagery during the middle of the growing season when vegetation is at its peak were used to calculate the average for this product (see section 2.5.4 temporal extent). Users are referred to the source data if they require an annual measure that requires a different analysis period (e.g., entire growing season).

6.2.2 Domain consistency

Average NDVI values were verified to be within the expected range of -1 to 1. In the green/grey rasters, all valid average NDVI pixels were assigned to either the green or grey class and all other pixels were masked from the datasets.

6.2.3 Format consistency

The use of well established commercial software to generate distribution formats ensures format consistency for product distribution.

6.2.4 Topological consistency

The projection and cell alignment were verified in the source data to ensure alignment before processing. The annual rasters were generated with an automated method, which controlled all projection and pixel alignment procedures.

6.3 Positional accuracy

Unknown. The data has been reprojected from its native Integrated Sinusoidal (ISIN) projection which may have introduced measurement positional error.

6.4 Temporal accuracy

Weekly NDVI images during peak summer conditions (Julian weeks 26 to 34, approximately late-June to late-August) were averaged to provide a measure of vegetation condition for each year. The first Julian week of a given year is the one that contains the first Thursday of January, and its start date is the preceding Monday. As a result, Julian weeks 26-34 represent slightly different periods, depending on the specific year (see Table 2). In the source data, the weekly value for each pixel is selected by removing low-quality observations (those degraded by snow cover, shadow, cloud, aerosols, and low sensor zenith angles) and selecting the pixel with the highest NDVI value from the remaining observations. Therefore, the date of maximum NDVI for a given week may not be consistent within and between years.

6.5 Thematic accuracy

The green class defined in this analysis corresponds to pixels with an average NDVI greater than or equal to 0.5, representing areas that are predominantly vegetated (Figure 1). Pixels with lower values are considered 'grey' and are largely non-vegetated, though patches of grass, shrubs or crops, or other unhealthy/poor condition vegetation will be included. The selection of the 0.5 cut-off for identifying green and grey areas was determined after analysis

of more than 50 sites using historical high-resolution imagery available in Google Earth Pro, various imagery basemaps and the application of NDVI trends and vegetation change tools available in Google Earth Engine. The greenness layers and changes were also compared visually to the urban greenness score for 10 sites.[1] The areas showing decrease of greenness were similar on both products. Water areas were excluded from the analysis if the pixel area was 50% or more covered by 1:50,000 scale CanVec Hydrography features. NDVI values for pixels containing residual water may have affected the average NDVI value and subsequent green/grey classification.

Figure 1
Examples of urban pixels classed as green or grey

Note: The green or grey class is based on the MODIS NDVI value.

7 Data capture

7.1 Description

The average NDVI and green/grey classification are variables that represent urban vegetation condition. The variables are derived from NDVI generated from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery. NDVI is an indicator of vegetation presence and quantity. It is an index with values ranging from -1 to +1, where high values (close to +1) correspond to healthier vegetation (dense green leaves) whereas low NDVI values (0.1 and below) indicate less or no vegetation (barren rock, sand, snow, water or impervious surfaces such as roads and buildings).

The input data source for this analysis originated from the MODIS Weekly Best-Quality Maximum-NDVI product generated by Agriculture and Agri-Food Canada's Canadian Ag-Land Monitoring System (AAFC CALMS). For the Weekly Best-Quality Maximum-NDVI product, the weekly value for each pixel is selected by removing low-quality observations (those degraded by snow cover, shadow, cloud, aerosols, and low sensor zenith angles) and selecting from the remaining values the pixel with the highest NDVI value.

Statistics Canada's Agriculture Division produces a modified version of the Weekly Best-Quality Maximum-NDVI product as an input for their Crop Condition Assessment Program (CCAP). For CCAP, the data has been reprojected from its native Integrated Sinusoidal (ISIN) projection and additional cloud-masking has been performed.

1. Czekajlo, A., Coops, N. C., Wulder, M. A., Hermosilla, T., Lu, Y., White, J. C., & van den Bosch, M. (2020). The urban greenness score: A satellite-based metric for multi-decadal characterization of urban land dynamics. *International Journal of Applied Earth Observation and Geoinformation, 93*, 102210 (accessed November 12, 2020).

For the urban greenness analysis, the CCAP weekly NDVI images during peak summer conditions (Julian weeks 26 to 34, approximately late-June to late-August) were averaged to provide a measure of vegetation condition for each year (average NDVI dataset).

The green/grey classification images contain two classes: green and grey. If the average NDVI value was greater than or equal to 0.5, it was classed as green, else it was classed as grey.

Water was masked using the 1:50,000 scale CanVec Hydrography layer acquired in 2019 and used by Statistics Canada's Statistical Geomatics Centre for 2021 Census boundary file layer and attribute creation purposes. This file is available upon request. Pixels have been masked if the pixel area was covered by 50% or more by water.

"NoData" values in both datasets represent areas that are not considered Canadian land area (e.g., water or international land area).

7.2 Reference to the specification scope

Main

8 Data maintenance

8.1 Description

The data series is updated on an annual basis.

8.2 Reference to the specification scope

Main

9 Portrayal

Not applicable

10 Data product delivery

10.1 Delivery format information:

GeoTIFF

10.1.1 Format name

GeoTIFF: Geographic Tagged Image File Format

10.1.2 Version

GeoTIFF 6.0

10.1.3 Specification

GeoTIFF is a format extension for storing georeference and geocoding information in a TIFF 6.0 compliant raster file by tying a raster image to a known model space or map projection.

10.1.4 File structure

Not applicable

10.1.5 Language

eng–English

10.1.6 Character Set

utf8

10.2 Delivery medium information for static files

10.2.1 Units of delivery

Each dataset from the time series is delivered by year following these naming conventions:

Average NDVI: andvi_mivdn_YYYY.tif

Ex. Average NDVI dataset for the year 2000: andvi_mivdn_2000.tif

Green/grey classification: ggc_cvg_YYYY.tif

Ex. Green/grey classification for the year 2000: ggc_cvg_2000.tif

10.2.2 Transfer size

For average NDVI, the file size is about 1GB for GeoTIFF and 230MB when compressed as a .zip file. For the green/grey classification, the file size is about 10MB for GeoTIFF and 6MB when compressed as a .zip file.

10.2.3 Medium Name

File transfer

Open Government of Canada website

https://geo.ca/index.html

10.2.4 Other delivery information

Information regarding the use of the data is defined in the Statistics Canada Open Licence.

10.3 Reference to specification scope

Main

11 Additional information

Statistics Canada also produces tabular estimates of urban greenness (average NDVI and average greenness) from the two datasets in this document as part of the CoE. Details on the method applied to generate tabular estimates on urban greenness can be found on the Ecosystem Condition Accounts page from the *Methodological Guide: Canadian System of Environmental-Economic Accounting*.

12 Metadata

12.1 Reference to specification scope

Main