Environment and Climate Change Canada
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LAND-USE CHANGE

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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Environment and Climate Change Canada
Public Inquiries Centre
12th floor, Fontaine Building
200 Sacré-Coeur boul.
Gatineau, QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-938-3860
Fax: 819-938-3318
Email: enviroinfo@ec.gc.ca

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

LAND-USE CHANGE

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Land-use change

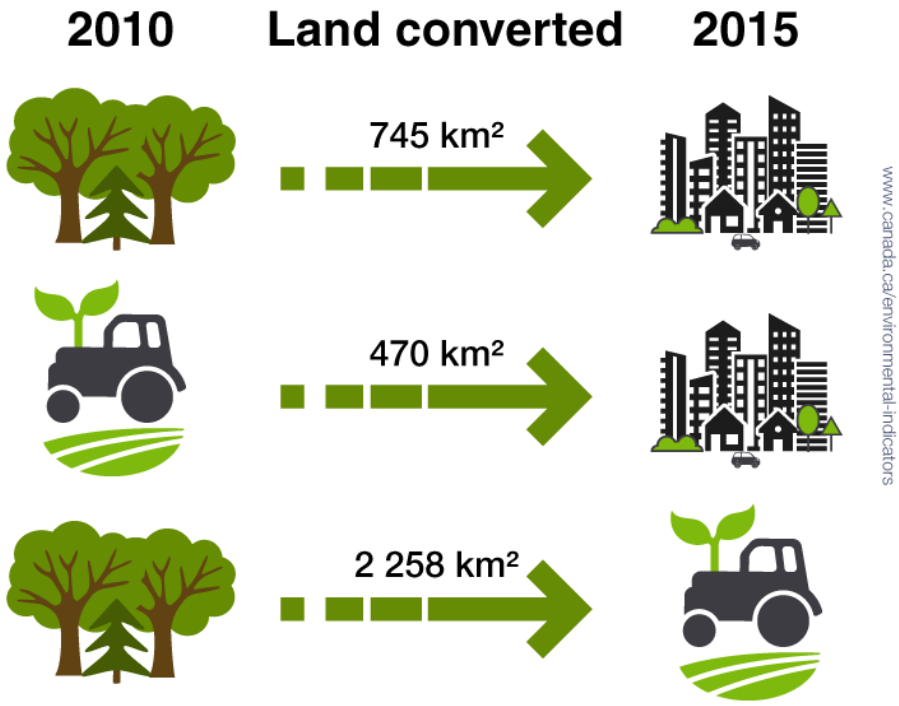
Changes in land use transform the landscape and can contribute to the loss of natural land. This can affect the environment and result in population declines in wildlife species. Loss of natural areas such as forests or wetlands can disrupt the ecosystem services that support human wellbeing, resulting in a decline in air and water quality, an increase in air and water temperatures and an increased risk of flooding. As cities grow outward, urban expansion often encroaches on surrounding areas, including agricultural land, forests and other natural areas. When cropland is lost to urban growth, there can be additional pressure to convert natural areas to cropland to increase agricultural capacity. By tracking changes between forests, cropland and settlement land uses, it is possible to measure how human activities are changing these landscapes.

Key results

Looking at land-use changes between cropland, forest and settlement south of 60° North (the southern territorial border of Yukon, Northwest Territories and Nunavut) from 2010 to 2015:[1]

- 3 473 km^2 of land-use change was observed, representing well under 1% of the overall area
- Of the land-use change observed, a large proportion (65% or 2 258 km^2) was the conversion of forest to cropland
- About 1 215 km^2 of cropland and forest were converted to settlement

Figure 1. Conversion of total area by land-use class, Canada, 2010 to 2015



Data for Figure 1

Note: Cropland includes agricultural land used for growing perennial or annual crops. Forest includes forest cover, wetlands with forest cover, forest regenerating after harvest, and forest regenerating after fire. Settlement refers to all residential, commercial, industrial, transportation or other built infrastructure use. Values are only reported for the portion of Canada south of 60° North.
Source: Agriculture and Agri-Food Canada (2021) Science and Technology Branch.

[1] Data from previous years continue to be developed and will be included in future updates.

Deforestation means converting forests to other land uses. In Canada, deforestation is mainly caused by cropland expansion or conversion to settlement land uses, such as the mining, oil and gas development.[2,3] Deforestation depletes biodiversity and wildlife habitat, and degrades air, water and soil quality. Also, because forests store carbon and reduce the impacts of drought and flooding, the loss of forests reduces carbon sequestration[3] and climate resilience.

The conversion of forests to cropland was the largest land-use change observed between 2010 and 2015 (2 258 km^2). Agricultural expansion is the main driver for the loss of natural land in Canada and around the world.[4,5] Forested lands located near existing urban and agricultural areas are most at risk of being converted to cropland.[6]

Land conversion to settlement is also a significant driver of land-use change. This can impact local environments by degrading or paving over soil,[7] altering water and nutrient cycles, and increasing water and air pollution. In the Toronto, London, St. Catharines–Niagara and Windsor metropolitan areas, 85% of the land converted to settlements between 1971 and 2011 was high-value agricultural land. In the same time period, large amounts of forests were also converted to settlement in the Halifax, St. John's, Saint John and Trois-Rivières metropolitan areas.[8]

The methodologies for compiling the data for land-use change improve over time. Data and analysis are based on the best information currently available.

Regional land-use change

Key results

Between 2010 and 2015,

- the Ontario and Quebec region experienced the largest loss of forest cover (1 150 km^2), followed by the Prairies region (1 096 km^2)
- the Ontario and Quebec region had the largest conversion to settlement (610 km^2), followed by the Prairies region (256 km^2)

[2] Environment and Climate Change Canada (2021) National Inventory Report 1990-2019: Greenhouse gas sources and sinks in Canada. Retrieved on April 27, 2021.

[3] Natural Resources Canada (2020) The State of Canada's Forests 2020. Retrieved April 6, 2021.

[4] Natural Resources Canada (2020) Deforestation in Canada: Key myths and facts. Retrieved April 6, 2021.

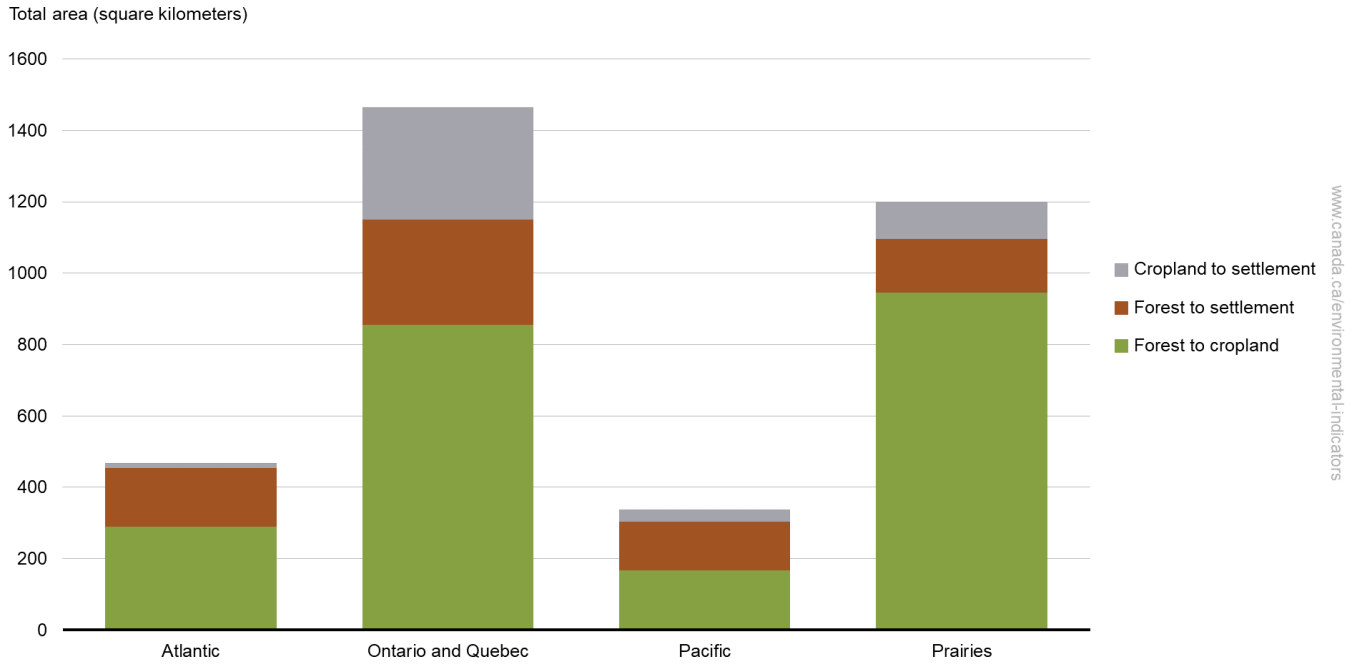
[5] Organisation for Economic Co-operation and Development (2018) Monitoring land cover change. Retrieved March 23, 2021.

[6] Yemshanov D et. al. (2015) Assessing land clearing potential in the Canadian agriculture–forestry interface with a multi-attribute frontier approach. Ecological Indicators 54:71-81.

[7] Paving over the soil covers it with impermeable materials, such as asphalt or concrete.

[8] Statistics Canada (2016) Human Activity and the Environment 2015. The changing landscape of Canadian metropolitan areas. Retrieved April 7, 2021.

Figure 2. Total area converted to cropland or settlement by region, Canada, 2010 to 2015



Data for Figure 2

Note: Values of land conversion to forest were not included because the indicator focuses on the conversion from natural and semi-natural land for human activity. No settlement was converted back to cropland or forest from 2010 to 2015. The Atlantic region includes the provinces of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. The Prairie region includes the provinces of Manitoba, Saskatchewan and Alberta. The Pacific region consists of the province of British Columbia. Cropland includes agricultural land used for growing perennial or annual crops. Forest includes forest cover, wetlands with forest cover, forest regenerating after harvest, and forest regenerating after fire. Settlement refers to residential, commercial, industrial, transportation or other built infrastructure use. Values are only reported for the portion of Canada south of 60° North.
Source: Agriculture and Agri-Food Canada (2021) Science and Technology Branch.

Ontario and Quebec showed the most land-use conversion to settlement, likely driven by population growth and subsequent urban expansion.[9] Cities grow in size when built infrastructure is expanded to accommodate population growth. Making more efficient use of existing built infrastructure protects cropland, forests and other natural infrastructure within and around Canadian cities, and can enrich the amenities accessible to residents.

Most of Canada's land suitable for growing crops are in the Prairies, and Ontario and Quebec. Accordingly, these regions showed the most forest to cropland land-use change.

The Pacific region, which consists of British Columbia, showed the smallest amount of land-use change. British Columbia experiences the lowest annual amount of forest land conversion to cropland and settlement, and this has been noted consistently in recent decades.[10]

[9] Statistics Canada (2016) The changing landscape of Canadian metropolitan areas – Section 2: The census metropolitan area landscape. Retrieved April 7, 2021.

[10] Gilani HR and Innes JL (2020) The state of British Columbia's forests: A global comparison. Forests 11: doi:10.3390/f11030316.

About the indicator

What the indicator measures

This indicator measures the amount of land-use change from 2010 to 2015. It reports the proportion of agricultural land that has been converted to settlement and the amount of forest that has been converted to cropland or settlement in Canada south of 60° North.

Why this indicator is important

Land-use change is the main cause of biodiversity loss globally. Agricultural expansion and intensification are leading factors in the loss of natural areas. Natural areas provide habitat for wildlife and ecosystem services such as water purification, carbon storage, and climate regulation. Additionally, most newly built artificial surfaces are constructed on cropland. Conversion of land from agriculture to settlement is further associated with increased pressure on biodiversity, soil degradation, and flood risk.[11] Measuring land-use change provides a way to quantify pressures on ecosystems and biodiversity, and can be used to inform environmental management and policy to prevent further loss of ecological integrity.

Sustainably managed lands and forests

This indicator supports measuring progress towards the following 2019 to 2022 Federal Sustainable Development Strategy long-term goal: Lands and forests support biodiversity and provide a variety of ecosystem services for generations to come.

In addition, the indicator contributes to the Sustainable Development Goals of the 2030 Agenda for Sustainable Development. It is linked to the 2030 Agenda's Goal 15: Life on Land.

Related indicators

Canada's conserved areas indicators report the amount and proportion of Canada's terrestrial and marine area that is conserved.

The Extent of Canada's wetlands indicator measures the extent of Canadian wetlands, and provides a baseline from which change can be measured.

The Sustainability of timber harvest indicator compares the amount of timber harvested with the wood supply. It is one measure of the success of Canada's forest stewardship.

The Wildlife habitat capacity on agricultural land indicator provides a measure of the suitability of agricultural land as habitat for terrestrial vertebrates.

The Land-based greenhouse gas emissions and removals indicator tracks exchanges of greenhouse gas (GHG) emissions and removals between the atmosphere and Canada's managed lands.

Data sources and methods

Data sources

Data for this indicator are from the 2010 and 2015 Land Use maps produced by the Science and Technology Branch of Agriculture and Agri-Food Canada (AAFC). The AAFC Land Use Time Series maps cover all areas of Canada south of 60° North at a spatial resolution of 30 m. The land-use classes follow the protocol of the Intergovernmental Panel on Climate Change (IPCC) and consist of forest, water, cropland, grassland, wetland, settlement and other land (rock, beaches, ice and barren land).

[11] Organisation for Economic Co-operation and Development (2018) Monitoring land cover change. Retrieved March 23, 2021.

The AAFC Land Use Time Series maps, and a complete list of the datasets incorporated as evidence, are available on the Government of Canada's Open Government data portal.

More information

The AAFC Land Use Time Series is a culmination and curated meta-analysis of several high-quality spatial datasets that were produced between 1990 and 2021 and published as open data. The principal datasets that were integrated to form the time series were:

- Agriculture and Agri-Food Canada: Annual Crop Inventories 2010-2020
- Agriculture and Agri-Food Canada: Land Cover for Agricultural Regions of Canada, circa 2000
- Canadian Council of Forest Ministers: Forest Disturbance and Recovery 1985-2011
- Canadian Forest Service: Canada Landsat Disturbance (CanLaD) Forest Disturbance 1984-2015
- Canadian Forest Service: Earth Observation for Sustainable Developments of Forests (EOSD) Land Cover 2000
- European Commission Joint Research Centre: Global Surface Water 1984-2020
- Global Land Analysis and Discovery and Global Forest Watch: Global Forest Change 2000-2020
- NASA Earth Science Enterprise GeoCover 1990
- Natural Resources Canada: Topographic Data of Canada – CanVec Series
- University of Maryland: Global Forest Canopy Height 2019
- University of Maryland: Global Forest Change 2000-2019
- University of Maryland and United States Geological Survey: Global Tree Cover 2010
- University of Maryland and United States Geological Survey: Global Bare Ground 2010

Information from the selected datasets were embedded within a grid of 30 m by 30 m pixels to create consolidated pixel histories. Informed by many sources of high-quality evidence and visual observation of imagery in Google Earth, an incremental strategy was applied to develop a coherent best current understanding of what has happened in each of the 6.7 billion pixels through the time series.

Logical rules were developed to reduce error and improve land-use stability through time. For example, there were logical rules to the effect that settlement cannot be converted back to forest, and another to the effect that pixels that were wetland in a recent year were also wetland in the prior years. Most rules were more complex and relied on multiple pieces of evidence. For example, if the Canadian Forest Service CanLaD Forest Disturbance dataset indicates there was tree canopy loss in 2011 and the AAFC Crop Inventory always identified cropland from 2013 to 2017, visual inspection of satellite imagery would confirm that these pixels showed a land-use change from forest in 2010 to cropland in 2015. This was applied as a logical rule to improve accuracy where those specific conditions were met.

To date, several thousand unique logical rules have been documented and applied, using visual inspection of imagery in Google Earth as empirical evidence to define each rule. The AAFC Land Use Time Series data are evidence-based and reflect the current best understanding we have. They continue to be updated and improved as pertinent new information becomes available and new logical rules are developed.

Methods

This indicator summarizes the amount of land converted from one land-use class to another for the years 2010 to 2015. An interval of 5 years was used for long-term change detection within the data. This interval is large enough to reduce the effects of short-term and temporary changes that could appear due to snow cover, flooding, or uncertainty.

More information

Land-use categories used for analysis of the Land-use change indicator were settlement, forest and cropland. Summaries of land-use change were determined by:

1. Identifying all pixels that had a change in land use from 2010 to 2015
2. Creating a change matrix summarizing land-use changes by land-use class for all areas of Canada south of 60° North and by the following provincial groupings:

- Atlantic – New Brunswick, Newfoundland and Labrador, Nova Scotia and Prince Edward Island
- Ontario and Quebec
- Prairies – Alberta, Manitoba and Saskatchewan
- Pacific Coast – British Columbia

Caveats and limitations

The land-use land-cover (LULC) datasets contributing land class information were created using a mixture of satellite mounted sensor imagery and other spatially related information. Evidence from these datasets were compiled within a common framework of 30 m by 30 m pixels. Some level of error is always expected in classifying earth observation data. Information on the level of errors may be identified in the metadata of source data.

The area of deforestation reported by Canada in National Greenhouse Gas Inventory reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and annual reporting on the State of Canada's Forests differs from the areas reported in the Land-use change indicator. Canada's official deforestation monitoring data were produced using a different methodology,[12] which has undergone detailed expert review coordinated by the UNFCCC secretariat. Furthermore, the Canadian territories are not included in the Land Use Time Series dataset used in the development of this indicator. The dataset does not account for land-use change north of 60° North. Users of the data are encouraged to consult Canada's official deforestation reporting and evaluate methodologies in order to make well-informed use of the data.

The indicator measures only the quantity of land-use change. The quality and value of the land or reasons for land-use change are not reported.

At this time, only data for 2010 to 2015 have been completed. Data from previous years are currently being developed. They will be incorporated in the indicator in future updates. Also, work to estimate land-use change for grassland and wetlands is underway, with the aim of reporting such changes in the future.

More information

Classes are identified by their spectral characteristics and the context of their location. Spectral characteristics of certain land classes can sometimes be difficult to differentiate from one another, and pixels may not always be classified correctly. This issue mainly occurs when spectral reflectance is similar, where information is missing, and along class boundaries.

A limitation also arises from the spatial resolution of the dataset used. The pixel size in the data used was 30 m by 30 m, covering an area of 900 m^2. The class of the pixel is determined by the dominant spectral or class characteristics of each pixel. Where 2 or more classes occur within the same pixel, the entire pixel area is classified to represent the majority of the pixel.

Resources

References

Dyk A, Leckie D, Tinis S and Ortlepp S (2015) Canada's National Deforestation Monitoring System: System description. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre. Retrieved April 27, 2021.

Environment and Climate Change Canada (2021) National Inventory Report 1990-2019: Greenhouse gas sources and sinks in Canada. Retrieved on April 27, 2021.

Gilani HR and Innes JL (2020) The state of British Columbia's forests: A global comparison. Forests 11: 10.3390/f11030316. Retrieved March 29, 2021.

[12] Dyk A, Leckie D, Tinis S and Ortlepp S (2015) Canada's National Deforestation Monitoring System: System description. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre. Retrieved April 27, 2021.

Natural Resources Canada (2020) The State of Canada's Forests 2020. Retrieved April 6, 2021.

Natural Resources Canada (2020) Deforestation in Canada: Key myths and facts. Retrieved April 6, 2021.

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Statistics Canada (2016) Human Activity and the Environment 2015. The changing landscape of Canadian metropolitan areas. Retrieved April 7, 2021.

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Yemshanov D, Kock FH, Riiters KH, McConkey B, Huffman T and Smith S (2015) Assessing land clearing potential in the Canadian agriculture–forestry interface with a multi-attribute frontier approach. Ecological Indicators 54:71-81.

Annexes

Annex A. Data tables for the figures presented in this document

Table A.1. Data for Figure 1. Conversion of total area by land-use class, Canada, 2010 to 2015

Land-use classes	Cropland, 2015 (square kilometers)	Forest, 2015 (square kilometers)	Settlement, 2015 (square kilometers)	Total (square kilometers)
Cropland, 2010 (square kilometers)	429 420	0	470	**429 890**
Forest, 2010 (square kilometers)	2 258	3 710 113	745	**3 713 116**
Settlement, 2010 (square kilometers)	0	0	82 232	**82 232**
Total (square kilometers)	**431 678**	**3 710 113**	**83 447**	**4 225 239**

Note: Cropland includes agricultural land used for growing perennial or annual crops. Forest includes forest cover, wetlands with forest cover, forest regenerating after harvest, and forest regenerating after fire. Settlement refers to all residential, commercial, industrial, transportation or other built infrastructure use. Values are only reported for the portion of Canada south of 60° North.
Source: Agriculture and Agri-Food Canada (2021) Science and Technology Branch.

Table A.2. Data for Figure 2. Total area converted to cropland or settlement by region, Canada, 2010 to 2015

Region	Forest to cropland (square kilometers)	Forest to settlement (square kilometers)	Cropland to settlement (square kilometers)	Total (square kilometers)
Atlantic	289	164	15	**468**
Ontario and Quebec	855	295	315	**1 466**
Pacific	168	135	35	**339**
Prairies	945	151	105	**1 201**
Total	**2 258**	**745**	**470**	**3 473**

Note: Values of land conversion to forest were not included because the indicator focuses on the conversion from natural and semi-natural land for human activity. No settlement was converted back to cropland or forest from 2010 to 2015. The Atlantic region includes the provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. The Prairie region includes the provinces of Manitoba, Saskatchewan and Alberta. The Pacific region consists of the province of British Columbia. Cropland includes agricultural land used for growing perennial or annual crops. Forest includes forest cover, wetlands with forest cover, forest regenerating after harvest, and forest regenerating after fire. Settlement refers to residential, commercial, industrial, transportation or other built infrastructure use. Values are only reported for the portion of Canada south of 60° North.
Source: Agriculture and Agri-Food Canada (2021) Science and Technology Branch.

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