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LAND-BASED GREENHOUSE GAS EMISSIONS AND REMOVALS

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

LAND-BASED GREENHOUSE GAS EMISSIONS AND REMOVALS

October 2020

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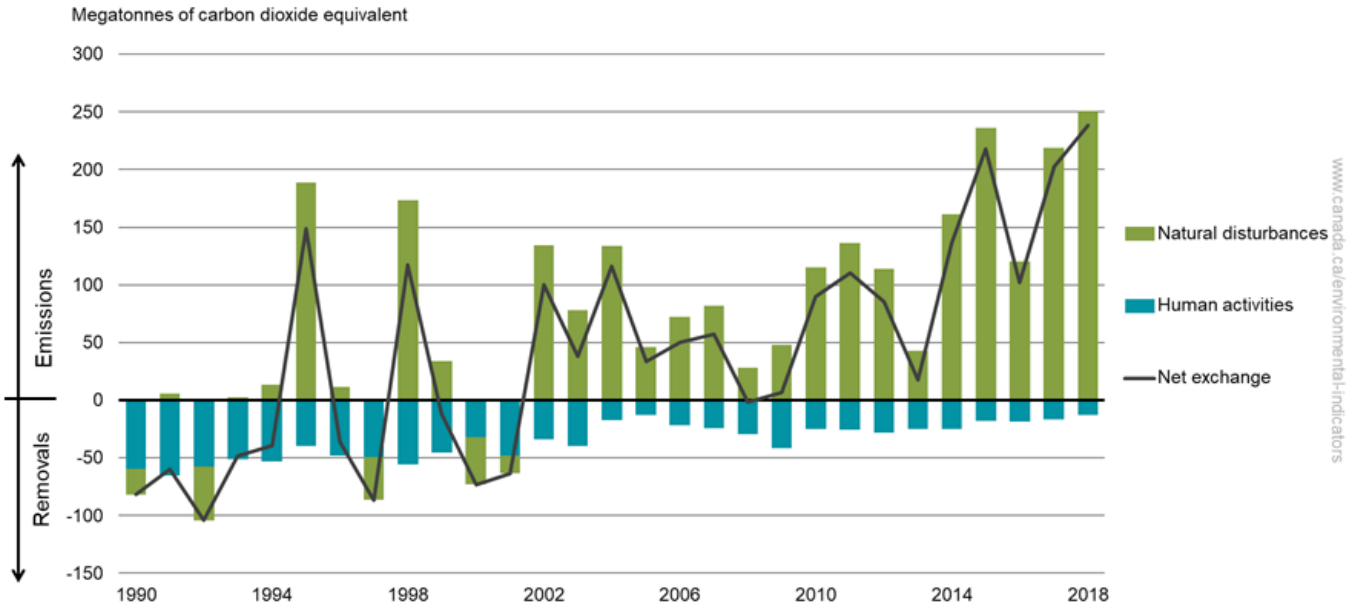
Land-based greenhouse gas emissions and removals

Greenhouse gas (GHG) emissions are the major drivers of climate change. Land-use activities such as forestry, agriculture and the conversion of lands to settlements, as well as natural disturbances such as forest fires and insect infestations result in GHG emissions to the atmosphere and removals from the atmosphere (for example carbon being converted into wood by trees). Land management decisions can help mitigate climate change by increasing carbon dioxide removals from the atmosphere or decreasing GHG emissions from the land. This indicator provides estimates of Canada's emissions and removals of GHGs from managed lands.[1]

Key results

- Between 1990 and 2018, land-based GHG emissions and removals ranged from removals of about 100 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) [2] in 1992 to emissions of about 240 Mt CO_2 eq in 2018
- In 2018,
    - natural disturbances (such as wildfires and severe insect infestations) accounted for emissions of about 250 Mt CO_2 eq
    - human activities accounted for removals of 13 Mt CO_2 eq

Figure 1. National land-based greenhouse gas emissions and removals, 1990 to 2018



Data for Figure 1

Note: Natural disturbances refer to emissions and removals related to wildfires and large forest insect infestations. Human activities refer to emissions and removals from managed lands and includes settlements, the forestry sector, agricultural land and wetlands. Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

[1] Managed lands include agricultural lands (cropland and agricultural grassland), wetlands (peat extraction and flooded lands), settlements (all roads and transportation infrastructure, rights-of-way, power transmission and pipeline corridors, residential, recreational, commercial and industrial lands in urban and rural settings and land used for resource extraction other than forestry) and managed forests (managed for timber and non-timber resources or subject to fire protection). See section 6.2 of the National Inventory Report for more information on the land category definitions.

[2] Estimates for emissions and removals in the text of the indicator are rounded to the number of significant digits in accordance with the rounding protocol in Part III Annex 8 of the National Inventory Report and may differ slightly from estimates in the tables and figures.

Natural disturbances such as forest fires and large insect infestations have occurred in Canada's forests for thousands of years. These disturbances are part of the natural life cycle of the forest and generally help the forest renew itself. However, there is evidence that climate change is driving an increase in natural disturbances. These disturbances can contribute to the release of large amounts of GHGs into the atmosphere through burning and decay of dead trees, as well as significant removals as forest regenerates over time.[3] For the past 20 years, the total net GHG exchange (that is, the land-based GHG emissions minus removals) has been significantly impacted by these natural disturbances.

In managed forests, emissions and removals due to natural disturbances such as forest fires or insect infestations are associated with human activities under specific circumstances. These circumstances are described in the methods section.

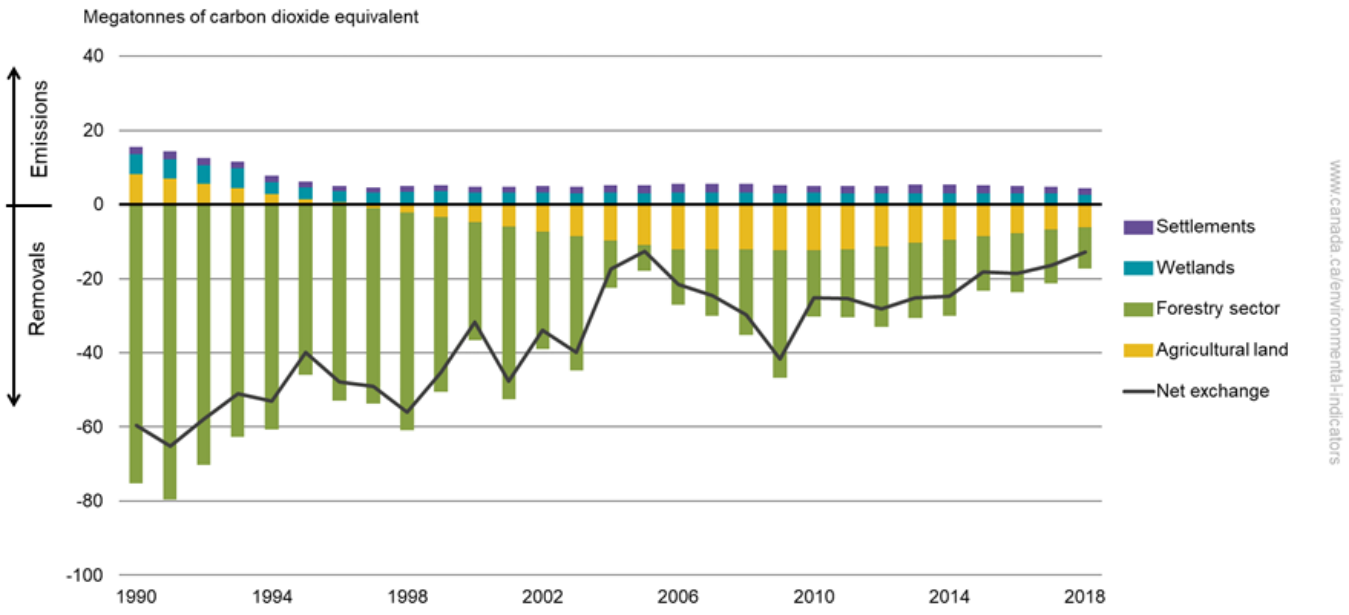
Land-based GHG emissions and removals from human activities

Land-based GHG emissions and removals from human activities are commonly referred to as land use, land-use change and forestry (LULUCF) according to international standards.

Key results

- In 2018, lands dominated by human activities removed 13 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) from the atmosphere
    - forestry and agricultural land contributed removals of 11 and 6.2 Mt CO_2 eq, respectively
    - wetlands and settlements contributed emissions of 2.6 and 1.8 Mt CO_2 eq, respectively
- The forestry sector had the largest influence on the totals for all years in the time series and displayed the greatest variations between years

Figure 2. Land-based greenhouse gas emissions and removals from human activities by activity sector, Canada, 1990 to 2018



Data for Figure 2

Note: Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

[3] Warren FJ and Lemmen DS, editors (2014) Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. Government of Canada, Ottawa, ON, 286p.

Forestry sector

The forestry sector category refers to emissions and removals from forest management activities such as timber harvesting, thinning and replanting, and ecological processes such as tree growth and decomposition. It also includes emissions from harvested wood products, which are the wood materials removed from the harvested site and turned into consumer products, such as timber for construction, furniture or paper products. The carbon removed from the atmosphere by trees is stored in the harvested wood products and tracked over the lifespan of the consumer products. The carbon is emitted back into the atmosphere at the end of the products' useful life.

Net removals from the forestry sector have decreased from 75 Mt CO_2 eq in 1990 to 11 Mt CO_2 eq in 2018. This decrease is related to reduced carbon accumulation in forests due to natural disturbances (such as forest fires and insect infestations) and changes in harvest rates over time, in particular in the Mountain and Boreal regions. Harvesting causes a shift in forest age to younger forests that are either emitting carbon or removing less carbon compared to the forests that were harvested. Natural disturbances increase emissions from decomposition in some cases (for example insect infestations) and reduce the areas of mature growing trees that are removing carbon.

Agricultural land

The agricultural land category reports emissions and removals from cropland, as well as from forest lands and grassland converted to cropland, and managed agricultural grassland. Cropland includes lands in annual crops, summerfallow and perennial crops. Managed agricultural grassland refers to "unimproved" natural pasture or rangeland that is used only for grazing domestic livestock.

Agricultural land switched from net emissions of 8.1 Mt CO_2 eq in 1990 to net removals of 12 Mt CO_2 eq in 2010 and 6.2 Mt CO_2 eq in 2018. The switch was due to reduced soil disturbance resulting from changing agricultural practices such as the adoption of conservation tillage and reduced use of summerfallow.

Wetlands

The wetlands category includes activities such as peat extraction for use in horticulture and flooding of lands for hydropower development. GHG emission rates from drained and excavated wetlands are fairly constant. Net emissions in the wetlands category fluctuated between 5.4 Mt CO_2 eq (1993) and 2.6 Mt CO_2 eq (2018).

Settlements

The settlements category refers to emissions and removals occurring on developed lands (such as urban environments, transport infrastructure, oil and gas infrastructure and mining) and from land conversion of forests and agricultural lands to settlements. Net emissions for settlements fluctuated between 1.5 Mt CO_2 eq (1996) and 2.3 Mt CO_2 eq (2007). The fluctuations were mainly driven by rates of conversion from forested lands. Emissions from the conversion of land to settlements are offset by the storage of carbon in urban trees (annual removals of 4.0 Mt CO_2 eq throughout 1990 to 2018).

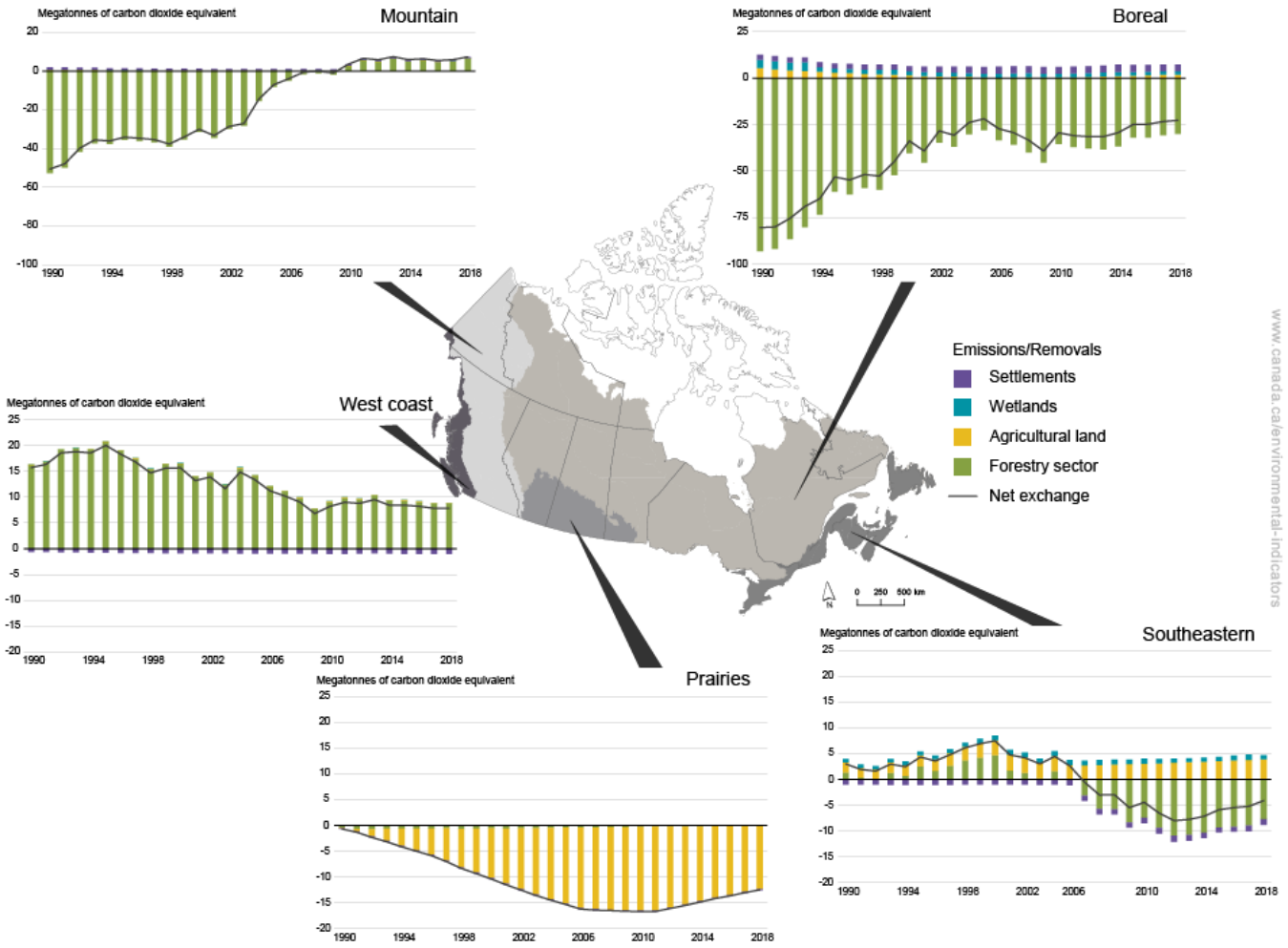
Regional land-based emissions and removals from human activities

Key results

From 1990 to 2018,

- the agriculturally important Prairie region increased removals from 0.65 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) to 12 Mt CO_2 eq
- the Southeastern region went from emissions of 3.0 Mt CO_2 eq to removals of about 4.1 Mt CO_2 eq
- the Mountain region, which is important for forestry, went from removals of 51 Mt CO_2 eq to emissions of about 7.3 Mt CO_2 eq

Figure 3. Regional land-based greenhouse gas emissions and removals from human activities, Canada, 1990 to 2018



Data for Figure 3

Note: Regions are based on the location of the human activities across the country. Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

The increased removals of GHGs in the Prairies can be attributed to changes in agricultural land management practices, such as the adoption of conservation tillage and the reduced use of summerfallow. These changes in land management resulted in decreased soil disturbance and thereby lower releases of carbon from soil organic matter.

In the West Coast and Southeastern regions, forestry management practices (changes in harvest rates and forest regeneration) contributed to the reduction in emissions.

The decrease in GHG removals in the Mountain and Boreal regions is related to increased forest harvesting (in part in an effort to salvage timber after Mountain Pine beetle kill) and to a reduction in carbon removals from forests. The latter is due to insect infestations and fire in managed forests, which reduced the area of mature growing trees in these forests, increased decomposition and increased harvesting of dead or dying standing trees (salvage logging).

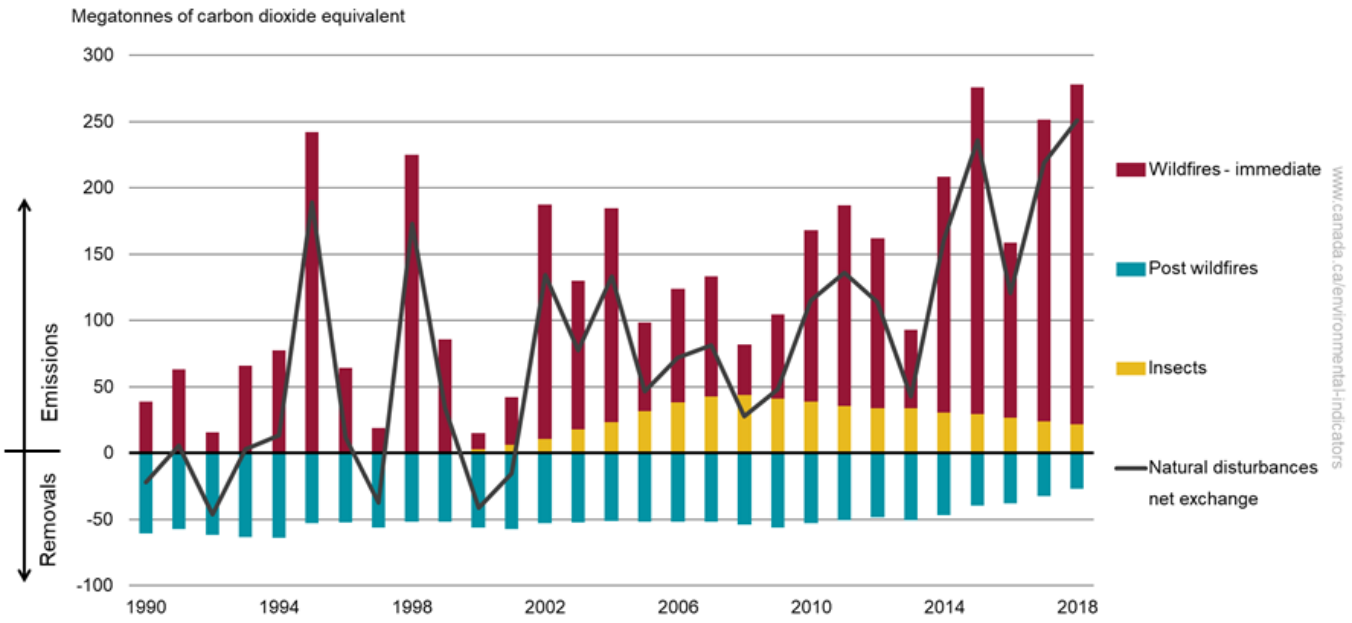
Land-based emissions and removals from natural disturbances

Forests remove carbon from the atmosphere as they grow and release it along with other GHGs when they decay after dying or burn in forest fires.

Key results

- Wildfires had the largest influence on land-based emissions and removals from natural disturbances (emissions of 260 megatonnes of carbon dioxide equivalent [Mt CO_2 eq] in 2018)
- Emissions caused by insect infestations reached a peak of 44 Mt CO_2 eq in 2008 and in 2018 were 22 Mt CO_2 eq
- Removals due to forest regrowth post wildfire reached a peak of 64 Mt CO_2 eq in 1994 and in 2018 were 27 Mt CO_2 eq

Figure 4. Land-based greenhouse gas emissions and removals from natural disturbances in managed areas, Canada, 1990 to 2018



Data for Figure 4

Note: Wildfire emissions and removals are divided in 2 categories, (1) wildfires - immediate and (2) post wildfires. Wildfires - immediate include emissions from trees and soils from the burning of wildfires. Post wildfires include emissions released by the decay of dead trees and soil organic matter and removals related to forest regeneration. Insect disturbances include emissions from the decay of organic matter and removals from natural regeneration. Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020).National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

Natural disturbances are an important factor in determining whether forests remove or release GHGs each year. These disturbances result in immediate emissions such as from the burning of trees, as well as post-disturbance emissions and removals. Post-disturbance emissions are from the gradual decay of dead organic matter. Post-disturbance removals are related to the natural regeneration and regrowth of forests.

The variability in emissions and releases from natural disturbances can be very large from year to year. For example, emissions from managed lands were lower in 2016 than in adjacent years because of the smaller area burned.[4] However, since the mid-2000s, emissions from wildfires and insect disturbances have generally been higher than in previous years.

[4] Natural Resources Canada (2019) The State of Canada's Forests 2018.

About the indicator

What the indicator measures

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. Reported GHG emissions and removals from human-related activities result from land use and land-use change activities from the forestry sector (managed forested land and harvested wood products), agricultural land (cropland and grassland), wetlands (peat extraction and reservoirs for hydropower) and settlements. The indicator also tracks GHG emissions and removals from natural disturbances (insect infestations and wildfires) on Canada's managed lands.

Why this indicator is important

GHG emissions and their increasing concentrations in the atmosphere are having significant impacts on the environment, human health and the economy. Tracking the trends in Canada’s land-based GHG emissions and removals provides a useful context for understanding how different management activities could reduce emissions and increase removals over time. This indicator could also help identify opportunities for mitigating the impacts of climate change and the potential for enhancing carbon sequestration.

The distinction between emissions and removals from human activities versus natural disturbances allows for a better understanding of emissions that could be directly managed in the near to medium term. The National Inventory Report has made this distinction since 2017.

Related indicators

The Greenhouse gas emissions indicators report trends in total anthropogenic (human-made) GHG emissions at the national level, per person and per unit gross domestic product, by province and territory and by economic sector.

The Global greenhouse gas emissions indicator provides a global perspective on Canada's share of global GHG emissions.

The Carbon dioxide emissions from a consumption perspective indicator shows the impact of Canada's consumption of goods and services, regardless of where they are produced, on the levels of carbon dioxide released into the atmosphere.

The Progress towards Canada's greenhouse gas emissions reduction target indicator provides an overview of Canada's projected GHG emissions up to 2030.

The Greenhouse gas emissions from large facilities indicator reports GHG emissions from the largest GHG emitters in Canada (industrial and other types of facilities).

Data sources and methods

Data sources

Emissions and removals data from Canada's National Inventory Report are used to produce the Land-based greenhouse gas emissions and removals indicator for natural disturbances and land use, land-use change and forestry (LULUCF) activity on managed lands. Managed lands are defined by the Intergovernmental Panel on Climate Change (IPCC) as "land where human interventions and practices have been applied to perform production, ecological or social functions."[5] Information on the land category definition and representation of managed lands is available in Chapter 6 of the National Inventory Report.

Land-based greenhouse gas (GHG) emissions and removals include emissions and removals of carbon dioxide (CO_2). It also includes emissions of methane (CH_4), nitrous oxide (N_2O), and indirect CO_2 from the atmospheric

[5] Intergovernmental Panel on Climate Change (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 4: Agriculture, Forestry and Other Land Use. Retrieved May 6, 2020.

oxidation of carbon monoxide (CO) due to controlled biomass burning; CH_4 and N_2O emissions from wetland drainage and rewetting due to peat extraction; and N_2O released following land conversion to cropland.

More information

Data used to develop the land-based emission and removal estimates presented in the National Inventory Report are drawn from published and unpublished sources from various government departments, industry sources and scientific papers.

Land-based GHG emission estimates are provided at the national level, by sector and by region. Annual GHG emission estimates are updated each year; the most recent edition of the inventory reported estimates for the period from 1990 to 2018. Complete details of the temporal coverage for each data source used for the indicators can be found in chapter 6 of the National Inventory Report.

Preparation of the GHG inventory, including the land-based emission and removal estimates, takes almost 16 months from the end of the reporting year because of the time needed to collect, validate, calculate and interpret the data. In keeping with good practice guidance for national inventories, methods and data are improved on an on-going basis to reflect new knowledge and improved data or methods. Inventory estimates are prepared by Environment and Climate Change Canada's Pollutant Inventories and Reporting Division with input from numerous experts and scientists across Canada. Preliminary estimates and draft text are reviewed extensively by experts and officials, before they are finalized. The final report is submitted electronically to the United Nations Framework Convention on Climate Change (UNFCCC) no later than mid-April, as required.

Methods

Land-based GHG emissions and removals are quantified using methods that are consistent with an internationally agreed methodological framework set out in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The methodologies used to estimate emissions and removals are reviewed, updated and improved on a periodic basis. Collaborative work with sector experts from within and outside Environment and Climate Change Canada is undertaken to incorporate available expertise and the latest advancements in scientific knowledge. Further information on these methods is available through Environment and Climate Change Canada's National Inventory Report.

More information

Land-based GHG emissions and removals are reported in carbon dioxide equivalents (CO_2 eq), determined by multiplying the amount of emissions of a particular GHG by the global warming potential of that gas. GHGs differ in their ability to absorb heat in the atmosphere due to their differing chemical properties and atmospheric lifetimes. For example, over a period of 100 years, the potential of methane to trap heat in the atmosphere is 25 times greater than that of carbon dioxide. Therefore, methane is considered to have a global warming potential of 25. The UNFCCC Reporting Guidelines (PDF; 258 KB) publish the global warming potentials and atmospheric lifetimes to be used for each GHG reported in national GHG inventories; these can be found in Table 1-1 of the National Inventory Report.

Areas of the managed forest are subject to both forest management and natural disturbances. Emissions and removals from these areas are associated with human activities under specific circumstances. All stands harvested or that have been affected by stand-replacing natural disturbances in the past but have reached commercial maturity, or a minimum operable age (for a given region) are recognized to be under human influence. Commercially mature stands subject to natural disturbances causing less than or equal to 20% biomass mortality (for example some insects that cause defoliation but low mortality) remain associated with human activities. Large, uncontrollable natural disturbances (for example wildfires or insect outbreaks causing more than 20% biomass mortality) are recognized to result from natural occurrences and the associated emissions and removals are reflected in the natural disturbance

category. See Part II Annex 3 of the National Inventory Report for more information on the tracking and reporting of natural disturbances.[6]

Spatial aggregation

Estimates for the land use, land-use change and forestry (LULUCF) sector in the National Inventory Report are provided for 18 reporting zones (Chapter 6, Figure 6-1 Canada's National Inventory Report). These reporting zones are similar to the ecozones of the National Ecological Framework, a hierarchical, spatially consistent national ecosystem classification.

In this indicator, the reporting zones were grouped into regional categories that better reflect trends in management practices. Table 1 shows the indicator regional categories and the corresponding National Inventory Report reporting zones.

Table 1. Indicator regional categories and National Inventory Report reporting zones

Indicator regional categories	National Inventory Report reporting zones
Mountain	Taiga Cordillera
	Boreal Cordillera
	Montane Cordillera
Boreal	Taiga Plains
	Taiga Shield West
	Boreal Plains
	Boreal Shield West
	Hudson Plains
	Boreal Shield East (excluding Newfoundland)
	Taiga Shield East
West Coast	Pacific Maritime
Prairies	Subhumid Prairies
	Semiarid Prairies
Southeastern	Boreal Shield East (Newfoundland)
	Atlantic Maritime
	Mixedwood Plains
Not reported	Arctic Cordillera
	Northern Arctic
	Southern Arctic

Land-based greenhouse gas emissions and removals by land use categories

In this indicator, calculated emissions and removals data from the National Inventory Report are grouped into 4 broad classes. Table 2 shows the categories of Land-based GHG emissions and removals reported in the indicator compared with those reported in the National Inventory Report.

[6] Kurz et al. (2018) Quantifying the impacts of human activities on reported greenhouse gas emissions and removals in Canada's managed forest: conceptual framework and implementation. Canadian Journal of Forest Research 48: 1-14.

Table 2. Land-based emissions and removals categories

Land-based emissions and removals categories reported in the indicator	Land-based emissions and removals categories reported in the National Inventory Report
Forestry sector	Forest land
	Harvest wood products (HWP)
Agricultural land	Cropland
	Agricultural Grassland
Wetlands	Peat extraction and flooded lands
Settlements	Settlements

Note: Definitions for land-use change and forestry sector as reported in the National Inventory Report are consistent with the International Panel on Climate Change (IPCC 2006) land categories.

Caveats and limitations

The methodologies for compiling land-based GHG emissions and removals improve over time. As a result, the land-based emissions and removals data reported in the indicator may be different from previously published estimates.

Canada is a vast country with heterogeneous landscapes and climates. Factors such as geographic location, climatic conditions, plant species and age, and management activities all play a role in affecting the net amount of GHG that is removed or released back to the atmosphere from each location in Canada. The land-based emissions and removals data provide a simplified representation of the complex reality and may not account for all relevant ecological processes.

Current reporting of land-based emissions and removals does not account for climate feedback other than that expressed through changes in disturbance regimes. Climate feedback mechanisms can either amplify (positive feedback) or diminish (negative feedback) the effects of a changing climate. For example, as rising concentrations of GHGs warm Earth's climate, permafrost begins to melt. This melting releases the organic carbon stored, contributing to GHG releases that cause more warming, which causes more melting, and so on, in a self reinforcing cycle.

For a complete discussion of the caveats and limitations with respect to land-based GHG emissions and removals data, refer to the methodological issues sections in Chapter 6 of Canada's 2020 National Inventory Report.

Resources

References

Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse gas sources and sinks in Canada. Retrieved on May 6, 2020.

Intergovernmental Panel on Climate Change (2003) Good Practice Guidance for Land Use, Land-use Change and Forestry. Retrieved on May 6, 2020.

Intergovernmental Panel on Climate Change (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 4: Agriculture, Forestry and Other Land Use. Retrieved on May 6, 2020.

Kurz WA, Hayne S, Fellows M, MacDonald JD, Metsaranta JM, Hafer M and Blain D (2018) Quantifying the impacts of human activities on reported greenhouse gas emissions and removals in Canada's managed forest: conceptual framework and implementation. Canadian Journal of Forest Research 48: 1-14. Retrieved on August 5, 2020.

Warren FJ and Lemmen DS, editors (2014) Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. Government of Canada. Retrieved May 6, 2020.

Related information

Canada's Action on Climate Change

Climate Change

Greenhouse gas emissions

Greenhouse gas emissions: drivers and impacts

Annex

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

Table A.1. Data for Figure 1. National land-based greenhouse gas emissions and removals, 1990 to 2018

Year	Natural disturbances (megatonnes of carbon dioxide equivalent)	Human activities (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
1990	-22.19	-59.63	-81.82
1991	5.58	-65.28	-59.69
1992	-46.29	-57.76	-104.05
1993	2.63	-51.14	-48.51
1994	13.43	-52.99	-39.56
1995	188.83	-39.97	148.86
1996	11.72	-47.95	-36.23
1997	-37.40	-49.14	-86.55
1998	173.20	-56.00	117.20
1999	33.62	-45.28	-11.66
2000	-41.43	-31.79	-73.22
2001	-15.66	-47.76	-63.41
2002	134.41	-34.00	100.41
2003	77.78	-39.99	37.79
2004	133.51	-17.34	116.17
2005	46.29	-12.71	33.58
2006	72.13	-21.65	50.48
2007	81.56	-24.51	57.05
2008	27.94	-29.70	-1.76
2009	48.27	-41.63	6.64
2010	115.10	-25.24	89.86
2011	135.98	-25.39	110.60
2012	113.66	-28.06	85.59
2013	42.56	-25.25	17.31
2014	160.99	-24.72	136.27
2015	236.07	-18.15	217.92
2016	120.58	-18.53	102.05
2017	219.10	-16.41	202.69
2018	251.08	-12.86	238.22

Note: Natural disturbances refer to emissions and removals related to wildfires and large forest insect infestations. Human activities refer to emissions and removals from managed lands and includes settlements, the forestry sector, agricultural land and wetlands. Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

Table A.2. Data for Figure 2. Land-based greenhouse gas emissions and removals from human activities by activity sector, Canada, 1990 to 2018

Year	Forestry sector (megatonnes of carbon dioxide equivalent)	Agricultural land (megatonnes of carbon dioxide equivalent)	Wetlands (megatonnes of carbon dioxide equivalent)	Settlements (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
1990	-75.18	8.13	5.34	2.08	-59.63
1991	-79.55	7.03	5.22	2.03	-65.28
1992	-70.27	5.56	5.04	1.91	-57.76
1993	-62.63	4.32	5.42	1.75	-51.14
1994	-60.69	2.84	3.23	1.63	-52.99
1995	-46.05	1.42	3.12	1.54	-39.97
1996	-53.00	0.54	3.03	1.49	-47.95
1997	-52.82	-0.94	3.12	1.49	-49.14
1998	-58.72	-2.20	3.42	1.50	-56.00
1999	-47.19	-3.37	3.68	1.60	-45.28
2000	-31.79	-4.76	3.16	1.60	-31.79
2001	-46.55	-5.90	3.15	1.55	-47.76
2002	-31.60	-7.35	3.16	1.80	-34.00
2003	-36.28	-8.56	3.01	1.84	-39.99
2004	-12.74	-9.79	3.18	2.01	-17.34
2005	-6.83	-11.02	3.07	2.07	-12.71
2006	-15.03	-12.11	3.19	2.30	-21.65
2007	-17.88	-12.16	3.21	2.32	-24.51
2008	-23.11	-12.13	3.26	2.28	-29.70
2009	-34.46	-12.30	3.08	2.06	-41.63
2010	-17.99	-12.31	3.10	1.96	-25.24
2011	-18.25	-12.20	2.97	2.10	-25.39
2012	-21.78	-11.34	3.02	2.03	-28.06
2013	-20.24	-10.37	3.05	2.31	-25.25
2014	-20.65	-9.46	3.09	2.30	-24.72
2015	-14.69	-8.61	2.90	2.25	-18.15
2016	-15.91	-7.69	2.95	2.12	-18.53
2017	-14.43	-6.81	2.97	1.86	-16.41
2018	-11.15	-6.17	2.63	1.82	-12.86

Note: Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

Table A.3. Data for Figure 3. Regional land-based greenhouse gas emissions and removals from human activities, Canada, 1990 to 2018

Region	Year	Forestry sector (megatonnes of carbon dioxide equivalent)	Agricultural land (megatonnes of carbon dioxide equivalent)	Wetlands (megatonnes of carbon dioxide equivalent)	Settlements (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
Mountain	1990	-52.61	0.60	0.20	1.20	-50.61
Mountain	1991	-49.92	0.60	0.19	1.20	-47.92
Mountain	1992	-41.70	0.57	0.18	1.11	-39.84
Mountain	1993	-37.32	0.56	0.17	1.02	-35.56
Mountain	1994	-37.66	0.48	0.11	0.93	-36.14
Mountain	1995	-35.62	0.44	0.11	0.92	-34.16
Mountain	1996	-36.12	0.44	0.10	0.84	-34.74
Mountain	1997	-36.76	0.41	0.10	0.83	-35.42
Mountain	1998	-39.00	0.41	0.09	0.81	-37.68
Mountain	1999	-35.36	0.41	0.09	0.81	-34.05
Mountain	2000	-31.32	0.39	0.08	0.80	-30.06
Mountain	2001	-34.51	0.38	0.08	0.75	-33.30
Mountain	2002	-29.76	0.36	0.07	0.70	-28.63
Mountain	2003	-28.19	0.35	0.07	0.66	-27.11
Mountain	2004	-15.46	0.32	0.07	0.68	-14.40
Mountain	2005	-8.11	0.33	0.06	0.67	-7.04
Mountain	2006	-5.03	0.30	0.06	0.70	-3.97
Mountain	2007	-1.60	0.24	0.06	0.75	-0.55
Mountain	2008	-1.12	0.26	0.06	0.71	-0.09
Mountain	2009	-1.89	0.24	0.05	0.64	-0.95
Mountain	2010	2.61	0.22	0.05	0.68	3.56
Mountain	2011	5.48	0.24	0.05	0.79	6.55
Mountain	2012	4.82	0.22	0.05	0.75	5.84
Mountain	2013	6.33	0.23	0.05	0.79	7.40
Mountain	2014	4.94	0.23	0.04	0.67	5.89
Mountain	2015	5.45	0.23	0.04	0.63	6.37
Mountain	2016	4.50	0.24	0.04	0.63	5.41
Mountain	2017	4.99	0.24	0.04	0.59	5.86
Mountain	2018	6.47	0.22	0.04	0.57	7.30
Boreal	1990	-93.04	5.50	4.48	2.65	-80.41
Boreal	1991	-91.88	4.88	4.38	2.62	-80.01
Boreal	1992	-86.63	4.35	4.19	2.68	-75.41
Boreal	1993	-80.25	3.97	4.58	2.65	-69.05
Boreal	1994	-73.38	3.52	2.41	2.67	-64.78
Boreal	1995	-61.01	2.93	2.31	2.64	-53.14

Region	Year	Forestry sector (megatonnes of carbon dioxide equivalent)	Agricultural land (megatonnes of carbon dioxide equivalent)	Wetlands (megatonnes of carbon dioxide equivalent)	Settlements (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
Boreal	1996	-62.44	2.83	2.21	2.68	-54.72
Boreal	1997	-59.07	2.35	2.22	2.72	-51.77
Boreal	1998	-59.94	2.11	2.48	2.72	-52.62
Boreal	1999	-52.23	1.89	2.69	2.80	-44.85
Boreal	2000	-40.30	1.47	2.17	2.89	-33.77
Boreal	2001	-45.38	1.24	2.12	2.87	-39.15
Boreal	2002	-34.69	1.02	2.13	3.20	-28.34
Boreal	2003	-36.89	0.90	2.06	3.29	-30.64
Boreal	2004	-30.17	0.74	2.13	3.45	-23.85
Boreal	2005	-27.88	0.48	2.02	3.56	-21.82
Boreal	2006	-33.47	0.37	2.18	3.76	-27.16
Boreal	2007	-35.67	0.43	2.21	3.73	-29.30
Boreal	2008	-39.86	0.48	2.27	3.77	-33.34
Boreal	2009	-45.34	0.40	2.11	3.64	-39.19
Boreal	2010	-35.37	0.44	2.06	3.56	-29.31
Boreal	2011	-37.04	0.51	2.07	3.62	-30.84
Boreal	2012	-37.82	0.67	2.17	3.57	-31.40
Boreal	2013	-38.31	0.92	2.24	3.75	-31.40
Boreal	2014	-36.58	1.16	2.29	3.86	-29.27
Boreal	2015	-32.01	1.34	2.04	3.76	-24.87
Boreal	2016	-31.90	1.58	1.92	3.66	-24.75
Boreal	2017	-30.64	1.86	1.89	3.56	-23.33
Boreal	2018	-29.94	1.91	1.79	3.58	-22.66
West coast	1990	16.21	0.11	0.01	-0.63	15.71
West coast	1991	16.83	0.13	0.01	-0.65	16.33
West coast	1992	19.12	0.12	0.01	-0.70	18.55
West coast	1993	19.40	0.11	0.01	-0.73	18.80
West coast	1994	19.18	0.11	0.01	-0.76	18.54
West coast	1995	20.66	0.13	0.01	-0.79	20.01
West coast	1996	18.98	0.11	0.01	-0.81	18.29
West coast	1997	17.47	0.11	0.01	-0.83	16.77
West coast	1998	15.39	0.13	0.01	-0.85	14.68
West coast	1999	16.33	0.12	0.01	-0.87	15.60
West coast	2000	16.45	0.11	0.01	-0.91	15.66
West coast	2001	13.93	0.13	0.01	-0.89	13.17
West coast	2002	14.65	0.12	0.01	-0.91	13.88
West coast	2003	12.38	0.12	0.01	-0.91	11.60

Region	Year	Forestry sector (megatonnes of carbon dioxide equivalent)	Agricultural land (megatonnes of carbon dioxide equivalent)	Wetlands (megatonnes of carbon dioxide equivalent)	Settlements (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
West coast	2004	15.65	0.12	0.01	-0.93	14.85
West coast	2005	14.14	0.12	0.01	-0.95	13.32
West coast	2006	12.00	0.13	0.01	-0.95	11.20
West coast	2007	11.02	0.12	0.01	-0.95	10.20
West coast	2008	9.86	0.13	0.01	-0.97	9.04
West coast	2009	7.66	0.13	0.01	-0.99	6.82
West coast	2010	9.06	0.11	0.01	-1.01	8.18
West coast	2011	9.86	0.12	0.01	-1.01	8.99
West coast	2012	9.59	0.13	0.01	-0.95	8.78
West coast	2013	10.25	0.13	0.01	-0.91	9.49
West coast	2014	9.28	0.11	0.01	-0.98	8.42
West coast	2015	9.31	0.12	0.01	-1.00	8.44
West coast	2016	9.04	0.15	0.01	-1.00	8.20
West coast	2017	8.67	0.14	0.02	-1.01	7.81
West coast	2018	8.73	0.13	0.02	-1.03	7.85
Prairies	1990	-0.42	-0.07	0.00	-0.16	-0.65
Prairies	1991	-0.65	-0.48	0.00	-0.16	-1.29
Prairies	1992	-0.70	-1.42	0.00	-0.17	-2.29
Prairies	1993	-0.62	-2.35	0.00	-0.17	-3.14
Prairies	1994	-0.57	-3.36	0.00	-0.17	-4.11
Prairies	1995	-0.57	-4.23	0.00	-0.17	-4.97
Prairies	1996	-0.60	-5.06	0.00	-0.17	-5.83
Prairies	1997	-0.55	-6.26	0.00	-0.18	-6.98
Prairies	1998	-0.68	-7.44	0.00	-0.18	-8.30
Prairies	1999	-0.58	-8.53	0.00	-0.18	-9.29
Prairies	2000	-0.53	-9.63	0.00	-0.18	-10.34
Prairies	2001	-0.57	-10.72	0.00	-0.18	-11.48
Prairies	2002	-0.50	-11.81	0.00	-0.19	-12.50
Prairies	2003	-0.54	-12.82	0.00	-0.19	-13.55
Prairies	2004	-0.44	-13.82	0.00	-0.19	-14.45
Prairies	2005	-0.37	-14.74	0.00	-0.19	-15.30
Prairies	2006	-0.38	-15.62	0.00	-0.19	-16.19
Prairies	2007	-0.42	-15.78	0.00	-0.19	-16.40
Prairies	2008	-0.36	-15.92	0.00	-0.19	-16.48
Prairies	2009	-0.33	-16.07	0.00	-0.20	-16.60
Prairies	2010	-0.29	-16.16	0.00	-0.20	-16.65
Prairies	2011	-0.21	-16.22	0.00	-0.20	-16.64

Region	Year	Forestry sector (megatonnes of carbon dioxide equivalent)	Agricultural land (megatonnes of carbon dioxide equivalent)	Wetlands (megatonnes of carbon dioxide equivalent)	Settlements (megatonnes of carbon dioxide equivalent)	Net exchange (megatonnes of carbon dioxide equivalent)
Prairies	2012	-0.23	-15.63	0.00	-0.20	-16.06
Prairies	2013	-0.23	-15.04	0.00	-0.20	-15.47
Prairies	2014	-0.17	-14.45	0.00	-0.19	-14.82
Prairies	2015	-0.06	-13.90	0.00	-0.19	-14.15
Prairies	2016	-0.07	-13.36	0.00	-0.19	-13.62
Prairies	2017	0.04	-12.84	0.00	-0.20	-12.99
Prairies	2018	0.08	-12.33	0.00	-0.20	-12.45
Southeastern	1990	1.38	1.99	0.64	-0.98	3.03
Southeastern	1991	0.42	1.90	0.64	-0.99	1.97
Southeastern	1992	0.02	1.95	0.65	-1.00	1.62
Southeastern	1993	1.33	2.02	0.66	-1.03	2.98
Southeastern	1994	0.74	2.10	0.69	-1.04	2.49
Southeastern	1995	2.55	2.16	0.70	-1.06	4.35
Southeastern	1996	1.72	2.22	0.70	-1.05	3.59
Southeastern	1997	2.66	2.45	0.79	-1.06	4.83
Southeastern	1998	3.75	2.59	0.83	-1.00	6.16
Southeastern	1999	4.28	2.75	0.89	-0.97	6.94
Southeastern	2000	4.70	2.90	0.90	-0.99	7.51
Southeastern	2001	1.76	3.07	0.93	-0.98	4.78
Southeastern	2002	1.31	2.97	0.94	-1.00	4.21
Southeastern	2003	0.29	2.91	0.87	-1.02	3.04
Southeastern	2004	1.66	2.85	0.97	-0.99	4.48
Southeastern	2005	-0.08	2.79	0.98	-1.02	2.67
Southeastern	2006	-3.12	2.72	0.93	-1.02	-0.50
Southeastern	2007	-5.72	2.84	0.93	-1.03	-2.98
Southeastern	2008	-5.75	2.92	0.92	-1.03	-2.94
Southeastern	2009	-8.29	3.00	0.90	-1.04	-5.44
Southeastern	2010	-7.39	3.07	0.98	-1.07	-4.41
Southeastern	2011	-9.40	3.15	0.84	-1.10	-6.51
Southeastern	2012	-10.90	3.27	0.79	-1.13	-7.96
Southeastern	2013	-10.75	3.39	0.75	-1.11	-7.72
Southeastern	2014	-10.30	3.49	0.75	-1.06	-7.12
Southeastern	2015	-9.30	3.60	0.80	-0.96	-5.85
Southeastern	2016	-9.15	3.70	0.98	-0.97	-5.44
Southeastern	2017	-8.92	3.80	1.02	-1.09	-5.19
Southeastern	2018	-7.67	3.90	0.79	-1.10	-4.08

Note: Regions are based on the location of the human activities across the country. Net exchange is calculated by subtracting removals from emissions.
Source: Environment and Climate Change Canada (2020) National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

Table A.4. Data for Figure 4. Land-based greenhouse gas emissions and removals from natural disturbances in managed areas, Canada, 1990 to 2018

Year	Wildfires – immediate (megatonnes of carbon dioxide equivalent)	Post wildfires (megatonnes of carbon dioxide equivalent)	Insects (megatonnes of carbon dioxide equivalent)	Natural disturbances net exchange (megatonnes of carbon dioxide equivalent)
1990	38.11	-60.96	0.66	-22.19
1991	62.44	-57.52	0.67	5.58
1992	15.19	-61.99	0.51	-46.29
1993	65.57	-63.35	0.41	2.63
1994	76.96	-63.90	0.37	13.43
1995	241.53	-53.08	0.37	188.83
1996	63.61	-52.29	0.40	11.72
1997	18.35	-56.17	0.42	-37.40
1998	224.59	-51.86	0.47	173.20
1999	85.16	-52.02	0.48	33.62
2000	11.88	-56.34	3.04	-41.43
2001	35.46	-57.49	6.37	-15.66
2002	176.66	-52.71	10.47	134.41
2003	112.20	-52.30	17.76	77.67
2004	161.09	-51.15	23.55	133.49
2005	66.75	-52.10	31.62	46.27
2006	85.42	-51.68	38.38	72.12
2007	90.85	-51.93	42.64	81.56
2008	38.10	-54.07	43.91	27.94
2009	63.49	-56.09	40.87	48.27
2010	129.24	-52.75	38.61	115.10
2011	151.19	-50.77	35.56	135.98
2012	128.57	-48.57	33.65	113.66
2013	59.30	-50.48	33.75	42.56
2014	177.41	-47.11	30.70	160.99
2015	246.58	-39.64	29.13	236.07
2016	132.14	-38.15	26.59	120.58
2017	227.89	-32.44	23.65	219.11
2018	255.93	-26.71	21.87	251.08

Note: Wildfire emissions and removals are divided in 2 categories, (1) wildfires - immediate and (2) post wildfires. Wildfires - immediate include emissions from trees and soils from the burning of wildfires. Post wildfires include emissions released by the decay of dead trees and soil organic matter and removals related to forest regeneration. Insect disturbances include emissions from the decay of organic matter and removals from natural regeneration. Net exchange is calculated by subtracting removals from emissions.

Source: Environment and Climate Change Canada (2020).National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.

Additional information can be obtained at:

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